Westinghouse Electric Corporation Energy Systems

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Mr. P. G. Trudel
Sequoyah Project Engineer
Tennessee Valley Authority
Sequoyah Nuclear Power Plant, OSC-A
P. O. Box 2000
Soddy Daisy, TN 37379

Dear Mr. Trudel:

Tennessee Valley Authority
Sequoyah Units 1 and 2
Pressurizer Vents at Cold Shutdown

The purpose of this letter is to inform TVA that Westinghouse has identified a potential issue related to limitations of pressurizer venting for decay heat removal at cold shutdown. During a loss of RHR cooling transient, there is a potential for water hold-up in the pressurizer if the reactor coolant is allowed to boil. It is possible that the steam velocity in the surge line would be high enough that liquid entrainment prevents water from draining back from the pressurizer into the hot leg. This effect is also called surge line flooding. The attachment to this letter describes three technical concerns associated with surge line flooding and provides some recommendations for utility and WOG consideration.

Westinghouse is unable to evaluate whether deficiencies or failures to comply would create a substantial safety hazard. This is because the significance of this issue depends upon procedures, training, and outage schedules individual PWR stations have adopted for shutdown operations. It is recommended that utilities review their shutdown procedures for loss of decay heat removal with regard to the concerns discussed herein and revise them if appropriate. This topic is also being referred to the Westinghouse Owners Group for their consideration.

Westinghouse has performed loss of RHR cooling analyses for Sequoyah. These analyses were done as part of plant outage support and to assist you with your response to the NRC's Generic Letter 88-17, "Loss of Decay Heat Removal." The information transmitted for Sequoyah will be reviewed and revised as necessary to account for the surge line flooding concerns. Westinghouse will transmit this supplemental information at a later date.

TVA PLANS TO REMOVE THE BONNET ON A HOT LEG INJECTION CHECK VALVE TO PROVIDE AN ALTERNATE VENT PATH.

This information is being provided to TVA under the requirements delineated in 10CFR21.21(b) which requires Westinghouse to inform affected customers of this determination and the details of the situation such that licensees may make arrangements to evaluate the situation pursuant to 10CFR21.21(a).

Very truly yours,

B. J. Garry, Project Manager
TVA, Sequoyah Project
Domestic Customer Projects

Attachment
0221K

cc: M. A. Cooper - Sequoyah Site
R. Fortenberry - Sequoyah Site
W SSM Office - Sequoyah Site
D. M. Lafever - Sequoyah Site
R. Beecken - Sequoyah Site
W. C. Ludwig - Sequoyah Site

D. F. Goetcheus - Chattanooga Office 1101 Market Street

Pressurizer Vents at Cold Shutdown

Technical Description

Summary

During a loss of RHR cooling transient, there is a potential for water hold-up in the pressurizer if the reactor coolant is allowed to boil. It is possible that the steam velocity in the surge line would be high enough that liquid entrainment prevents water from draining back from the pressurizer into the hot leg. This effect (water held in the pressurizer because of high surge line steam velocity) is also called "surge line flooding". This would occur if there is a large vent on the pressurizer, the decay heat is high, and all or most of the decay heat generates steam (due to boiloff) that goes to the pressurizer. This letter describes three technical concerns associated with surge line flooding and provides some recommendations for utility and WOG consideration.

Issue Description

It is sometimes necessary or desirable during an outage to create large openings in the RCS to allow for various maintenance or inspection activities. Frequently, a large hot side vent is provided by removal of the pressurizer manway or by removal of the pressurizer safety valves. A large hot leg side vent would be provided, for example, to limit the pressure on the steam generator nozzle dams, to prevent a rapid loss of RCS inventory through potential cold side openings, and/or to allow some capability to gravity feed from the RWST. Per Generic Letter 88-17 (Reference 1), these would all be valid reasons for using a large hot leg side vent.

If the pressurizer has a large vent, then steam generated in the RCS during a loss of RHR cooling event would be relieved through the pressurizer surge line and out the opening(s) near the top of the pressurizer. If the decay heat is high, it is possible that the steam velocity through the surge line would be high enough to cause water to be held up in the pressurizer. This water held up in the pressurizer could have been initially forced into the pressurizer because of swelling following the onset of boiling, or entrainment with the boil-off steam, or the RCS may have been initially filled to some level in the pressurizer. This process of surge line flooding and water hold-up in the pressurizer could continue even if the core is being uncovered.

In a report prepared for the NRC, EG&G calculated that surge line flooding in a typical 4-loop Westinghouse plant (14 inch diameter surge line) would occur at atmospheric pressure if more than 3 MWt went into generating steam traveling through the surge line (Reference 3). With less than 3 MW, surge line flooding was calculated not to occur. Higher pressures would permit a higher decay heat. Uncertainty exists in the calculation, as it depends upon the correlation used. (EG&G used the Kutateladze correlation.) Considering the beneficial affect of even small pressure increases above atmospheric, and other heat losses in the RCS, Westinghouse suggests that surge line flooding should be considered as a possibility at all times prior to core refueling. (Note that after refueling and 30 days after shutdown, decay heat for a typical 4-loop plant should not exceed 4 MW.)

