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Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

TO: T. R. QUAY

SUBJECT: AP600 HYDRODYNAMIC LOADS ROADMAP

Dear Mr. Quay:

The attachment to this letter is a list of the AP600 testing and analysis documents that constitute the application of the ADS Phase B1 test data to the AP600 plant IRWST. This information is provided in response to an action taken during a January 21, 1997 telecon between Westinghouse and the NRC. This submittal closes this action item.

Please contact Gene Pliplica on (412) 374-5310 if you have any questions concerning this transmittal.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/jml

attachment

cc: W. Huffman, NRC
J. Kudrick, NRC
N. J. Liparulo, Westinghouse (w/o attachment)

E004

AP600 Hydrodynamic Load Roadmap

The approach for resolving the hydrodynamic loading issue for the AP600 consisted of a testing program, and an analytical program. The testing program was performed by ENEA in the Vapore test facility, and consisted of a full scale single sparger submerged in a non-prototypic test tank full of water. The sparger was connected to a steam supply system capable of supplying saturated steam and steam/water two-phase mixture, to simulate different full flow operating conditions for the ADS system. The test program was divided into phase A (steam discharge only) and phase B (both steam and two-phase mixture discharge through the sparger). The first part of phase B testing (B1) was intended to duplicate the design conditions for the sparger discharge in the AP600. The following is a summary of the results from the phase B1 testing:

1. Choked flow occurred at more than one point in the ADS flow path simultaneously, and included at the open ADS valves, at the inlet to the sparger, at the sparger arm inlet from the body, at the sparger arm holes (discharge holes).

2. Sparger operation was smooth with steam and two-phase fluid, and the resultant pressure peaks appeared to be within the expected magnitudes.

3. The sparger arm geometry created a strong mixing current in the quench tank during the blowdown when the tank was subcooled. However, complete mixing to the bottom of the tank did not occur.

4. Blowdown in the fully heated tank (212°F) expelled a significant amount of water from the tank.

5. The pressure pulses measured in the quench tank when the water was hot (212°F) were significantly reduced compared with blowdown in cold water (90°F).

6. No instability in steam condensation was observed at elevated pool temperatures > 179°F to saturation temperature.

7. Air and water clearing loads were not dominant.

8. No significant pressure oscillations due to chugging were observed.

   A. Information that documents that the ADS testing performed at VAPORE adequately simulated and provided blowdown conditions that are directly applicable to the AP600 plant is listed below.

      - WCAP-14303, "Facility Description Report — AP600 Automatic Depressurization System Phase B1 Tests", AP600 Document Number RCS-T3R-001, Rev. 0, March 1995.

        This document provides a detailed description of the VAPORE facility. It is a good reference document for details on the physical layout, the instrumentation, and components of the VAPORE test facility.

      - WCAP-14324, "Final Data Report for ADS Phase B1 Tests", AP600 Document Number RCS-T2R-100, Rev. 0, April 1995.

        This document provides detailed information on the actual performance of the Phase B1 testing, and provides the verified test data. Sections of interest include:

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- Section 1.2, describes the test matrix

- Section 2.0, pp 2-1 to 2-21, provides a concise description of the test facility.

- Section 4.0 provides reduced test data on each test run including the blowdown flow rate vs. time, the fluid quality vs. time, and the pressure drops through the facility at different times. Table 4.5-1 on p. 4-151 provides a summary of the quasi-steady state pressure and fluid quality upstream of the test facility ADS package, the ADS package delta-P, the pressure and fluid quality as discharged from the sparger, and the flow rate achieved in each test run.

- Appendix C provides a set of selected at plots for each test which includes the pressure pulse time histories for quench tank pressure sensors and their associated power density spectrum.

• WCAP-14305, "AP600 Test Program Test Analysis Report", AP600 Document Number RCS-T2R-110, Rev. 1, June 1995.

  This document analyses the ADS Phase B1 test data to obtain needed information on ADS behavior, pressure drops, flow rates and flow splits through the stages, and two phase multipliers. These results are used to validate the computer models of the ADS in the NOTRUMP and WCOBRA/TRAC computer codes used in SSAR Chapter 15 analyses. This information does not directly apply to the analysis of the ADS/IRWST interaction, but is referenced to illustrate the detailed review performed on the actual test data.

• WCAP-14676, "AP600 Automatic Depressurization System Stage 1, 2 and 3 Cold Flow Test", AP600 Document Number RCS-T2R-020, Rev. 0, July 1996.

