Westinghouse

FAX COVER SHEET

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COMMENTS:

Tom,

Here is first installment of info for Thursday's phone call.

We will formally respond to open RAIs this month.

Page 9.2-21, Revision 6 is basis for response to 410.283.

Page 410.292 is the response currently in review

Pages 3B-6 thru 3B-9 are basis for responses to 410.263, OI 373, and

DSER-OI 10.4.9-2(1164)

Last ~~four~~ three pages are responses going into review.

processed in the demineralized water transfer and storage system to remove dissolved oxygen. In addition to supplying water for makeup of systems which require pure water, the demineralized water is used to sluice spent radioactive resins from the ion exchange vessels in the chemical and volume control system (as described in subsection 9.3.6), the spent fuel pool cooling system (as described in subsection 9.1.3), and the liquid radwaste system (as described in section 11.2) to the solid radwaste system.

The demineralized water treatment system is described in subsection 9.2.3.

9.2.4.1 Design Basis

9.2.4.1.1 Safety Design Basis

The demineralized water transfer and storage system serves no safety-related function other than containment isolation, and therefore has no nuclear safety-related design basis except for containment isolation. See subsection 6.2.3 for the containment isolation system.

9.2.4.1.2 Power Generation Design Basis

- The demineralized water transfer and storage system provides demineralized water through the demineralized water storage tank to fill the condensate storage tank and to meet required demands and usages of demineralized water in other plant systems.

- The demineralized water transfer pumps provide adequate capacity and head for the distribution of demineralized water.

- The demineralized water storage tank supplies a source of demineralized water to the chemical and volume control makeup pumps during startup and required boron dilution evolutions. The demineralized water transfer and storage system supplies the required amount of water to the chemical and volume control system for reactor water makeup.

- The oxygen content of water supplied to the demineralized water distribution system from the demineralized water storage tank is 100 ppb or less.

- Sufficient storage capacity is provided in the condensate storage tank to satisfy condenser makeup demand based on maximum steam generator blowdown operation during a plant startup duration.

- The condensate storage tank provides the water supply for the startup feedwater pumps during startup, hot standby, and shutdown conditions.

- The condensate storage tank provides a sufficient supply of water to the startup feedwater system to permit 8 hours of hot standby operation, followed by an orderly plant cooldown from normal operating temperature to conditions which permit operation of the normal residual heat removal system over a period of approximately 6 hours.

PRELIMINARY

AP600

Question 410.292

In Section 10.4.9.2.1 of the SSAR (Revision 4), Westinghouse changed the pump capacity of the startup feedwater system to two 50-percent from two 100-percent pumps. Section 10.4.9.1.2 of the SSAR, Item H, states that two startup feedwater pumps are provided with a single pump capable of satisfying the startup feedwater system flow for decay heat removal. Justify how a single 50-percent capacity pump (with one pump in standby) can satisfy the flow demand and redundancy requirements.

Response:

The Startup Feedwater Pump portion of SSAR subsection 10.4.9.2.2, Revision 6, is now consistent with subsection 10.4.9.1.2. Each startup feedwater pump can supply 100 percent of the required flow to the steam generators to meet decay heat requirements.

SSAR Revision: NONE

PRELIMINARY

reactor plants (which have not experienced stress corrosion cracking in the auxiliary stainless steel piping).

Main Steam Line and Main Feedwater Line

The main steam piping is constructed from ferritic steel. Stress corrosion cracking in ferritic steels commonly result from a caustic environment. A source of a caustic environment in the main steam piping would be moisture carryover from the steam generator. However, the secondary side water treatment utilizes all volatile treatment. All volatile treatment effectively precludes causticity in the steam generator bulk liquid environment. For some operating plants prior to implementing all volatile treatment, the phosphate water treatment caused a caustic chemical imbalance resulting in stress corrosion cracking of steam generator tubing. Under all volatile treatment water treatment conditions, there is no instance of caustic stress corrosion cracking on the ferritic steam lines indicating no significant caustic carryover. The operating secondary side chemistry precludes stress corrosion cracking on the ferritic main steam line.

Stress corrosion cracking is not expected to occur in the main feedwater line piping because of control of the oxygen to very low levels. There has been no experience with stress corrosion cracking in feedwater lines in operating plants of Westinghouse design. The operating secondary side chemistry precludes stress corrosion cracking on the main feedwater line.

Based on the above discussion, stress corrosion cracking does not have an adverse effect on the integrity of AP600 leak-before-break piping systems.

3B.2.3 Water Hammer

Primary Loop Piping

The reactor coolant loop is designed to operate at a pressure greater than the saturation pressure of the coolant, thus precluding the voiding conditions necessary for water hammer to occur. The reactor coolant primary system is designed for Level A, B, C, and D (normal, upset, emergency, and faulted) service condition transients. The design requirements are conservative relative to both the number of transients and their severity. Relief valve actuation and the associated hydraulic transients following valve opening have been considered in the system design. Other valve and pump actuations cause relatively slow transients with no significant effect on the system dynamic loads.