Steam generator cooling, including cooling via reflux condensation, is an effective means of decay heat removal if RHR cooling is lost for a prolonged period of time during shutdown. This assumes that the RCS is intact or has small vents, i.e., vents having roughly one square inch total area or smaller. However, large vents in the pressurizer, such as an open manway, can contribute to surge line flooding.

Safety Significance

The phenomenon of surge line flooding introduces the following three concerns:

1. Calculations previously performed to determine the limiting times to core uncovery would be non-conservative (too long) if these calculations have taken credit for the water held up in the pressurizer.

2. With the water hold-up and/or high steam flow, some RCS level indication systems would read erroneously high.

3. With water hold-up in the pressurizer and high steam flow in the surge line, the RCS pressure in the loops could be high enough to prevent gravity feed from the RWST, depending on the elevation of the RWST.

For the first concern, without water hold-up in the pressurizer, one might expect that a large hot side vent path located near the top of the pressurizer would allow a longer time to core uncovery than that expected if the vent path is located near the top of the hot leg (e.g., an open hot side steam generator manway). For the pressurizer vent case, it might be assumed that any initial water in the pressurizer would not be lost, nor would water be lost from the RCS piping due to spilling (due to swelling and entrainment) after the reactor coolant starts to boil. Referring to Case 8.9 in WCAP-11916 (Reference 4), for a typical 4-loop plant with 12 MWt decay heat and with RCS level initially at mid-loop, the time to core uncovery would be increased from about 1.5 hours to more than 2 hours if the steam generator "spill penalty" is not assumed for the pressurizer vent case. However, if surge line flooding occurs, the time to core uncovery for the pressurizer vent case would be reduced due to water hold-up and the resulting time to core uncovery would become more comparable to the time to core uncovery for the open hot side steam generator manway case. Note that if boiling occurs, a larger initial water inventory in the RCS (above mid-loop) may not significantly lengthen the time to core uncovery -- more water may be simply transferred to the pressurizer and either spilled or held up there.

For the second concern noted, water in the pressurizer or even significant flow up the surge line will cause an erroneously high reading on some reactor vessel level instrumentation systems, particularly those having an upper tap in the pressurizer. Thus, an operator could be misled into believing he had a full reactor vessel, as well as water in the pressurizer, even though water level in the reactor vessel could be below the bottom of the nozzles. With this false indication, the operator may not add water when he should. False reactor vessel level indication due to boiling is also discussed in Chapter 8 of NUREG-1410 (Reference 2).

Regarding the third concern, a vent at the top of the pressurizer may not support gravity feed from the RWST as an alternate for sustained decay heat removal once the RCS starts to boil. Gravity feed from the RWST is sometimes considered as a passive alternate to the RHR System for decay heat removal since it is independent of ac power. As noted above, high steam flow in the surge line and/or substantial water hold-up in the pressurizer will increase the RCS pressure in the loops, thereby reducing the capability to gravity feed from the RWST. Therefore, gravity feed from the RWST could be limited to a "one-shot" addition of coolant, dependent upon the initial RCS inventory and the RWST level. (Note that in some plants, the water level in the RWST is below the vent at the top of the pressurizer. This would make it impossible to drain water from the RWST into the RCS if the pressurizer is nearly full. On other plants, the RWST is high enough that gravity feed could be effective for long-term heat removal even with high decay heat and after RCS boiling.)

Recommended Actions

It is recommended that utilities review their shutdown procedures for loss of decay heat removal with regard to the concerns discussed here, and revise them if appropriate. It is also recommended that, in the process of reviewing outage schedules, utilities consider (a) the above concerns when evaluating the need or desire to provide a large pressurizer vent, and (b) the desirability of maintaining steam generator heat removal capability when practical while on RHR.

This topic is also being referred to the Westinghouse Owners Group for their consideration in maintaining or revising the ARG-1 guideline and background information (Reference 5) to include information on surge line flooding and water holdup in the pressurizer.

Questions on this topic can be addressed to Dave Campbell of the WOG Project Office (412-374-6206), or Toby Burnett, Advisory Engineer, Risk Management and Operations Improvement (412-374-5599).

References

1. U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Generic Letter 88-17, "Loss of Decay Heat Removal," October 17, 1988.

2. U.S. Nuclear Regulatory Commission Incident Report Loss of Vital AC Power and the Residual Heat Removal System During Mid-Loop Operations at Vogtle Unit 1 on March 20, 1990, NUREG-1410, June 1990.

3. Fletcher, C.D., et al, Thermal-Hydraulic Processes Involved in Loss of Residual Heat Removal During Reduced Inventory Operation, EGG-EAST-9337, Rev. 1, February 1991.

4. Andreychek, T.S., et al, Loss of RHRS Cooling While the RCS is Partially Filled, WCAP-11916, Westinghouse Proprietary Class 3, July 1988.

5. "Background Information for Westinghouse Owners Group Abnormal Response Guideline ARG-1, Loss of RHR While Operating at Mid-Loop Conditions," Rev. 0, March 15, 1990, transmitted with letter WOG-90-067 from K.J. Voytell to Westinghouse Owners Group Primary Representatives, March 26, 1990.