  This document presents delta-P data and determines the overall and individual component resistances in the ADS valve package experienced with single-phase cold water flow. This information does not directly apply to the analysis of the ADS/IRWST interaction, but is referenced for completeness.

• WCAP-14727, "AP600 Scaling and PIRT Closure Report", AP600 Document Number PXS-GSR-020, Rev. 0, September 1996.

  - Section 5.0 of this document presents a concise summary of the ADS Phase B1 test and the phenomena important for LOCA type analysis.

  - Section 5.2 presents the ADS Phase B1 test scaling basis for each component and is of interest in documenting the applicability of the data.

  - Section 5.3 discusses the scaling distortions of the ADS facility.

  - Section 5.4 describes any unanticipated phenomena which occurred during the test program.

  - Section 5.5 compares the ADS Phase B1 tests run with the performance of the ADSs during the transient simulated at the SPES-2 and OSU integral systems tests.

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B) Information describing how the ADS test data on the quench tank pressure pulses was utilized to establish the pressure pulse design criteria for the plant, and how was this information incorporated into the plant IRWST structural design is provided in the following documents. These documents were developed as part of the AP600 FOAKE program but are available for review at the Westinghouse Rockville office or at the Energy Center Site in Monroeville, PA.

- MT01-S3C-012, Rev. 0, AP600 Document, April 1996, "ADS Discharge Investigation and IRWST Hydrodynamic Global Analysis".

  This report documents the selection of pressure loads for the structural analysis of the IRWST. The selection was based on the expected operating conditions of the ADS, being conservatively enveloped by the test data from the B1 testing based on the following parameters: mass flow rate vs. quality, and quality and mass flow rate derivative. Two tests were selected as representative for enveloping expected operating conditions, one representing the frequency spectrum up to 40 hz, the other for higher frequencies. Selected short time periods were then selected from each test and used as pressure time history input loading in the ANSYS model for the IRWST. The displacement time history of critical locations are also documented.

- AP600 letter MIS/FOK0019, Gordon K. Ashley II (SciEnTec) to R. Hundal (W), "Generation of an Acoustic Source Function for the Ansaldo Pressure Trace IRW330", dated October 22, 1996.

  This report evaluated the pressure traces used by the ANSALDO analysis, to determine the extent of test tank influence in the pressure trace used in the analysis. The intent was to develop a pure acoustic pressure source by determining the part of the frequency content of the measured pressure trace which was due to the test tank. The results of this investigation was that the test tank frequency could not be determined with certainty since there was no value for the sonic velocity determined n the test tank. Based on the assumptions made by ANSALDO for sonic speed of 1440 m/s resulting from near rigid test tank walls, the test tank acoustic resonance frequency is approximately 50 hz. However, with a sonic frequency of 872 m/s, based on measurements in the Kraftwerk Union GKM II-M test tank which was expected to have similar wall stiffness to the ANSALDO tank, the test tank frequency will be approximately 30 hz. The measured pressure response in the test tank contained peaks at both of these frequencies. It was, however, concluded that these acoustic resonance peaks included in the source loading used by ANSALDO for the analysis of the IRWST, provide additional conservatism in terms of the source loading.

- WCAP-14766, "The Hydrodynamic Effect of the Automatic Depressurization System (ADS) Discharge on the AP600 RCS," December 1996.

  This report documents a detailed analysis of the steam generator 1, which is located adjacent to the wall of the IRWST and therefore sees the greatest loads from the ADS discharge/sparger operation. The report documents the evaluation based on both monolithic concrete properties and cracked concrete properties, and evaluates the loads transferred to the steam generator via supports, snubbers and bumpers. A linear analysis was performed to evaluate the hypothetical effects of supports without gaps, and a non-linear analysis showed the effects of expected gaps in the supports. The conclusions of this study are as follows:

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1. The high-frequency, low amplitude input is not sufficient to overcome the inertia of the steam generator, and therefore does not produce significant steam generator movements.

2. There is no bumper/SG interaction if the gap exceed 0.013 inch at one bumper, or 0.005 inch at each bumper.

3. The SG snubbers are not active during an ADS event if the "dead band" for the snubber assembly exceeds 0.007 inch.

4. There is no appreciable amplification of the input motion by the SG or the SG internal structures.

5. The loads and displacements generated by the response to the ADS hydrodynamic loading on the reactor coolant system are less than 10 percent of those produced by the SSE. The combined ADS and SSE loads adds less than 0.3 percent to those produced by the SSE alone, and are not considered significant. Therefore, the ADS generated hydrodynamic loads can be ignored as design basis events.