MEETING WITH R.E. GINNA NUCLEAR POWER PLANT, LLC (GINNA LLC), REGARDING EXTENDED POWER UPRATE AMENDMENT APPLICATION (TAC NO. MC7382)

Thursday, November 17, 2005
LOCATION: U.S. Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

POST-LOCA LONG-TERM COOLING RAIS

DRAFT RESPONSE PLAN

Enclosure 2

1. *The long-term cooling analysis and boric acid precipitation analysis are based on a 1975 Westinghouse letter that the NRC staff does not consider acceptable. Submit a new analysis that contains the following considerations for performing the long-term cooling analyses:*
   a. *The mixing volume must be justified and the void fraction must be taken into account when computing the boric acid concentration.*
   b. *Since the mixing volume is a variable quantity that increases with time, the boric acid concentration just prior to the switch to simultaneous injection should reflect the variable size of the mixing region set by the pressure drop in the loop. The fluid static balance between the downcomer and inner vessel region (i.e. lower plenum, core, and upper plenum regions of the vessel) can then be performed taking into account the loop pressure drop at a given steaming rate to compute the mixture volume in the core and eventually the upper plenum regions. The concentration in the resulting mixing volume just prior to expansion into the upper plenum (which will cause a sudden decrease in concentration due to the large area change in the upper plenum) must be shown to remain below the precipitation limit.*
   c. *The precipitation limit must be justified, especially if containment pressures greater than 14.7 psia are assumed or additives are contained in the sump water.*
   d. *The decay heat multiplier, as required by Appendix K to 10 CFR 50.46, must employ a multiplier of 1.2 for all times. 10 CFR 50.46(b)(5) states that "decay heat shall be removed for an extended period of time required by the long lived radioactivity remaining in the core." Subsection (I)(A)(4), "Fission Product Decay," of Appendix K states that "The heat generation from radioactive decay of fission products shall be assumed to be equal to 1.2 times the values for infinite operating time ..."*

Two boric acid analyses are being performed; LBLOCA and SBLOCA.

<u>LBLOCA Boric Acid Analysis</u>

Scenario

For large hot leg breaks, CL injection will provide flushing flow during the injection mode. After re-alignment to sump recirculation CL injection will be terminated if system pressure is below UPI cut-in pressure. Once CL injection is terminated, boric acid will begin to build up in the core. The LBLOCA boric acid analysis will determine the appropriate time for restoring CL injection.

Methodology

a. Mixing volume / void fraction / core boiloff was extracted from WCOBRA/TRAC hot leg break case hot leg break case.
b. Mixing volume to vary with time as predicted by WCOBRA/TRAC. WCOBRA/TRAC reflects system effects such as loop resistance.
c. The boric acid solubility limit is taken at atmospheric conditions. Neither containment overpressure nor sump additives were credited.
d. Appendix K decay heat was used in all calculations.

SBLOCA Boric Acid Analysis

Scenario

For small cold leg breaks where the system pressure stays above UPI cut-in pressure, boric acid will begin to build up in the core immediately after blowdown. Within 1 hour, operators will begin to depressurize the reactor coolant system in accordance with Emergency Procedure ES-1.2, Post LOCA Cooldown and Depressurization. So long as the system can be depressurized prior to reaching the boric acid atmospheric solubility limit, there is no potential for boric acid precipitation even with rapid inadvertent system depressurization using the pressurizer PORVs. The SBLOCA boric acid analysis will determine how long the boric acid concentration remains under atmospheric solubility limit. This time is available for system depressurization.

Methodology

a. Mixing volume / void fraction / core boiloff was extracted from NOTRUMP 4 inch break case as this break requires no operator action to depressurize.

b. Mixing volume to vary with time as predicted by NOTRUMP reflects system effects such as loop resistance.

c. The boric acid solubility limit is taken at atmospheric conditions. Neither containment overpressure nor sump additives were credited.

d. Appendix K decay heat was used in all calculations.

2. *Small breaks were not addressed. The boric acid concentration for the limiting SBLOCA needs to be evaluated. Provide a summary of the results to show that the boric acid concentration is not sufficient to cause precipitation should the operators inadvertently depressurize the reactor coolant system (RCS) in a rapid manner.*

A SBLOCA boric acid analysis is being performed for a break size such that system depressurization will occur without operator actions. A "system depressurization time" will be determined using the boric acid solubility limit at atmospheric conditions. Breaks smaller than this will require operator action to begin cooldown (assumed to be within 1 hour of the LOCA event). Depressurization to RHR cut-in pressure will occur within the "system depressurization time", assuring boric acid precipitation cannot occur. For very small breaks (approximately 1.0 inches) the RCS will can be refilled sufficiently such that natural circulation will be restored within the system depressurization time. (see next RAI response).

