UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION REGARDING GENERIC LETTER 81-21 - NATURAL CIRCULATION COOLDOWN SAN ONOFRE NUCLEAR GENERATING STATION, UNIT NO. 1 DOCKET NO. 50-206

1.0 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. This resulted in the generation of an NRC Generic Letter dated May 5, 1981 (Ref. 1) 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 the Southern California Edison Company (SCE) response for San Onofre Unit No. 1 (Ref. 2).

2.0 EVALUATION

In their submittal SCE referred 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 (Ref. 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 San Onofre plant is considered to be a T_{hot} plant.

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 plant design. The initial upper head temperature is conservatively set equal to the hot leg temperature. 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 transients.

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 no more than 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 performed by Westinghouse 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.

San Onofre concludes that these recommendations have been included in their plant operating procedures and therefore, use of their procedures will not result in reactor vessel voiding.

The San Onofre Unit No. 1 Technical Specification minimun on the volume of water in the Condensate Storage Tank and the Primary Plant Makeup Tank is 120,000 gallons. This is sufficient water to provide for approximately 28 hours of decay heat removal and cooldown. A 25°F/hr cooldown followed by a 20 hour soak would take 28 hours and therefore sufficient condensate-grade auxiliary feedwater supplies exist.

The licensee additionally concludes that the Condensate Storage Tank capacity is 240,000 gallons and normally contains at least 150,000 gallons. The Primary Plant Makeup Tank capacity is 150,000 gallons and normally contains at least 100,000 gallons. The licensee concludes that they normally would have sufficient condensate supplies to remove decay heat and cooldown for up to 72 hours after reactor trip. Finally the service water reservoir contains 2 to 3 million gallons of non-condensate grade water.

The analysis which included the effect of the CRDM fan cooling was performed on a generic rather than a plant specific basis. The capacity of the CRDM cooling system at San Onofre may differ from that used in the analysis. (This analysis assumed that the system was operating at full capacity removing 12KW/drive mechanism). The system is not safety grade and during a loss of offsite power event the system may or may not be capable of being powered by the diesel generator. The licensee has demonstrated however, that they have sufficient condensate supplies to support an extended cooldown without the CRDM cooling fans.

The San Onofre submittal includes their operating procedure for loss of reactor coolant pumps and for natural circulation cooldown. The licensee concludes that this procedure is included as part of the required review at their annual operator 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, Guidance for the Evaluation and Development of Procedures for Transients and Accidents. The Westinghouse Owners Group Emergency Response Guidelines include ES-0.2, Natural Circulation Cooldown. This guideline incorporates the results of the analyses previously discussed. These guidelines were reviewed and approved by the NRC staff as documented in a Safety Evaluation dated June 3, 1983 (Ref. 4). 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 licensees' training program should include discussions of the St. Lucie event, how voiding occurs, the safety significance of the consequences of voiding and a discussion of the applicable procedures. The licensees only specify that the procedures are covered in training and should review their program to ensure that all these items are addressed.

3.0 CONCLUSION

Upper head voiding, in itself, is not a safety concern provided that the operator is equipped with 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 Westinghouse analysis concludes that a 20 hour cooloff period before depressurization is necessary to prevent voiding when the CRDM fans are not operating. Natural circulation tests are planned at Diablo Canyon and will provide experimental verification of the upper head heat loss calculations. The staff concludes that the licensees have demonstrated their ability to cooldown without voiding and have sufficient condensate supplies.

This SER did not attempt a review of guidelines or procedures. This effort is being conducted under TMI Action Item I.C.1, Guidance for the Evaluation of Development of Procedures for Transients and Accidents. The staff finds that upon acceptable implementation of the NRC-approved Westinghouse Owners Group Emergency Response Guidelines, the licensees' procedures will be adequate to perform a safe natural circulation cooldown.

The licensees are requested to review their training program and confirm that the following items have been addressed:

a) The St. Lucie event,
b) how voiding occurs and the safety significance of its consequences,
c) signs that voiding is occurring,
d) discussion of procedures to prevent and mitigate voiding.

4.0 ACKNOWLEDGEMENT

The principle contributor to this Safety Evaluation was M. Keane.

Dated: August 9, 1983

REFERENCES

1. Generic Letter 82-21, "Natural Circulation Cooldown," May 5, 1981.

2. Letter, Baskin to Crutchfield, "Natural Circulation Cooldown, San Onofre Nuclear Generating Station," November 18, 1981.

3. Letter w/enclosure, Jurgensen to Check, "St. Lucie Cooldown Event Report," W-OG-57, April 20, 1981.

4. Generic Letter 83-22, "Safety Evaluation of Emergency Response Guidelines," June 3, 1983.