To provide dynamic system stability, reactor coolant parameters are controlled. Temperature during normal operation is maintained within a narrow range by control rod positioning. Pressure is controlled within a narrow range for steady-state conditions by pressurizer heaters and pressurizer spray. The flow characteristics of the system remain constant during a fuel cycle. The operating transients of the reactor coolant system primary loop piping are such that significant water hammer loads are not expected to occur.

Auxiliary Stainless Steel Piping

The passive core cooling system and automatic depressurization system are designed to minimize the potential for water hammer induced dynamic loads. Design features include:

- Continuously sloping core makeup tank and passive residual heat exchanger inlet lines to eliminate local high points
- Inlet diffusers in the core makeup tanks to preclude adverse steam and water interactions
- Vacuum breakers in the discharge lines of the automatic depressurization valves connected to the pressurizer

The AP600 pressurizer spray control valve is similar to what is used in the operating plants. There is no history of water hammer caused by the spray control valve.

The normal residual heat removal system isolation valves are slow closing valves, identical to operating plants, and therefore would not be a source of water hammer.

These features minimize the potential of water hammer in the auxiliary stainless steel piping system.

Main Feedwater Line

The feedwater piping, steam generator design details, and other component details in the feedwater system are designed to minimize the potential and severity of water hammer within the feedwater piping. The following addresses each aspect of the design incorporated to minimize water hammer.

Steam Generator Design: The AP600 steam generator design benefits from investigation of water hammer events and the resulting design changes developed to address the events (References 4 through 8).

- Top discharge feed flow through spray tubes (similar to J-tubes) from the feedring reduces the potential of void formation when the steam generator level drops below the feedring level. Previous steam generator feedring designs had incorporated bottom discharge holes that permitted feedring draining whenever the steam generator level dropped below the feedring.
- Separate startup feedwater and main feedwater nozzles are incorporated to provide for only heated feedwater from the deaerator entering the steam generator via the main feedwater line
- Feedwater nozzle design incorporates a welded thermal liner attached to the feedwater nozzle forging to form a positive seal to limit the potential for feedring drainage and therefore void formation within the feedring. Previous designs had included a "close fit"

but not a complete seal at the connection to the nozzle forging. The welded thermal liner design has no leak paths within the steam generator through which the water can drain from the feedring.

Feedwater piping design: The AP600 feedwater piping layout has incorporated features to limit void formation and water hammer initiation.

- A downward facing elbow is connected to the steam generator nozzle and thus complies with industry recommendations to minimize the horizontal feedwater piping connected to the steam generator. The short horizontal section minimizes amount of steam void which can form.
- The main feedwater piping inside containment continuously rises to the steam generator providing for natural venting of the steam generator in the event a steam void is formed.
- Long straight piping runs in the feedwater line are limited.

Component and system design selection:

- A major cause of water hammer problems in pressurized water reactor feedwater systems has been control valve instability. These instabilities resulted from factors such as oversized valve, unbalanced valve trim, damage to valve components, and incompatibility of the feedwater control valve with the rest of the feedwater system. These problems are minimized on AP600 by the following:
  - The specification of specialized valve trim to avoid instability
  - The use of variable speed feedwater pumps to reduce the demands on the control valve requirements
  - Reduced control requirements on the main feedwater control valve by the use of a startup feedwater line that provides feedwater flow control from either the startup feedwater pump or the main feed pump at lower feed demand (power) levels.
  - Main feedwater control valve positioning during normal operation is the function of the plant control system (see subsection 7.7.1.8) using a refinement of a standard three-element control scheme. The control scheme provides greater steam generator level stability and thus reduces potential feedwater transients.
- Rapid closure of some types of feedwater check valves may potentially cause water hammer in main feedwater lines. The controlled closure check valve specified for the AP600 main feedwater lines limits the magnitude of the closing loads generated by valve closure caused by depressurization of the feedwater line upstream of the check valve.

- Feedwater delivered to the main feedwater line is drawn only from the deaerator. The heated feedwater is normally at least 250°F and helps reduce the possibility of water hammer.

- Startup feedwater is piped directly to the steam generator. This feature helps prevent the need to introduce cold water directly into the main feedwater and thus minimizes the chances of steam water counterflow or steam bubble collapse type of water hammer events.

- Rapid resumption of feedwater flow to the steam generators is accomplished in the AP600 design. Numerous options are available to maintain or restore steam generator level with the feedwater system design. Based on the flow demand signal and level of feedwater isolation either the main feedwater pump(s) or the startup feedwater pumps can adequately provide level control. If there is no engineered safeguard features feedwater isolation signal present, the main feedwater pumps will provide adequate steam generator inventory control, via the main feedwater line or the startup feedwater line. If a main feedwater isolation signal exists then either the main feedwater pump(s) or the startup feedwater pump(s) provides startup feedwater flow via the startup feedwater line.

