



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

December 16, 2009

MEMORANDUM TO: ACRS Members

FROM: Christopher L. Brown, Senior Staff Engineer */RA/*
Reactor Safety Branch A, ACRS

SUBJECT: CERTIFICATION OF THE MINUTES OF THE ACRS ESBWR
SUBCOMMITTEE MEETING OPEN PORTION,
NOVEMBER 17-18, 2009, ROCKVILLE, MARYLAND

The minutes of the subject meeting were certified on December 9, 2009, as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc w/o Attachment: E. Hackett
 C. Santos

Certified by: M. Corradini
Certified: 12/09/09

Issued: 12/16/09

**ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MINUTES OF ACRS ESBWR SUBCOMMITTEE MEETING
NOVEMBER 17-18, 2009
ROCKVILLE, MARYLAND**

The ACRS Economic Simplified Boiling Water Reactor (ESBWR) Subcommittee held a meeting on November 17-18, 2009, in Room T-2B3, 11545 Rockville Pike, Rockville, MD. The purpose of this meeting was to review and discuss differences between TRACG and MELCOR modeling for the ESBWR containment heat removal. Design basis accident dose calculations, control room ventilation/reactor building holdup, and PRA design changes and the impact on the results were also discussed.

Christopher Brown was the designated Federal Official for this meeting. The Subcommittee received no written statements or requests for time to make oral statements from the public. The Subcommittee Chairman convened the open portion of this meeting on November 17, 2009 at 8:30 a.m. and adjourned the open portion of the meeting on November 18, 2009, at 11:30 a.m.

ATTENDEES:

ACRS Members

M. Corradini, Chairman
D. Bley
S. Abdel-Khalik
T. Kress, Consultant
G. Wallis, Consultant

S. Armijo
J. Stetkar

ACRS Staff

C. L. Brown, Designated Federal Official

NRC Staff

A. Cubbage, NRO
Ilka Berrious, NRO
Hossein Esmaili, NRO
Dennis Galvin, NRO
Syed Haider, NRO
Paul Peringer, NRO
M. Snodderly, NRO
J. O'Driscoll, NRO
J. Tills, Sandia

LeRoy Hardin, NRO
Allen Notafancisco
John McKirgan, NRO
C. Ader, NRO
Amar Pal, NRO
Mike Jung, NRO
Harry Wagage, NRO
E. Forrest, NRO
R. Gauntt, Sandia

General Electric-Hitachi (GEH) Staff

Wayne Marquino, GEH
Patricia Campbell, GEH
S. Moen, GEH
M. Solmos, GEH
R. Wachowiak, GEH

Steve Kimura, GEH
Rick Kingston, GEH
R. Miller, GEH
Mike Arcaro, GEH
Antonio Barrett, GEH

This portion of the meeting was open to members of the public. A complete list of attendees is available upon request. The presentation slides and handouts used during this portion of the meeting are attached to the transcript.

Opening Remarks and Objectives:

Dr. Michael L. Corradini, Chairman of the ACRS ESBWR Subcommittee, convened the open portion of the meeting on November 17 at 8:30 a.m. The NRC staff and the applicant compared modeling differences between TRACG and MELCOR. The remaining open items related to ventilation and dose (such as CRHA issues, movement of air, and uniform mixing) were also discussed along with the PRA audit. The presenters included representatives from the NRC's Office of New Reactors (NRO) and GE Hitachi (GEH), the applicant.

Containment Issues:

The main topics discussed were as follows: 1) TRACG modeling of the containment and comparisons with MELCOR, 2) Noncondensable gases in containment, 3) Performance of the Passive Containment Cooling System (PCCS)¹, 4) The "Drain pan" that receives PCCS condensate and the discharge from the PCCS fans, 5) The characteristics of the PCCS fans. Although the *flammability* issue was touched on tangentially, inasmuch as the discussions of the above items had implied effects on it, the *vacuum breaker leak detection* system was discussed in part.

The results predicted by these two codes are coming into convergence and it appears likely that both will meet NRC requirements for the pressure and temperature in containment over both the first 72 hours and the "long term" period out to 30 days.

