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Energy Systems

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DCP/NRC1268
NSD-NRC-98-5585
Docket No.: 52-003

February 24, 1998

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

ATTENTION: T. R. QUAY

SUBJECT: AP600 RESPONSE TO FSER OPEN ITEMS

Dear Mr. Quay:

Enclosed with this letter are the Westinghouse responses to FSER open items on the AP600. A summary of the enclosed responses is provided in Table 1. Included in the table is the FSER open item number, the associated OITS number, and the status to be designated in the Westinghouse status column of OITS.

The NRC should review the enclosures and inform Westinghouse of the status to be designated in the "NRC Status" column of OITS.

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

Eugene J. Piplica for
Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

Enclosures

cc: W. C. Huffman, NRC (Enclosures)
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Table 1
List of FSER Open Items Included in Letter DCP/NRC1268

FSER Open Item	OITS Number	Westinghouse status in OITS
440.742F	6254	Confirm W

Enclosure to Westinghouse
Letter DCP/NRC1268

February 24, 1998

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Question 440.742F (OITS - 6254)

In RAI 440.723, the staff has questioned the operability of the pressurizer safety valves to function for extended periods of time (up to 5 hours) during pressurization transients (loss of AC power, loss of normal feed, inadvertent operation of the ECCS, and CVS malfunctions). In Westinghouse's response to this RAI (NSD-NRC-97-5384 dated October 17, 1997), Westinghouse stated that there is insufficient stored energy in the system to cause the valves to fully open, and valve operation can be characterized as weeping. An evaluation of a typical spring-loaded safety valve under these conditions shows that the valves will be fluttering near the seat with a small amplitude. The effects of this motion near the seat may be that the valves will leak after the transient. However, there will be no structural damage that will cause the valves to fail to reseat. Safety valve operation under these conditions is acceptable because their operation is with steam at the inlet to the valve. Operation under these conditions are within their capabilities.

As discussed with Westinghouse during a telephone conversation on October 23, 1997, the staff does not agree with Westinghouse's conclusions. The staff believes that the safety valves will fully open when the safety valve setpoint is reached and significant blowdown will take place. Westinghouse has not demonstrated that the resultant level swell in the pressurizer will not result in the passing of liquid through the safeties which can result in valve failure. This remains and open item.

Response (Revision 1):

Based on discussions held on January 9, 1998 with Westinghouse, NRC staff and representatives of Crosby, a safety valve vendor, it was agreed that the AP600 analyses that show extended operation of the pressurizer safety valves at very low flow rates is representative of the behavior of spring-loaded safety valves. SSAR Section 5.4.9.3 has been updated to explain the operating characteristics of the safety valves with low pressurization rates.

To further supplement the characterization of the operation of the safety valves, the NRC has requested more information that could justify the modeling of the safety valves performance provided in the SSAR Chapter 15 analyses. Further justification that the safety valves will "weep" (pass steam at low flow rates) as the system pressure approaches the full-open set pressure, and will not pop fully open is provided in Reference 440.742F-1. In this paper, it is shown that, for Thermodisc designs of pressurizer safety valves, at 2% below the full open set pressure, the leakage rate is 50 cubic feet per hour (condensed at atmospheric conditions) at an inlet pressure of roughly 1050 psi for a 3 inch valve. This is substantial leakage which is equivalent to 3,120 lb/hr of steam (0.87 lb/sec). The AP600 safety valves have a similar thermodisc design and seat configuration differences are minimal. Noting that the tested valve is smaller in size than the AP600 valve and the test pressure is lower than the AP600 condition, one can expect a higher leakage with higher pressure (2485 psig versus 1050 psig) and larger size (6 inch versus 3 inch). This test provides further evidence that the characterization of the safety valves performance provided in the safety analysis is appropriate.

To verify the AP600 safety valve behavior, a type test is performed that verifies the safety valves pass a minimum flow prior to popping full-open. This test is described in SSAR subsection 5.4.9.4.

In addition to the justifications provided above, Westinghouse has performed conservative calculations that assess the maximum swell that can occur if the safety valves were to pop full-open and reclose with a 5% blowdown. This calculation assumes that the valve does not "weep" as modeled in the Chapter 15 accident analyses. Results of these calculations show th the maximum swell associated with this behavior is approximately 30 ft^3 when the average bulk RCS temperature (including the vessel, loop piping, CMTs and PRHR) is approximately 500°F. This average temperature is characteristic of the average temperature of the RCS for the Chapter 15 accident analyses where continued safety valve operation is predicted. This level swell is attributed to the density difference of the fluid at the opening pressure (2500 psia) and the closing pressure (2375 psia). However, this level swell is counteracted as the RCS pressure continues to increase. When the RCS pressure again approaches the safety valve set pressure, the pressurizer water level is restored to that shown in the analyses for that given time period, and there is no cumulative effect on pressurizer water level of the safety valves re-opening. Therefore, although the pressurizer water level could be 30 ft^3 higher at any given time during the transient (due to the valve fully opeing), the margin to pressurizer overfill is greater than 30 ft^3, and the pressurizer will not become water filled fo he transients presented in the SSAR where no overfill is predicted.