The above design provisions make the potential for steam generator water hammer in the feedwater line extremely low. However, with consideration for the main feedwater and steam generator design features, the susceptibility of the main feedwater line inside containment for water hammer has been evaluated. The most common historic causes were evaluated as well as the relevant modes of operation for susceptibility to the appropriate water hammer mechanisms (Reference 4). The limiting anticipated and unanticipated events were evaluated. The results of the analysis demonstrate that the system is acceptable for leak-before-break application.

Main Steam Line

The steam lines are not subject to water hammer by the nature of the fluid transported. The following system design provisions address concerns regarding steam hammer within the main steam line and identify the significant dynamic loads included in the main steam piping design.

- Design features that prevent water slug formations are included in the system design and layout. In the main steam system, these include the use of drain pots and the proper sloping of lines.

- The operating and maintenance procedures that protect against a potential occurrence of steam hammer include system operating procedures that provide for slowly heating up (to avoid condensate formation from hotter steam on colder surfaces), operating procedures that caution against fast closing of the main steam isolation valves except when necessary, and operating and maintenance procedures that emphasize proper draining.

- The stress analyses for the safety-related portion of the main steam system piping and components include the dynamic loads from rapid valve actuations, including actuation of the main steam isolation valves and the safety valves.

Based on the above discussion, water hammer does not have an adverse effect on the integrity of AP600 leak-before-break piping systems.

3B.2.4 Fatigue

Low-Cycle Fatigue

Low-cycle fatigue due to normal operation and anticipated transients is accounted for in the design of the piping system. The Class 1 piping systems comply with the fatigue usage requirements of the ASME Code, Section III.

A fatigue evaluation at the main feedwater nozzle equivalent to ASME Class 1 piping is performed. Also, a fatigue crack growth analysis at the main feedwater nozzle is performed.

Due to the nature of operating parameters, main steam line piping systems are not subjected to any significant transients to cause low-cycle fatigue.

Based on the above discussion, low-cycle fatigue is not a concern of AP600 leak-before-break piping systems.

High-Cycle Fatigue

High-cycle fatigue loads in the system result primarily from pump vibrations. The steam generator is designed so that flow-induced vibrations in the tubes are avoided (see subsection 5.4.2). The loads from reactor coolant pump vibrations are minimized by criteria for pump shaft vibrations during hot functional testing and operation. During operation, an alarm signals when the reactor coolant pump vibration is greater than the limits.

Main feedwater pump vibration is isolated from the leak-before-break feedwater line inside containment via the piping and equipment supports.

With these precautions taken, the likelihood of leakage due to fatigue in piping systems evaluated for leak-before-break is very small.

3B.2.5 Thermal Aging

Stainless Steel Piping

Piping used in the reactor coolant loop and other auxiliary lines are wrought stainless steel materials, rather than cast materials, so that thermal aging concerns are not expected for the AP600 piping and fittings. The welds used in the assembly of the AP600 are gas tungsten arc welds (GTAW). These welds are essentially as resistant to the effects of thermal aging

The Main Feedwater Line portion of SSAR Appendix 3B, subsection 3B.2.3, Revision 7, provides a more detailed discussion of the AP600 design features for minimizing water hammer. including piping layout features. As indicated in SSAR subsection 5.4.2.2, the statup feedwater piping layout includes the same features as the main feedwater piping layout. As indicated thoughout SSAR subsection 10.4.9, the startup feedwater system is sized, operated and has water sources consistent with minimizing the potential for water hammer.

SSAR Revision: None

Draft Response for 410.294

In Revision 6 of the SSAR, sections 10.4.9.2.1 and 10.4.9.2.2 have been revised to be consistent with the first bullet of section 10.4.9.1.2. The main feedwater system and the startup feedwater system are parallel systems. The main feedwater system draws water from the deaerator tank and delivers it to the main feed rings within the steam generators. The startup feedwater system draws water from the condensate storage tank and delivers it to the startup feedwater nozzle on the steam generators. They have a manual cross-connect between their respective pumps and control valves. This will allow the main feed pumps to supply water from the deaerator tank to the startup feedwater nozzles on the steam generators. A check valve (in addition to the normally closed isolation valve) in the cross-connect prevents the startup feedwater pumps from supplying water from the condensate storage tanks to the main feed header and steam generator main feed rings.

SSAR Rev: None

Draft Response for 410.291

SSAR subsections 10.4.7.1.1 and 10.4.9.1.1, Revision 7, include a more consistent description of safety related functions of the main and startup feedwater control and isolation valves. Subsection 10.4.7.1.1 discusses only main feedwater system functions and components. Subsection 10.4.9.1.1 discusses only startup feedwater functions and components. Bullet sections of subsection 10.4.9.1.1 are intended to reenforce the first paragraph of the subsection. Startup feedwater isolation valves close on any of containment isolation, steam generator isolation or feedwater isolation signals. They can also be closed by a remote manual signal.

SSAR Revision: None

Draft Response for 410.293