The pressure after a month is in the range 2.5 to 3.5 bars, which appears high for "reducing the pressure rapidly". Further, there is no indication of continuing reduction in pressure after this time, in the absence of operator intervention.

Jack Tills explained the investigation to resolve Long-term MELCOR/TRACG Pressure Offset. He also explained several differences between MELCOR and TRACG.

GEH provided a corrected version of Figure 9 from RAI 6.2-139 during the presentation. During discussions they stated that this figure had been superseded, first by the response to RAI 6.2-140 SO4 (Figure C4) and later by the response to RAI 6.2-140 SO5 (Figure C4). The Subcommittee members were provided with a copy of the letter.

These figures present the predictions of noncondensable gas concentration at several locations in the containment. While the details of these distributions may have little substantial effect on the overall pressure transient, they are important for assessing the concentration of flammable gases at various key locations, and for assessing features of TRACG modeling.

¹ The Passive Containment Cooling System (PCCS) is a passive engineered safety feature of the containment that will remove decay heat from containment after a loss-of-coolant accident (LOCA) for a minimum of 72 hours without operator action maintaining containment pressure and temperature within design limits.

In summary, GEH stated that the NRC staff and the ACRS's observations on nodalization have been addressed. Also, GEH stated that TRACG and MELCOR use different models for PCCS heat transfer. Both predict the ESBWR containment pressure is reduced via PCC fan operation, and continues to reduce through the 30 day evaluation. The staff summarized their presentation by indicating that MELCOR confirmatory calculations confirm DCD Revision 6 results were performed without GDCS pool tray function and with PCC/IC/Expansion pool refill management (both tray neglect and refill management are shown to trend the containment pressure lower than the DBA (audit) calculation). With the exception of early intervention transient effect (i.e., pressure "cliff"), the MELCOR and TRACG post- 3 day pressure trends are similar when design/operation parameters are similarly modeled, with MELCOR results showing an offsetting increase of ~ 0.4 bar at 30 days. The staff also indicated that the MELCOR DBA (audit) pressure calculation, based on ESBWR design/operation, during the late intervention period is flat with ~ 24% margin @ 30 days (720 hours).

Design Basis Accident Dose Calculations

The briefing on this topic was to address subcommittee questions concerning fission product transport and removal evaluation in the ESBWR containment. Confirmatory calculations were performed using RADTRAD and compared to GEH's evaluation for natural fission product deposition in main steam lines and main condenser. Staff evaluated containment aerosol removal. The results of staff independent confirmatory calculation bound the results of the GEH calculation. The staff concluded that the ESBWR meets the relevant dose criteria.

Control Room Ventilation and Reactor Building Holdup

Most of the RAIs presented to the subcommittee before the meeting focused on the heat balance for the control room. However, GEH discussed the control room habitability area (CRHA) thermal analysis model description / assumptions / results, the reactor building (RB) holdup / confinement model, and validation of RB Holdup / Confinement-Sensitivity. GEH stated that the ESBWR reactor building provides a holdup volume and delays the transport of radionuclides from the containment to the environment. A detailed holdup/transport analysis of the ESBWR Reactor Building using the code GOTHIC 7.2a has been performed. The analysis of the RB confirms that the mixing volume assumed in the ESBWR dose analysis is a conservative characterization of the RB holdup and transport delay of radionuclides. In summary, GEH stated that CRHA design meets GDC 19 habitability requirements. The EFU supply and circulation is adequate to support CRHA habitability. In addition, the CRHA Design Validation / Surveillance Procedures assure functions will be met. Further, the ESBWR RB provides a holdup volume and delays transport of radioactivity from the containment to the environment. Staff results were consistent with GOTHIC analysis predictions.