Inadvertent RCS depressurization will not cause boric acid precipitation when it occurs before the "system depressurization time" since the boric acid atmospheric solubility limit will not be exceeded. After the "system depressurization time" the UPI flow or natural circulation flow will be flushing the core.

3. *Provide information to show that for the largest break that does not actuate upper plenum injection (UPI) (where a cooldown is required) that there is sufficient time to perform this function given an appropriate precipitation time based on consideration of the four items in item 1 above.*

A break of approximately 4 inches or greater will depressurize to RHR cut-in pressure prior to reaching the boric acid atmospheric solubility limit. For breaks smaller than this, the operators will depressurize the reactor coolant system in accordance with Emergency Procedure ES-1.2, Post LOCA Cooldown and Depressurization. The SBLOCA boric acid analysis will determine the time until the boric acid atmospheric solubility limit is reached for this elevated pressure scenario. For very small breaks, the reactor coolant system will begin to refill once the system pressure drop to a point that SI flow exceeds the break flow. A cooldown analysis is being performed to indicate the break size where the RCS will can be refilled sufficiently such that natural circulation will be restored. Then a confirmatory case will be analyzed with a slightly larger break to demonstrate effective and timely depressurization.

GINNA EXTENDED POWER UPRATE

LONG TERM COOLING POST-LOCA BORIC ACID CONTROL PLAN

BREAK SIZE	SCENARIO	ANALYSIS
DEG 1.0 FT^2 0.8 FT^2 0.6 FT^2 8.0 IN 6.0 IN 4.0 IN	Breaks of this size will depressurize to RHR cut-in pressure without operator action.	LB Boric Acid Analysis
2.0 IN 1.8 IN 1.4 IN 1.4 IN 1.3 IN 1.2 IN 1.1 IN	For breaks of this size, operators will take action to depressurize RCS to RHR cut-in pressure before boric acid atmospheric solubility limit is reached.	SB Boric Acid Analysis
1.0 IN 0.9 IN 0.8 IN	Natural circulation is lost but regained before boric acid atmospheric solubility limit is reached.	Natural circulation will keep the core diluted.
0.7 IN 0.6 IN 0.5 IN	Natural circulation is not broken.	

0.375 IN - Charging Flow Makeup Capacity

4. *What is the temperature of the SI water entering the core at the time of SI re-initiation at 6 hours?*

The minimum SI temperature from the RWST and the minimum SI temperature from the containment sump will be provided. The mixing behavior of a cold dilute solution with a nearly-saturated hot solution is a double dilution problem. Questions concerning this subject were discussed in the Beaver Valley EPU RAI responses and were recognized by the NRC as generic in nature.

5. *Once UPI initiates, at what time following an LBLOCA would the core steaming rate be insufficient to entrain the hot-side injection?*

Unlike non-UPI plants, the hot side injection for Ginna is upper plenum injection rather than injection into the hot leg piping. Because of the large upper plenum volume, large flow areas, and the structures that would inhibit entrainment, there would be minimal entrainment out the hot legs once the blowdown transient is over.

6. *What are the guidelines for depressurizing the RCS below 140 psia? Describe the emergency operating procedure (EOP) requirements to accomplish this? Is there a time constraint for initiating a cooldown? Does the cooldown consider a failure of the steam generator atmospheric dump valves (ADVs)?*

Operators are trained and procedures are structured to rapidly depressurize the reactor coolant system during a LOCA. Emergency Procedure E-0, Reactor Trip or SI, will be implemented immediately after the reactor trip. In this procedure operators verify operation of Engineered Safety Features (ESF) equipment and diagnose the LOCA event. By experience in the simulator, after 10 minutes operators will transition to Emergency Procedure E-1, Loss of Reactor or Secondary Coolant, where additional equipment is verified operational to enhance the cooldown (charging, instrument air, service water, etc.) and the need to cooldown and depressurize is identified. Again, based on simulator experience, operators will transition to Emergency Procedure ES-1.2, Post LOCA Cooldown and Depressurization, in approximately 30 minutes. While in ES-1.2 operators will commence the plant cooldown and depressurization. Experience with simulator training crews indicates that the RCS cooldown will be started within one hour of the break occurring. There is no time constraint for initiating a cooldown and one is not necessary. Operators are aware of the importance of depressurizing the RCS in order to stop the loss of inventory and a time constraint for commencing a cooldown could be a distraction. The one-hour time constraint will be added to the emergency procedures background document.

