

**GENERIC SAFETY ISSUE (GSI) 189 - SUSCEPTIBILITY OF
ICE CONDENSER AND MARK III CONTAINMENTS TO EARLY
FAILURE FROM HYDROGEN COMBUSTION DURING A
SEVERE ACCIDENT**

TAC Nos: MB7245, MD5986

Last Update: 02/04/09
Lead NRR Division: DSS
Supporting Division: DPR
Supporting Office: RES

MILESTONES	DATE Target (T) Complete (C)
1. SPLB staff briefed DRIP/DSSA management to obtain management endorsement for actions to implement voluntary industry initiatives through issuance of generic letter.	11/15/04 (C)
2. SPLB staff, with assistance from SPSB & RPRP, briefed the ET/LT on closure plans for GSI-189. A consensus was reached at the ET/LT meeting to go forward with letters (in lieu of a generic letter) to the owners to capture voluntary licensee initiatives for providing backup power sources to the hydrogen igniters.	11/29/04 (C)
3. The NRC staff met with senior representatives of the six affected PWR and BWR licensees to discuss safety-security-related insights and briefed the industry regarding potential changes to the voluntary actions.	03/30/05 (C)
4. Issued memorandum to the Commissioners from the EDO to inform the Commission of the regulatory analysis results and staff's plans for resolution of GSI-189.	06/14/05 (C)
5. Update Commission regarding licensee plans for voluntary measures.	03/01/06 (C)
6. Conduct closed meetings with affected licensees to consider security insights.	01/17/07 (C)
7. Evaluate licensee commitments and inform Commission	04/23/07(C)
8. Issue letters to accept commitments and inform licensees of plans for verification	06/15/07(C)
9. Complete Temporary Instruction for TI 2515/174, "Hydrogen Igniter Backup Power Verification," verification inspections	02/12/08(C)
10. Complete verification inspections at one unit per site	08/31/2010(T)
11. Closeout issue	09/30/2010(T)

Description: NUREG/CR-6427, "Assessment of the Direct Containment Heat (DCH) Issue for Plants with Ice Condenser Containments," showed that the early containment failure probability of ice condensers is dominated by non-DCH hydrogen combustion events. The staff subsequently extended the issue to include BWR MARK III containments because their relatively low free volume and strength are comparable to PWR ice condensers. Following a severe accident concurrent with station blackout (SBO), the PWR ice condenser containment and BWR Mark III containment are vulnerable to failures from hydrogen deflagrations and detonations because the hydrogen igniters rely on AC power. The staff opened a generic safety issue, GI-189, in response to SECY 00-198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control)." To resolve the generic safety issue, GSI-189, the staff recommended the addition of a backup power supply for the combustible gas igniters for the plants with Ice Condenser or Mark III containments. The affected plants are the four dual-unit PWR nuclear stations with ice condenser containments - McGuire, Catawba, DC Cook, and Sequoyah; a single-unit PWR nuclear station with ice condenser containment - Watts Bar; and four single-unit BWR nuclear plants with Mark III containments - Grand Gulf, River Bend, Clinton, and Perry.

Historical Background: The staff conducted studies to determine whether providing an independent power supply for the igniter systems provides a substantial increase in the overall protection of the public health and safety with implementation costs that are justified in view of the increased protection. The staff continued work on this issue following an initial screening in accordance with MD 6.4.

The staff briefed the ACRS on June 6, 2002, and again on November 13, 2002. The ACRS recommended that the form of regulatory action should be through the plant-specific severe accident management guidelines. RES provided its technical assessment for resolving GI-189 to NRR in a memorandum dated December 17, 2002. RES concluded that further action to provide back-up to one train of igniters was warranted for both ice condenser and MARK III plants.

On January 30, 2003, NRR prepared a reply memorandum that outlined the next steps in the resolution of this GI. NRR prepared a Task Action Plan to complete MD 6.4, Stage 4, Regulation and Guidance Development, based on a preliminary decision to issue an Order. The staff reviewed the proposed regulatory actions and associated draft documents with senior management and OGC, and senior management decided to pursue Rulemaking rather than an Order. The staff held a public meeting on June 18, 2003, to receive feedback from licensees and other stakeholders regarding the need to provide a backup power supply to the hydrogen igniters and NRR's consideration of rulemaking for the resolution of GI-189. NRR staff briefed the ACRS on November 6, 2003, and recommended providing a backup power supply to the hydrogen igniters. On November 17, 2003, the ACRS Chairman wrote the NRC Chairman recommending the NRC proceed with rulemaking to require a backup power supply to the hydrogen igniters for PWR ice-condenser and BWR MARK III plants. The ACRS recommended that rulemaking include a small pre-staged generator with installed cables, conduit, panels, and breakers, or an equivalent diverse power supply. The ACRS also recommended that the rulemaking be accompanied by guidance that specifies the design requirements.