Results of ESBWR PRA Audit and Resolution of Open Items

The staff briefed the Subcommittee on the results of the audit of the ESBWR design PRA and resolution of open items. Some of the key audit topics discussed included the process for accounting for IE in accident sequences, changing category of SLCS injection line break from medium to small LOCA justified adequately, and failure data for vacuum breakers, squib valves and digital trip modules. The staff indicated that they performed a detailed review of the failure data associated with the containment vacuum breakers, squib valves and the digital Instrumentation and Control (DI&C) system components. Concerns regarding the adequacy of this data were raised by the Subcommittee. The staff reviewed the prior failure distribution and the resulting failure probability for containment vacuum breakers and found the values to be

reasonable. The staff reviewed failure probability estimates for digital trip modules and CCF of digital trip modules. The staff acknowledged that there is insufficient data and operating experience related to the DI&C system. The values used in the applicant's PRA report seem to be reasonable for gaining risk insights. BiMAC² performance was also discussed. The staff discussed the containment performance during erosion of sacrificial concrete for representative severe accident scenarios. The sacrificial material covering the BiMAC is now expected to be concrete, not Zirconia. Questions about the concrete were asked by a Member and addressed by GEH. Also, GEH responded to RAI 19.2-127 in MFN 09-407 (June 18, 2009) with an analysis of the effects of erosion products (gases and fission products) on containment performance. Overall, the staff accepts the GEH analysis.

SUBCOMMITTEE MEMBERS COMMENTS:

Although this issue was raised by Consultant Wallis, Chairman Corradini commented that the real open issue is the likelihood of hydrogen combustion in the PCCS due to efficient condensation. Staff was aware of this issue and are completing calculations to bound the expected behavior.

Chairman Corradini indicated that HVAC behavior for the control room was presented and that the Subcommittee would like the staff to closely review the sensitivity calculations where temperatures are 90 °F and 100%RH as well as the high temperature case (115 °F, 40%). This is expected to occur with the submittal of RAI 9.4-29 S03.

Chairman Corradini indicated that the Fan curve needs more precise clarification on the ITAAC.

PRA Level 1 detail is better but Stetkar and Bley are still uneasy given the brevity of the audit. Documentation is lagging the actual model as Mark Caruso indicated in presentation. PRA Level 2 is bounded by an alternative analysis w/o BIMAC Operation.

Member Abdel-Khalik indicated that the Human Factors is still all process with little substance.

Consultant Wallis commented that TRACG and MELCOR predictions for the overall pressure response are close to convergence, both for the 72-hour and 30-day periods. There are numerous anomalies and apparently non-physical features in the TRACG modeling of noncondensable concentrations in various regions of the DW. The modeling of the DW changes with each RAI response and may not have converged. The flammability issue requires careful assessment of several influencing phenomena. It may prove difficult to "bound" these by making limiting assumptions.

Consultant Kress commented that comparative results for containment pressure under long-term cooling conditions using MELCOR and TRACG presented at an earlier subcommittee meeting differed significantly in both trend and magnitude. The staff presented a study conducted by Jack Tills Associates to identify the sources of the calculational differences and attempt to resolve the issue related to the General Design Criteria (GDC) for containment pressure. This study was well done and, I believe sufficient to resolve the differences and show that containment pressure will reduce to an acceptably low level after the GDCS fans are turned on at 72 hours into the DBA. The issue of the quantity and location of (possibly stratified) radiolytically produced combustible non-condensable gases does not yet appear to be sufficiently resolved. The testing of the vacuum breaker leak detection system needs to

² the Basemat-internal Melt Arrest and Coolability

consider that slow leakage may have been occurring for a considerable time before the required function. This may "condition" the system to a degraded detection capability. The use of GOTHIC and CONTAIN to determine the control room temperature under loss of power conditions is an appropriate approach. There is, however, still some question as to the magnitude of humidity sources and to the capacity of internal structures as heat sinks.

SUBCOMMITTEE DECISIONS AND ACTIONS:

Following the GEH and staff presentations and discussions, Chairman Corradini asked if anyone had any further questions, thanked everyone for their presentations, and then adjourned the open portion of the meeting at 11:30 a.m.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE PRIOR TO THIS MEETING:

Staff RAIs.

Note: Additional details of this meeting can be obtained from a transcript of this meeting available for downloading or viewing on the Internet at <http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2007/> or purchase from Neal R. Gross and Co., Inc., (Court Reporters and Transcribers) 1323 Rhode Island Avenue, NW, Washington, DC 20005 (202) 234-4433.