For some events (inadvertent CMT operation and CVS malfunction) described in the SSAR where operator actions prevent pressurizer overfill the operation of the safety valves does not significantly affect the time available to the opearator to take actions to prevent pressurizer overfill, and the SSAR analyses are bounding.

References:

440.742F-1 R. E. Adams and J. L. Corcoran, "Sealing of High-Pressure Steam Safety Valves," Transactions of the ASME, November, 1950, pp 1137-1142

SSAR Revision:

Sections 5.4.9.3 and 5.4.9.4 as attached.

Certified Design Material Revision

CDM Section 2.1.2 as attached.

Condensate does not collect as a slug of water to be discharged during the initial opening of the valve. The discharge of the safety valve is routed through a rupture disk to containment atmosphere. The rupture disk is provided to contain leakage past the valve, is designed for a substantially lower set pressure than the safety valve set pressure, and does not function as a relief device. The reactor coolant system Piping and Instrumentation Drawing (Figure 5.1-1) shows the arrangement of the safety valves.

The relief valve in the normal residual heat removal system is located between the suction line of the pump and the valve that isolates the residual heat removal system from the reactor coolant system. The discharge from that valve is directed to the containment atmosphere. Subsection 5.4.7 discusses the residual heat removal system. Figure 5.4-6 shows a simplified sketch of the normal residual heat removal system.

In accordance with the requirements of 10 CFR 50.34(f)(2)(xi), positive position indication is provided for the pressurizer safety valves and the normal residual heat removal system relief valve, which provide overpressure protection for the reactor coolant pressure boundary.

Temperatures in the safety valve discharge lines are measured, and an indication and a high temperature alarm are provided in the control room. An increase in a discharge line temperature is an indication of leakage or relief through the associated valve. Leakage past the pressurizer safety valve during normal operation is collected and directed to the reactor coolant drain tank. Section 7.5 discusses the functional requirements for the instrumentation required to monitor the safety valves.

5.4.9.3 Design Evaluation

The pressurizer safety valves prevent reactor coolant system pressure from exceeding 110 percent of system design pressure, in compliance with the ASME Code, Section III. The relief valve on the suction line of the normal residual heat removal system protects that system from exceeding 110 percent of the design pressure of the system and from exceeding the pressure-temperature limits determined from ASME Code, Appendix G, analyses.

The reactor coolant system pressure transients are described in subsection 15.2.3 and are the basis for the ASME Code Overpressure Protection Report. In the analysis of overpressure events, the pressurizer safety valves are assumed to actuate at 2500 psia. The safety valve flowrate assumed is based on full flow at 2575 psia, assuming 3 percent accumulation.

In certain design basis events decribed in Chapter 15, the pressurizer safety valves are predicted to operate with very low flow rates. For these events, the reactor coolant system pressure is slowly increasing as a result of the mismatch between the decay heat removal rate from the passive residual heat removal heat exchanger and the core decay heat. This slow pressurization of the reactor coolant system results in a small amount of steam flow through the safety valves. Under these conditions, the safety valves do not fully open and would not experience significant cycling. Operation of the safety valves under these conditions could result in small leakage from the valve (much less than the capacity of the normal makeup system), but does not impair the valve overpressure protection capability.

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The relief valve on the normal residual heat removal system has an accumulation of 10 percent of the set pressure. The set pressure is the lower of the pressure based on the design pressure of the residual heat removal system and the pressure based on the reactor vessel low temperature pressure limit. The pressure limit determined based on the design pressure includes the effect of the pressure rise across the pump. The set pressure in Table 5.4-17 is based on the reactor vessel low temperature pressure limit. The lowest permissible set pressure is based on the required net positive suction head for the reactor coolant pump.

5.4.9.4 Tests and Inspections

The safety and relief valves are the subject of a variety of tests to validate the design and to verify pressure boundary and functional integrity. For valves that are required to function during a Service Level D condition, static deflection tests are performed to demonstrate operability. Section 3.10 describes these tests.