NRR developed design criteria for the backup power supply, and administered a contract to merge and enhance the existing technical assessment into a regulatory analysis. NRR held a public meeting with the public and industry on September 21, 2004, to get external stakeholders' input on the draft design criteria. The BWR owners indicated a willingness to make

modifications to supply power from the existing HPCS diesel generator, and agreed to provide additional information regarding implementation cost for the prestaged generator and relative risk contribution of SBO events at each of the four Mark III plants. Duke power, representing two PWR ice condenser sites, Catawba 1 & 2, McGuire 1 & 2, indicated a willingness to make modifications to an existing safe shutdown diesel generator that could manually connect to provide backup power source as needed. American Electric Power representatives indicated a willingness to provide backup power source for D. C. Cook 1 & 2 from the large diesel generators intended to support an increased allowed outage time for the emergency diesel generators. TVA, representing two PWR ice condenser sites, Sequoyah 1 & 2, Watts Bar 1, also indicated a willingness to provide a backup power source from a supplemental diesel generator. In November 2004, the staff reached a consensus to evaluate the proposed voluntary initiatives and pursue that path as a preferential solution.

In February and early March 2005, the NRR staff met with representatives of RES, NSIR, and OEDO to develop an understanding of newly identified safety/security interface issues and actions initiated in the security arena that could impact the solution of the issue. On March 30, 2005, the staff met with senior representatives of the six affected utilities to present security-related insights.

On June 14, 2005, the EDO issued a memorandum to the Commissioners to inform the Commission of the regulatory analysis results and recent staff activities on GSI-189. The regulatory analysis indicated that the backup power modification may provide a substantial safety benefit at a justifiable cost for the PWRs with an ice-condenser containment, and the proposed voluntary actions provide the majority of the benefit. The costs exceed the benefits for all BWR regulatory options, and none of the options for the BWRs provides a substantial increase in the overall protection of public health and safety. However, external events and security insights were not fully evaluated in the regulatory analysis, and defense-in-depth considerations in improving the balance among accident prevention and mitigation provide an additional un-quantified benefit for both containment types.

Current Status: Based on an understanding that many of the voluntary physical modifications had been completed, the staff elected to delay seeking specific commitments while security-related reviews of the facilities were ongoing. On March 1, 2006, the EDO issued a memo informing the Commission of the staffs intent to delay the request for commitments until after the security-related reviews were completed in September 2006. Because this issue was not incorporated in the scope of security-related modifications, the staff has held closed meetings in December 2006 and January 2007 to further explore the proper consideration of security insights in the design of the modifications. The staff received industry proposals for modifications that incorporate security insights in late February and early March 2007. The staff reviewed the industry proposals and concluded that the proposed modifications would resolve GSI-189 and provide benefit for some security scenarios. On April 23, 2007, the EDO issued a memo informing the Commission of the staffs intent to accept the commitments and perform verification inspections at the affected sites. On June 15, 2007, the NRC staff issued letters to affected licensees accepting the commitments. The NRC staff also notified licensees of the intent to perform verification inspections at the affected sites and clarified the scope of the inspection relative to the commitments.

Modifications are complete on all but two units, Catawba Units 1&2, which are expected to be completed in early 2010.

