UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

September 22, 2010

The Honorable Gregory B. Jaczko
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: LONG-TERM CORE COOLING FOR THE ECONOMIC AND SIMPLIFIED BOILING WATER REACTOR (ESBWR)

Dear Chairman Jaczko:

During the 575th meeting of the Advisory Committee on Reactor Safeguards (ACRS), September 9-11, 2010, we reviewed the NRC staff's safety evaluation of the adequacy for long-term core cooling as it applies to the ESBWR design certification application. Our ESBWR Subcommittee held meetings on November 17-18, 2009, and July 13, 2010, to discuss the technical aspects of the ESBWR design and its long-term core cooling performance. During these meetings, we had the benefit of discussions with representatives of the NRC staff and General Electric-Hitachi Nuclear Energy (GEH). We also had the benefit of the documents referenced.

CONCLUSION

We concur with the staff's assessment that the regulatory requirements for long-term core cooling for design basis conditions have been adequately met and that this issue can be closed for the ESBWR design.

BACKGROUND

On May 8, 2008, the Commission issued a Staff Requirements Memorandum (SRM) stating that, "The ACRS should advise the staff and Commission on the adequacy of the design basis long-term core cooling approach for each new reactor design based, as appropriate, on either its review of the design certification or the first license application referencing the reactor design." The main focus of the Commission's concern was the ability of the safety systems to provide adequate core cooling over extended time periods when the Emergency Core Cooling System (ECCS) recirculation mode is activated during a design basis accident (DBA).

The ESBWR is an advanced light water reactor design that uses a direct-cycle power conversion system with natural circulation in the reactor vessel during normal operation. A passive ECCS is activated and performs its intended function without the need of emergency AC power systems for core cooling within the first 3 days following a reactor transient or accident. The design employs a Passive Containment Cooling System (PCCS) to transport heat to the ultimate heat sink for all accident scenarios.

DISCUSSION

For the ESBWR, the limiting DBA is a Main Steam Line Break (MSLB). In the first few minutes, water and steam are discharged from the break into the drywell. As the drywell pressure increases, the horizontal vents between the drywell and wetwell clear. Subsequently, water and steam from the break flow through the vents into the wetwell suppression pool, where the steam is condensed, and the water is cooled to the pool temperature. Water makeup to the primary system is provided by actuation of the Gravity-Driven Cooling System (GDCS); i.e., the GDCS squib valves open and water flows by gravity head into the vessel from the GDCS pools. This occurs about ten minutes after the initiation of the accident. The reactor core is never uncovered during the DBA. Steam condensation in the suppression pool and pressure equilibration between the drywell and wetwell through the vacuum breakers reduce the drywell pressure causing the horizontal vents to close. The remaining noncondensible gases and steam in the drywell flow up through the PCCS heat exchanger. The steam is condensed as it passes through the PCCS tubes. Water condensate is collected and returned to the GDCS pools, and the noncondensible gases flow into the wetwell gas space. This establishes the recirculation mode of long-term core cooling.

Thus, the ESBWR design has a long-term core cooling mode (i.e., a recirculation mode of ECCS cooling) that is qualitatively different from current reactors, since the passive safety systems can respond to a DBA with no need for active safety systems in the first 3 days.

The containment response for the MSLB was simulated by GEH using the TRACG computer model. Audit calculations were performed by the staff and their contractors using the MELCOR computer model. These simulations examined the passive safety system response for 3 days and active and passive system response from 3 to 30 days. Both accident simulations indicate that the containment pressure stabilizes at less than 75 percent of design pressure and slowly decreases with time. There is a difference between the simulation results for the long-term (3 to 30 days) containment pressure after the limiting DBA. This difference is due to different PCCS heat transfer models in the two integral system computer models. The resulting containment pressure for each simulation remains well below the design pressure.

The generic issues that have normally raised concerns with respect to long-term core cooling in a recirculation mode for the ECCS are not present in this design because of the following:

- No fibrous insulation is used in the plant design, all containment surface coatings are qualified, and no complex water chemistry is present. Thus, in comparison to current operating reactors, minimal debris will be generated from the DBA blowdown, mobilization of latent debris will be reduced, and favorable water chemistry will minimize formation of chemical products.

- The debris which reaches the suppression pool is not transported to the PCCS, which is the recirculation cooling path for water condensate back to the GDCS and to the reactor vessel for long-term core cooling.

The design basis licensing analysis requires the use of only the passive safety systems. The automatic safety functions will actuate the GDCS water injection path, and the PCCS will passively recirculate water condensate back through the GDCS pool and piping to the vessel. The ESBWR design includes the capability for water injection and core cooling from the non-safety Fuel and Auxiliary Pools Cooling System (FAPCS) and the Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) system. These systems normally take suction from the suppression pool, and they have an alternate water supply from the fire protection water storage tanks. Guidance and emergency operating procedures for the use and alignment of these active cooling systems are not yet available. Therefore, it is not clear when or how active pumped cooling will be aligned, or if that capability is available during an accident scenario. FAPCS and RWCU/SDC flow from the suppression pool passes through strainers that are based on currently accepted and tested designs. As previously noted, the ESBWR design includes measures to minimize the potential for mobilization of latent fibrous material and other debris. Nevertheless, it is prudent to consider the presence of some debris in the suppression pool, its transport to the reactor core, and its effect on core cooling. GEH analysis indicates that upon FAPCS initiation with suction from the suppression pool, an assumed complete blockage of the inlet to an ESBWR flow channel would not cause a loss of adequate core cooling in any coolant channel or assembly throughout the accident. The staff considers this a bounding analysis that assures long-term core cooling to the ESBWR reactor core.

Based upon the capability of the reactor to maintain core cooling without recirculation from the suppression pool for many accident sequences, the minimal levels of latent fibrous debris, and the tolerance for inlet flow blockage demonstrated by the GEH analysis, we concur with the staff's assessment that the regulatory requirements for long-term core cooling for design basis conditions have been adequately met and this issue can be closed for the ESBWR design.

We look forward to working with the staff to conclude our review of the ESBWR design certification.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

References:

1. Letter to NRC, “Response to Portion of NRC Request for Additional Information Letter Number 375 Related to ESBWR Design Certification Application - Engineered Safety Systems – RAI Number 6.2-140 S05,” 11/16/2009 (ML0932201890)

2. Letter to NRC, “Response to Portion of NRC Request for Additional Information Letter Number 405 Related to ESBWR Design Certification Application - Engineered Safety Features – RAI Number 6.2-140 S06,” 02/27/2010 (ML100620606)

3. Letter to NRC, “ESBWR Design Control Document, Revision 7, Tier 1 and Tier 2,” 03/29/2010 (ML1013401430 and ML101340380)

4. Memorandum to R. W. Borchardt, “Staff Requirements - Periodic Briefing on New Reactor Issues, 1:00 P.M., Wednesday, April 30, 2008, Commissioners’ Conference Room, One White Flint North, Rockville, Maryland (Open to Public Attendance),” 05/08/2008 (ML081290255)

5. Letter to R. W. Borchardt, “Interim Letter 3: Chapters 4, 6, 15, 18, and 21 of the NRC Staff’s Safety Evaluation Report with Open Items Related to the Certification of the ESBWR Design,” 05/23/2010 (ML081330447)

6. Letter to Dr. William D. Travers, “Draft Safety Evaluation Report for the ESBWR Pre-Application Review,” 02/12/2004 (ML040440487)

7. Regulatory Guide 1.82, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident,” 08/2003 (ML032240713)

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