Emergency Operating Procedure ES-1.2 requires cooldown of the RCS at the maximum cooldown rate allowed by Technical Specifications. Operators are instructed to use both atmospheric dump valves (ADVs) to maximize the cooldown rate should the normal condenser dump valves not be available. Operators are also instructed to operate the ADVs locally if an active equipment failure causes remote operation to fail.

7. *If the RCS refills early during the cooldown for very small breaks and hot water is trapped in the pressurizer with a saturation temperature above the entry temperature to start residual heat removal (RHR), how is the pressurizer eventually cooled to initiate RHR? Explain the method to reduce RCS pressure under these conditions. Can cooldown be accomplished before the condensate storage tank supply is exhausted?*

   For very small breaks, the pressurizer is cooled using normal spray if reactor coolant pumps are operating. If normal spray is not available, a PORV is opened to depressurize and cool the pressurizer. If no PORV is available, auxiliary spray would be used with charging pumps available. Assuming none of the aforementioned methods are available, the Technical Support Center would be consulted, however, with subcooling and natural circulation available there is no Long Term Cooling concern. These actions are taken concurrent with continuing the RCS cooldown by steaming from the steam generators.

   The capacity of one Condensate Storage Tank (CST) is adequate to maintain the RCS in hot standby for two hours. Although two CSTs should be available, if only one tank is available it is possible that the water supply from that tank could be exhausted. In this case lake water is used as the ultimate heat sink to supply makeup water using the standby auxiliary feedwater pump.

8. *What precipitation limit is used for LBLOCAs and intermediate-break LOCAs? Explain whether debris in the sump water affects this limit and the time variation in boric acid concentration.*

While there are no known comprehensive industry studies of the effect of sump debris on boric acid precipitation characteristics, some relevant observations were made in the Fauske solubility tests discussed previously Beaver Valley EPU RAI responses. The Fauske test summary report indicated that powdered impurities introduced into a saturated boric acid water solution did not cause boric acid to precipitate out of solution. Questions concerning this subject were discussed in the Beaver Valley EPU RAI responses and were recognized by the NRC as generic in nature.

9. *For intermediate breaks that produce RCS pressures above the UPI shut-off head, the SI pumps are secured if the need to switch to recirculation should occur. Explain the procedure for assuring RHR can be actuated if the steam generators (SGs) have to be cooled down, especially with the loss of offsite power and failure of one of the ADVs. What is the timing for cooldown of the SGs to assure RHR will be operating when the switch to recirculation is made?*

   Operators will depressurize both steam generators using both ADVs. The single failure of an active component is overcome by local manual control of the ADVs as necessary. A high-head recirculation flow path is established upon entering the recirculation mode if the RCS pressure is above the shutoff head of the RHR pumps. The high-head recirculation flow path involves lining up the discharge of the RHR pumps to the SI pump suction. This lineup produces adequate injection pressure to assure continued injection flow at elevated RCS pressure.

   As previously stated, operators will maximize efforts to cool and depressurize the RCS. Given high-head recirculation, It is not necessary to depressurize the RCS below the RHR pump shutoff at the time of recirculation in order to continue injection.

10. *Following LBLOCAs, borated water is entrained in the steam exiting the core, which can enter the SG tubes. Since the secondary side is at high temperatures, the borated water can be boiled-off leaving behind the boric acid. What happens to the boric acid in the SGs? Can boric acid build-up sufficiently to increase the loop resistance and depress the two-phase level in the core?*

    Similar as to what was done for Beaver Valley EPU, an evaluation is being done to estimate the total amount of boric acid that might be deposited in the SGs. This estimate will provide some quantification of the issue. Further questions concerning this subject were discussed in the Beaver Valley EPU RAI responses and were recognized by the NRC as generic in nature.

