ENCLOSURE

Safety Evaluation Report for Salem Units 1 and 2 Regarding Generic Letter 81-21 Natural Circulation Cooldown

Background

On June 11, 1980, St. Lucie Unit 1 experienced a natural circulation cooldown event which resulted in the formation of a steam bubble in the upper head region of the reactor vessel. This resulted in the generation of an NRC Generic Letter dated May 5, 1981 to all PWR licensees. The licensees were to provide an assessment of the ability of their facility's procedures and training program to properly manage similar events. This assessment was to include:

(1) A demonstration (e.g., analysis and/or test) that controlled natural circulation cooldown from operating conditions to cold shutdown conditions, conducted in accordance with their procedures, should not result in reactor vessel voiding.

(2) Verification that supplies of condensate grade auxiliary feedwater are sufficient to support their cooldown method, and

(3) A description of their training program and the revisions to their procedures.

The licensee responded to this request in the reference 2 letter. The following is our evaluation of the licensee's response to the concerns outlined above.

Evaluation

The licensee has incorporated instructions in its procedures based on the Westinghouse Owner's Group guidelines. The guidelines are based on a study performed by Westinghouse for the Owner's Group. This study evaluates the potential for steam formation in Westinghouse NSSS's and recommends modifications to the operator guidelines.

The results of the Westinghouse report, W-OG-57 (Reference 3), are applicable to all 2, 3, and 4 loop plants. The report concludes that in previous analyses for operating guidelines and safety analyses, void formation in the upper head is explicitly accounted for if it is calculated to occur. These previous analyses indicate that voiding is not a safety concern because the voids will collapse when they come in contact with the subcooled region of the vessel.

The present analysis differentiates between T_{hot} and T_{cold} plants. T_{cold} plants are those which have sufficient flow between the downcomer and the upper head such that the temperature of the upper head is approximately the same as the cold leg temperature. T_{hot} plants have an upper head temperature between the hot leg and cold leg temperature. This SER will deal with the T_{hot} analysis because the Salem Units are considered to be T_{hot} plants.

The analysis is done for two cooldown rates, 25°F/hr and 50°F/hr. An analysis is also done which accounts for the effect of the Control Rod Drive Mechanism (CRDM) cooling fans. These fans blow air across the vessel head and provide some additional cooling of the upper head.

One of the conditions that must be met during a cooldown is that the primary system pressure be 400 psia when the primary system temperature is 350°F. These are conditions which would permit the Residual Heat Removal System (RHRS) to be used. The analysis shows that neither cooldown rate can meet this condition without upper head voiding unless the depressurization is halted when the primary temperature reaches 350°F and the upper head is given time to cool off. A hand calculation shows this cool-off period is approximately 20 hours for a 25°F/hr cooldown rate and is approximately 27 hours for a 50°F/hr cooldown rate.

An additional analysis includes the effect of the CRDM cooling fans and results in a significant increase in the rate of cooldown of the upper head. The CRDM cooling fans provide cooling of the CRDM magnetic jack coil winding. The system consists of axial fans that pull containment air past the coil housings and across the Reactor Vessel Head. The analysis was based on a hand calculation. This calculation assumed that the CRDM fan cooling system removes 780KW at full power. This energy removal is equal to an upper head cooldown rate of 32°F/hr when the upper head temperature is 600°F. Assuming that the cooldown rate is proportional to the temperature difference between the upper head metal and the containment atmosphere, the CRDM fans would cool the upper head at a rate of 17°F/hr when the upper head fluid is 350°F.

Based on these analyses the Westinghouse report makes the following conclusions and recommendations for operator guidelines:

1. If the CRDM cooling effect is included the operator can reach shutdown cooling entry conditions without void formation if a 25°F/hr cooldown rate is used. The operator should maintain 50°F subcooling in the system.

2. If the CRDM fans are not available, the operator should commence a 25°F/hr cooldown and should depressurize at a rate which maintains 50°F subcooling until the system reaches 1900 psi. At this point the depressurization rate should be changed so that a 200°F subcooling margin is maintained until the system reaches 1200 psi. At this time the depressurization should be stopped. When the primary temperature reaches 350°F, a 20-hour cool-off period should be allowed before depressurization.