Contacts:

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References:

1. SECY-00-0198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50.
2. NUREG/CR-4551, Vol. 3, Rev. 1, Part 1, "Evaluation of Severe Accident Risks: Surry Unit 1, Main Report," October 1990.
3. NUREG/CR-4551, Vol. 3, Rev. 1, Part 3, "Evaluation of Severe Accident Risks: Surry Unit 1, External Events," December 1990.
4. NUREG/CR-4551, Vol. 5, Rev. 1, Part 1, "Evaluation of Severe Accident Risks: Sequoyah, Unit 1, Main Report," December 1990.
5. NUREG/CR-4551, Vol. 6, Rev. 1, Part 1, "Evaluation of Severe Accident Risks: Grand Gulf, Unit 1, Main Report," December 1990.
6. NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," December 1990.
7. Letter from V. Mubayi, Brookhaven National Laboratory, to H. VanderMolen, NRC, "NUREG-1150 Consequence Calculations," July 20, 1994.
8. T. D. Brown *et al.*, "NUREG-1150 Data Base Assessment Program: A Description of the Computational Risk Integration and Conditional Evaluation Tool (CRIC-ET) Software and the NUREG-1150 Data Base," letter report, March 1995.
9. NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," Final Report, January 1997.
10. 10 CFR 50.44, "Standards for combustible gas control system in light-water-cooled power reactors," January 1, 2000 (last revised 1987).
11. NUREG/CR-6427, "Assessment of the DCH Issue for Plants with Ice Condenser Containments," April 2000.
12. NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," July 2000.
13. Memorandum to Samuel Collins, Director, Office of NRR, from Ashok Thadani, Director, Office of RES, September 29, 2000, regarding Research Information Letter RIL-0005, "Completion of Research to Address Direct Containment Heating Issue for All Pressurized Water Reactors." (ML003755724).
14. Memorandum to Ashok Thadani, Director, Office of RES, to Samuel Collins, Director, Office of NRR, November 22, 2000, regarding Research Information Letter RIL-0005, "Completion of Research to Address Direct Containment Heating Issue for All Pressurized Water Reactors." ML003761979).
15. NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program, Main Report," Draft Report for Public Comment, April 2001.

16. Memorandum to John Flack, Chief, Regulatory Effectiveness and Human Factors Branch, Division of Systems Analysis and Regulatory Effectiveness, RES, from Mark Cunningham, Chief, Probabilistic Risk Analysis Branch, Division of Risk Analysis and Applications, RES, "Information Concerning Generic Issue on Combustible Gas Control for PWR Ice Condenser and BWR Mark III Containment Designs," August 15, 2001 (ML012330522).
17. Memorandum to M. Snodderly (NRC) from M. Zavisca and M. Khatib-Rahbar (ERI), "Combustible Gas Control Risk Calculations (DRAFT) for Risk-Informed Alternative to Combustible Gas Control Rule for PWR Ice Condenser, BWR Mark I, and BWR Mark III (10 CFR 50.44)," October 22, 2001.
18. Management Directive 6.4 (MD 6.4), "Generic Issues Program," December 4, 2001.
19. Management Directive 6.3 (MD 6.3), "The Rulemaking Process," July 31, 2001.
20. Memorandum from John H. Flack, Chief, REAHFB:DSARE:RES to Jack E. Rosenthal, Chief, SMSAB:DSARE:RES and Mark A. Cunningham, Chief, PRAB:DRAA:RES, dated February 6, 2002, regarding "Panel Review of GSI-189, Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident."
21. Memo from Farouk Eltawila, Director, RES, to Ashok C. Thadani, Director RES, dated February 13, 2002, regarding RES Task Action Plan for Resolving Generic Safety Issue 189: "Post Accident Combustible Gas Control in Pressure Suppression Containments."
22. Memorandum from William Travers, EDO, to The Commissioners, dated May 13, 2002 (SECY-02-0080), Proposed Rulemaking--Risk Informed 10CFR50.44, "Combustible Gas Control In Containment", (WITS 20010003).
23. Advisory Committee on Reactor Safeguards Meeting Minutes, 493rd Meeting, June 6, 2002, regarding Technical Assessment Generic Safety Issue (GSI)-189.
24. Backup Power for PWRs with Ice Condenser Containments and for BWRs with Mark III Containments under SBO Conditions: Impact Assessment, Rev. 2, September 24, 2002, by Information Systems Laboratories, Inc., Rockville, MD.
25. Hydrogen Control Calculations for the Sequoyah Plant, draft letter report, Rev. 3, September 30, 2002, by Sandia National Laboratories.
26. Memorandum from Ashok Thadani, RES to William Travers, EDO, dated October 1, 2002, regarding, "Revision to NRC's Regulatory Analysis Guidelines [NUREG/BR-0058] and RES Office Letter 1 to Conform to OMB's Information Quality Guidelines."
27. Benefit Cost Analysis of Enhancing Combustible Gas Control Availability at Ice condenser and Mark III Containment Plants, draft letter report, October 4, 2002, by Brookhaven National Laboratory. ADAMS ML022880554.
28. Advisory Committee on Reactor Safeguards Subcommittee on Thermal-Hydraulic Phenomena and Subcommittee on Reliability and Probabilistic Risk Assessment Meeting Minutes, November 5, 2002, regarding Generic Safety Issue (GSI)-189.
29. Advisory Committee on Reactor Safeguards Meeting Minutes, 497th Meeting, November 7, 2002, regarding Technical Assessment Generic Safety Issue (GSI) -189.
30. Memo from George E. Apostolakis, Chairman Advisory Committee on Reactor Safeguards, to the Commission Chairman Richard A. Meserve, dated November 13, 2002, regarding "Recommendations Proposed by the Office of NRR for Resolving Generic Safety Issue -189, Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident. ML023230513
31. Memo from Ashok C. Thadani, Director RES, to Samuel J. Collins, Director, Office of Nuclear Reactor Regulation, dated December 17, 2002, regarding RES Proposed Recommendation for Resolving Generic Safety Issue 189: "Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion

- During a Severe Accident." ML023510161
32. Attachment to Memo from Ashok C. Thadani, Director RES, to Samuel J. Collins, Director, Office of Nuclear Reactor Regulation, dated December 17, 2002, "Technical Assessment Summary for GSI-189: Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident."
 33. Memo from John A. Zwolinski, Director, Division of Licensing Project Management, NRR to Farouk Eltawila, Director, Division of Systems Analysis and Regulatory Effectiveness, RES, dated January 21, 2003, regarding, "Resolution Process for Generic Safety Issue (GSI) 189, "Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident."
 34. Memo from Jack Rosenthal, Branch Chief, Safety Margins and Systems Analysis Branch, Division of Systems Analysis and Regulatory Effectiveness, Office of Nuclear Regulatory Research to John Hannon, Branch Chief, Plant Systems Branch, Division of Systems Safety and Analysis, Office of Nuclear Reactor Regulation dated June 19, 2003, regarding, Final Contractor's Reports: Generic Safety Issue 189: "Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident."
 35. Benefit Cost Analysis of Enhancing Combustible Gas Control Availability at Ice Condenser and Mark III Containment Plants, Final Letter Report, Energy Sciences and Technology Department, Brookhaven National Laboratory, December 23, 2002 (ML031700011).
 36. Backup Power for PWRs with Ice Condenser Containments and for BWRs with Mark III Containments under SBO Conditions: Impact Assessment, Revision 2, Information Systems Laboratories, Inc., September 24, 2002 (ML031700015).
 37. Hydrogen Control Calculations for the Sequoyah Plant, Final Letter Report, March 2003, Prepared By Sandia National Laboratories, March 2003 (ML031700025).
 38. Memorandum from Luis A. Reyes, EDO, to The Commissioners, dated June 14, 2005, "Status of Staff Activities to Resolve Generic Safety Issue 189, 'Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident' (WITS 20010144) (ML051440875).
 39. Attachment to Memorandum from Luis A. Reyes, EDO, to The Commissioners, dated June 14, 2005, "Background - Status of Staff Activities to Resolve Generic Safety Issue 189, 'Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident' (WITS 20010144) (ML051590380).
 40. Regulatory Analysis for Proposed Action to Address Generic Safety Issue 189: Susceptibility of Ice Condenser and Mark III Containments to Early Failure from Hydrogen Combustion During a Severe Accident, May 24, 2005 (ML051450060).
 41. Memorandum from Luis A. Reyes, EDO, to The Commissioners, dated March 1, 2006, "Update on Status of Staff Activities to Resolve Generic Safety Issue 189, 'Susceptibility of Ice Condenser and Mark iii Containments to Early Failure from Hydrogen Combustion During a Severe Accident'" (WITS 200600039) (ML060390122).
 42. Memorandum from Luis A. Reyes, EDO, to The Commissioners, dated April 23, 2007, "Licensee Commitments and Staff Actions Addressing Backup Power for Hydrogen Igniters" (WITS 200700082) (ML070890613).