Safety Evaluation Report for

Sequoyah Units 1 and 2 and McGuire 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.

This SER evaluates both the Sequoyah and McGuire submittals because of similarities in their responses. The Sequoyah response is documented in reference 2 and the McGuire response is documented in reference 3. The following is our evaluation of the licensee's response to the concerns outlined above.

Evaluation

In the Sequoyah submittal the licensee states that low power natural circulation tests were conducted as part of the Sequoyah Unit 1 start up test program. They conclude that these tests demonstrated that the plant can be safely shutdown and cooled to 450°F without void formation using natural circulation cooling.

The Sequoyah and McGuire submittals refer to a Westinghouse study that 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 4), 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_{cold} analysis because the Sequoyah and McGuire units are considered to be T_{cold} plants.

The analysis is done using the WFLASH code. The WFLASH code has 2-phase capability and can track void propagation. The analysis assumes a best estimate model and an inverted top hat upper support plate design. Metal heat addition to the upper head area from the vessel and internals is taken into account. It is assumed that the reactor coolant pumps are stopped at the beginning of the transient.

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 for a 25°F/hr cooldown rate void formation can be avoided by maintaining a 50°F subcooling margin in the hot leg and for a 50°F/hr cooldown rate there will be no void formation if a 100°F subcooling margin is maintained.

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 30°F/hr when the upper head temperature is 572°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 50°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 plant can be cooled down to shutdown cooling entry conditions without upper head void formation if a 50°F/hr cooldown rate is used and the operator maintains 100°F subcooling in the hot leg.

The Sequoyah submittal states that the licensee will revise its procedures to include the Westinghouse recommendations on cooldown rate, subcooling margin and the use of the CRDM cooling fans. The licensee's technical specification limit on the minimum Condensate Storage Tank

level provides condensate supplies for 6 hours following reactor trip. Assuming a 50°F/hr cooldown rate, this allows the operator to remain at hot standby for two hours before beginning a cooldown. Additionally the ERCW system provides an essentially unlimited amount of cooling water. The licensee concludes they have sufficient condensate supplies.

The McGuire submittal concludes that the Westinghouse generic analysis is applicable to McGuire and that the recommendations made were used in the development of the McGuire Operating Procedures. The McGuire units have a Technical Specification minimum of 240,000 gallons of condensate grade water and a maximum capacity of 297,500 gallons of condensate grade water. 240,000 gallons is sufficient to hold the plant at hot standby for two hours followed by a cooldown to the residual heat removal system cut-in point in five hours. The licensee concludes that this is a sufficient condensate supply.

The Sequoyah operators have received training on natural circulation during the startup test program, operator training program and operator retraining program. These programs include a review of all IE Bulletins and Power Reactor Event reports. This includes a review of the St. Lucie event. Discussions are held on the temperature difference between different areas of the RCS and natural circulation is shown on the simulator. The licensee's procedures include cautions on rapid pressurizer level increases during depressurization and give instructions on mitigation of void formation.

The McGuire operators receive training on the provisions of their procedures and on industry experiences such as the St. Lucie event. Their procedures include cautions that an increase in pressurizer level indicates upper head voiding is occurring. Establishing and maintaining natural circulation is also included in the operator's simulator training.

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 licensees appropriately implement 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 staff concludes that the Sequoyah and McGuire training programs adequately address upper head voiding during natural circulation cooldown.

Conclusion

Upper head voiding, in itself, does not present any safety concerns provided that the operators have adequate training and procedures to properly 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 licensees conclude that use of their procedures will not result in upper head voiding. They further conlcude that they have sufficient condensate supplies to support their cooldown methods. The staff finds the Sequoyah and McGuire responses acceptable.

This SER did not attempt a review of guidelines. 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 (Generic Letter 83-22), 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, Mills to Adensam, "Tennessee Valley Authority, Docket Nos. Report," 50-327, 50-328," dated December 1, 1981.
3. Parker, W. O. to E. G. Adensam, " McGuire Nuclear Station, Natural Circulation Cooldown," January 20, 1982.
4. Letter w/enclosure, Jurgensen to Check, "St. Lucie Cooldown Event Report," W-OG-57, April 20, 1981.
5. Generic Letter 83-22, "Safety Evaluation of Emergency Response Guidelines," June 3, 1983.