Safety valves similar to those connected to the pressurizer have been tested within the Electric Power Research Institute safety and relief valve test program. These valves have been found adequate for steam flow and water flow, even though water flow is not anticipated through the pressurizer safety valves. The completion of this program addresses the requirements of 10 CFR 50.34(f)(2)(x) as related to reactor coolant system relief and safety valve testing. The normal residual heat removal system relief valve is designed for water relief and is not a reactor coolant system pressure relief device since it has a set pressure less than reactor coolant system design pressure. Therefore, the valve selected for the normal residual heat removal system relief valve is independent from the Electric Power Research Institute safety and relief valve test program.

Reactor coolant system pressure relief devices are subjected to preservice and inservice hydrostatic tests, seat leakage tests, operational tests, and inspections, as required. The preservice and inservice inspection and testing programs for valves are described in subsections 3.9.6 and 5.4.8 and Section 6.6. The test program for the safety valves complies with the requirements of ANSI/ASME OM, Part 1.

The pressure boundary portion of the valves are required to be inservice inspected according to the rules of Section XI of the ASME Code. There are no full-penetration welds within the valve body walls. Valves are accessible for disassembly and internal visual inspection.

Type testing of the pressurizer safety valves is performed to verify that the valves act in a stable manner at low flow rates as modeled in the Chapter 15 accident analyses. The testing correlates leakage through the valve as a function of inlet pressure and demonstrates that the leakage through the safety valves at set pressure conditions will be greater than or equal to that modeled in the accident analyses (approximately 0.35 lbm/sec). The duration of the testing need not duplicate the times indicated in the accident analysis results but should last for a sufficient time to demonstrate stable valve operation. Stable valve performance for a 15 minute time duration is sufficient.

7. a) The Class 1E equipment identified in Table 2.1.2-1 as being qualified for a harsh environment can withstand the environmental conditions that would exist before, during, and following a design basis accident without loss of safety function for the time required to perform the safety function.

   b) The Class 1E components identified in Table 2.1.2-1 are powered from their respective Class 1E division.

   c) Separation is provided between RCS Class 1E divisions, and between Class 1E divisions and non-Class 1E cable.

8. The RCS provides the following safety-related functions:

   a) The pressurizer safety valves provide overpressure protection in accordance with Section III of the ASME Boiler and Pressure Vessel Code.

   b) The pressurizer safety valves operate to mitigate design basis events.

   c) The reactor coolant pumps (RCPs) have a rotating inertia to provide RCS flow coastdown on loss of power to the pumps.

   d) The RCS provides automatic depressurization during design basis events.

9. The RCS provides the following nonsafety-related functions:

   a) The RCS provides circulation of coolant to remove heat from the core.

   b) The RCS provides the means to control system pressure.

10. Safety-related displays identified in Table 2.1.2-1 can be retrieved in the main control room (MCR).

11. a) Controls exist in the MCR to cause the remotely operated valves identified in Table 2.1.2-1 to perform active functions.

   b) The valves identified in Table 2.1.2-1 as having protection and safety monitoring system (PMS) control perform an active safety function after receiving a signal from the PMS.

   c) The valves identified in Table 2.1.2-1 as having diverse actuation system (DAS) control perform an active safety function after receiving a signal from DAS.

12. a) The motor-operated valves identified in Table 2.1.2-1 perform an active safety-related function to change position as indicated in the table.

REACTOR COOLANT SYSTEM
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AP600

Table 2.1.2-4 (cont.) Inspections, Tests, Analyses, and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
8.a) The pressurizer safety valves provide overpressure protection in accordance with Section III of the ASME Boiler and Pressure Vessel Code.	i) Inspections will be conducted to confirm that the value of the vendor code plate rating is greater than or equal to system relief requirements.	i) The sum of the rated capacities recorded on the valve ASME Code plates of the safety valves exceeds 800,000 lb/hr.
	ii) Testing and analysis in accordance with ASME Code Section III will be performed to determine set pressure.	ii) A report exists and concludes that the safety valves set pressure is 2485 psig $\pm$ 25 psi.
8.b) The pressurizer safety valves operate to mitigate design basis events.	***Tests or type tests are performed to correlate flow through the safety valves as a function of inlet pressure.***	***A report exists and concludes that the flow through the safety valves is greater than or equal to 0.35 lbm/sec at a pressure below the valve full-open set pressure.***
8.c) The RCPs have a rotating inertia to provide RCS flow coastdown on loss of power to the pumps.	Inspection of as-built RCP vendor data will be performed.	The calculated rotating inertia of each RCP is no less than 5000 lb-ft^2

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