11. *Following a SBLOCA, the RCS can boil for an extended period of time. While the boric acid will remain in solution at the high temperatures, the sudden need to depressurize the RCS rapidly could cause an inadvertent precipitation. Explain what guidelines or EOP directives are available to the operators to assure this does not happen.*

    Analysis using the NOTRUMP computer code demonstrates that for smaller breaks the RCS will be filled, natural circulation will start and core boiling will cease before the boric acid concentration exceeds the precipitation limit for atmospheric pressure. For larger breaks the RCS will be depressurized to the point where simultaneous injection will begin, also before the boric acid concentration exceeds the precipitation limit for atmospheric pressure. Boron concentration will at no time exceed the saturation limit for a depressurized state and there is no concern that rapid depressurization of the RCS could cause boron precipitation.

12. *Explain how the EOPs guide the operators to assure them that they can refill the RCS for all small breaks and re-establish natural circulation to flush the boric acid from the vessel.*

Operator training and procedures establish and maintain a high priority on depressurizing the RCS, returning normal level to the pressurizer and maintaining subcooling. If the break size is small enough to support refilling the RCS, natural circulation will begin and core boiling and boron buildup will cease. If the break size is too large to support refilling the RCS, the RCS will be depressurized to the point where simultaneous injection will prevent boric acid buildup.

13. *What is the size of the bottom mounted instrument tubes? Are failed instrument tubes in the bottom of the head part of the design basis? If so, was a failed tube analyzed at extended power uprate conditions? Also, is operator action required to assure the core remains below 2200 EF with one tube assumed failed?*

No plant specific analyses were performed for Ginna as part of the Extended Power Uprate (EPU) program with regards to failures of bottom mounted instrumentation (BMI) tubes. However, in response to the Davis Besse and South Texas Unit 1 events, a comprehensive Westinghouse Owners Group (WOG) program for both traditional Westinghouse and Combustion Engineering System 80 reactor vessels was developed several years ago to assess the impacts of a postulated leak or failure of one or more BMI nozzles. The WOG program included the following tasks.

- Historical information review to determine the extent to which BMI breaks have been analyzed and to determine the effort required to address the potential consequence of a BMI failure.

- Small Break LOCA analyses to evaluate the potential effect of various failures of BMI tubes. These results are then utilized to support a probabilistic risk assessment of BMI failures.

- A materials assessment which evaluates the potential for failure based on phenomenological considerations. This includes Failure Modes and Effects Analysis (FMEA)

- Evaluation of the effectiveness of the Emergency Response Guidelines (ERGs) in dealing with this postulated scenarios and provisions for recommending modifications to the guidance.

During the execution of this program, various organizations discussed the benefits of providing a coordinated fleet-wide response to BMI related issues. As such, a joint effort between the WOG, B&W Owners Group (BWOG) and MRP was developed to provide this response. The effort culminated in the development of internal documentation which supports the various conclusions reached in regards to these issues. A meeting to present the WOG and BWOG results to the NRC was held on September 30 of this year. A summary of the observed LOCA response is provided below:

- Different plant groups demonstrate similar responses to the BMI small LOCA event. Evaluated thermal hydraulic analysis cases representative of Ginna show that a Bottom Mounted Nozzle (BMN) break of approximately 1.0 inch equivalent diameter can be withstood under timely operator action (45 minutes) to depressurize without core uncovery.

14. *Explain the impact of the refilling of the loop seals (for breaks on the side of the cold leg) on the mixing volume and boric acid concentration.*

Loop seal refilling would temporarily increase the loop pressure drop and would depress the mixture level in the core. Loop seal refilling would be significant to the calculations only if the loop seal closure was sustained. Neither LOCA ECCS Evaluation Models (EMs) nor observations during the ROSA tests (discussed in Reference 1) predict sustained loop seal closure, but instead predict cyclic loop seal refilling and clearing. Cyclic loop seal refilling/clearing would promote mixing in the vessel by forcing liquid from the core region to the lower plenum and downcomer. Effective mixing resulting from this type of oscillatory behavior was observed in the modified VEERA facility tests (Reference 2).

1. Letter from Westinghouse to NRC, NSD-NRC-97-5092, "Core Uncovery Due to Loop Seal Re-Plugging During Post-LOCA Recovery, March 1997.

2. J. Tuunanen, et al., Experimental and analytical studies of boric acid concentrations in a VVER-440 reactor during the long-term cooling period of loss-of-coolant accidents, Nuclear Engineering and Design, Vol. 148, 1994, pp. 217-231