The licensee concludes that its operators are instructed to cooldown at a rate of 20-25°F/hr, soak at 350°F to allow the upper head to cool off, and then depressurize at less than 750 psi/hr. The licensee notes that a natural circulation cooldown test was performed during the Salem Unit No. 2 Startup Test Program. Although this test was not a complete cooldown to Cold Shutdown, the licensee concludes that the results support their assertion that their procedures allow for a natural circulation cooldown without void formation. The Startup Test Program Report states that this test included a cooldown from 555°F to 480°F at a rate of approximately 19°F/hr. The pressurizer pressure decreased to approximately 1800 psia. The staff notes that the saturation temperature corresponding to 1800 psia is 620°F and thus no voiding would occur regardless of the cooldown rate of the upper head . The results of the Westinghouse analysis do indicate, however, that voiding can be prevented.

The licensee concludes that it has sufficient condensate grade auxiliary feedwater supplies to support its cooldown procedures. A review of the Salem 1 auxiliary feedwater supplies (Reference 4) lists the following sources. The seismic Category I Auxiliary Feedwater Storage Tank contains 220,000 gallons which will provide for 8 hours of decay heat removal. There are two non-seismic Demineralized Storage Tanks that contain 500,000 gallons each. Back-up sources include the fire protection and domestic water storage tank and the service water system. Approximately 1/2 hour would be needed to connect these systems.

The staff emphasizes the importance of training and procedures in resolving this issue. The review of generic guidelines was part of TMI Action Item I.C.1, Generic Review of Vendor Guidelines. The Westinghouse Owners Group Emergency Response Guidelines includes ES-0.2, Natural Circulation Cooldown. This guideline incorporates the results of the analyses previously discussed. These guidelines were reviewed and approved by issuance of the Reference 5 Safety Evaluation Report. The staff concludes that if the licensee appropriately implements the generic emergency guidelines into their plant-specific procedures, adequate procedures will be available for the operator to safely conduct a controlled natural circulation cooldown even if limited upper head voiding should occur.

The licensee's submittal included copies of their Lesson Plan, Instructors Lesson Plan, and St. Lucie Study Assignment Sheets from their requalification training program. The staff concludes the licensee's training program adequately addresses upper head voiding during natural circulation cooldown.

Conclusion

Upper head voiding, in itself, does not present any safety concerns provided that the operator has adequate training and procedures to recognize and react to the situation. Voiding in the upper head makes RCS pressure control more difficult and therefore if the situation warrants, natural circulation cooldown should be done without voiding.

The licensee's procedures call for a 20-25°F/hr cooldown rate with thermal soak at 350°F to allow the upper head to cooloff. The Westinghouse study concludes this cooloff period is on the order of 20 hours. Natural circulation tests are planned for Diablo Canyon and will provide experimental verification of the upper head heat loss calculations. The staff concludes that the licensee has demonstrated its ability to cooldown without voiding and has condensate supplies consistent with its procedures.

This SER did not attempt a review of guidelines since this effort is being conducted under TMI Action Item I.C.1., Generic Review of Vendor Guidelines. The staff finds that upon acceptable implementation of the NRC-approved Westinghouse Owners Group Emergency Response Guidelines, the licensee's procedures will be adequate to perform a safe natural circulation cooldown.

References

1. Generic Letter 81-21, "Natural Circulation Cooldown," May 5, 1981.
2. Letter, Uderitz to Eisenhut, "Natural Circulation Cooldown Generic Letter 81-21, Salem Generating Station, "November 16, 1981.
3. Letter w/enclosure, Jurgensen to Check, "St. Lucie Cooldown Event Report," W-OG-57, April 20, 1981.
4. NUREG-0611, "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in Westinghouse-Designed Operating Plants," January 1980.
5. Mattson, R. J and H. Thompson to D. G. Eisenhut, "SER for Westinghouse Emergency Response Guidelines," May 19, 1983.