U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Mark I and Mark II BWRs Containment Venting Systems

Guidance for Order EA-13-109

August 7, 2014

Japan Lessons Learned

Agenda

- Introductions
- Opening remarks
- Industry presentation
- NRC presentation
- Public questions and comments

- Toll free number: **888-390-5220** and pass code: **25636**

Agenda - Topics

- Industry proposal for re-sequencing vent order for Phase 2 compliance development and deliverable milestones
- Vent Order Phase 1 implementation
- NEI HCVS WP-03, Hydrogen/Carbon Monoxide Control Measures, Revision 0, June 24, 2014
- Temperature requirements for the Severe Accident capable drywell vent
- Filtering strategies rulemaking (discussion of alternatives)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Industry Presentation

Japan Lessons Learned

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Presentation

Japan Lessons Learned

Staff Comments - EA 13-109 OIP

Overall Integrated Plan (OIP) Status

- June 30, 2014 – OIPs for 29 units received
  - 1 unit requesting deferral until 2020
- NRC Interim Staff Evaluations (ISE)
  - Audits using the streamlined portal system
  - ISEs for 8 units by December 31, 2014
  - Remaining ISEs by June 30, 2015
- Open Audit Process until Phase 1 complete

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Staff Comments - EA 13-109 OIP

Audit Process

- ✓ OIP submission
- ❑ ISE-open/confirmatory items
- ❑ 6 month update reports
- ❑ Implementation outage
  - ❑ open/confirmatory item resolution
- ❑ Safety Evaluation
- ❑ HCVS inspections the under ROP

Staff Comments - EA 13-109 OIP

Typical Open Items

- Perform final sizing evaluation for HCVS batteries
- Determine approach to address control of combustible gases
- Perform vent capacity calculation confirming 1% thermal capacity of HCVS

Staff Comments - EA 13-109 OIP

Typical Open Items

- Determine location of HCVS battery transfer switch
- Confirm Suppression Pool Heat Capacity
- Identify qualification method for HCVS instrument
- Determine Location of Remote Operating Station

NRC Staff Comments NEI HCVS-WP-03

Hydrogen/Carbon Monoxide Control Measures

Revision 0, June 24, 2014

Japan Lessons Learned

Staff Comments - HCVS-WP-03 Rev 0

1. Document focuses only on detonable mixtures Deflagrations (falling short of a DDT) should also be avoided.

2. Many countries, particularly in Europe, have already installed venting systems. There is no information to indicate if this document draws upon such experience. If it did, describe any consensus of the design approaches taken. Describe any other installations and experiments that support the basis.

3. Ignition sources should always be assumed to exist since the energy for ignition is so low. Reference 20 should be removed as it is based on just theory and there is no experimental basis to support it. Staff thinks that in systems like severe accident venting, there must always be an assumption of an ignition source. For instance, fission products could heat-up and provide a spark for ignition.

4. The term "venting evolution" is frequently used in the document (e.g., item 2 in the table on page 2). It is not clear what the term means. Describe what it means in relation to this document.

Staff Comments - HCVS-WP-03 Rev 0

5. Item 5 in the table on page 4 cites NUREG/CR-4905 in claiming 11.5% hydrogen by volume for the initiation of DDT. This value corresponds to a gas temperature of 293°K. A later research report (NUREG/CR-5525) puts the minimum hydrogen concentration at 9.4% by volume for a gas temperature of 373°K. The point is DDT is possible at a relatively low hydrogen concentration and variation exists in laboratory experimental results so considerable uncertainty exists for in-plant severe accident venting conditions and potential for DDT.
6. On page 5, the document mentions research into hydrogen deflagration and detonation since the events of March 2011 in claiming that a large amount of energy is required to facilitate a prompt detonation. What are the published references on hydrogen research, post March 2011, that the whitepaper cites or should be citing to backup the mentioned research Large energy requirement for prompt detonation has been known for quite some time. It is also recognized that flame propagation does not require a large amount of energy source, and flame acceleration can lead to DDT.

Staff Comments - HCVS-WP-03 Rev 0

7. Ex-vessel core-concrete-interaction (CCI) can generate as much combustible gases in the long-term as in-vessel metal-water reaction. Page 6 of the WP does not appear to sufficiently emphasize this.

8. Page 12 and 13 Section 5.0 Options table appears to be lacking inclusion of designing the vent to support an open and leave open operating scheme (until other means of containment cooling were to be established that allow for pressure control). The advantage would be that flow would be continuously moving out the vent line minimizing the possibility of air entering the vent line from the discharge point, a form of inerting strategy. Disadvantage is that an external filter may be necessary to ensure radioactive aerosols release is acceptably low.

Staff Comments - HCVS-WP-03 Rev 0

9. Page 15 appears to suggest a design that would “preclude” a DDT occurring would establish acceptability for vent operation with combustible mixtures up close to the DDT threshold without designing for detonations. Given the uncertainties involved with the DDT phenomena the staff thinks it best that vent designers focus on either preventing the presence of combustible mixtures or being tolerant of detonations.
10. Page 23 near the bottom indicates that dilution fans could be a means of purging or diluting the mixing chamber region at the base of a stack/chimney if that is where the vent pipe ends. If supporting the venting function, powering any fans for dilution purposes could not rely on FLEX portable equipment for the first 24 hours. Also, any fans needed for dilution air flow would need to be seismically rugged and have power connections suitable for severe accident use.

Staff Comments - HCVS-WP-03 Rev 0

- The white paper appears to shift the emphasis on inerting and design capable of withstanding detonations in Appendix H of NEI 13-02 to design only that would "preclude" a DDT. Requires higher scrutiny during staff reviews and audits, and potential for success path is low.

- Preliminary count from the OIPs is that four units (Hatch 1 & 2, Cooper, Pilgrim) intend to route the vent to plant chimney (elevated release point). Appendix H or the white paper needs to address the associated long length of pipes most of which could be underground and potential for detonations inside the chimney.

Staff Comments - HCVS-WP-03 Rev

- All other plants OIPs have HCVS vent pipes routed to the reactor building roof line. Some plants do not show or explicitly identify a control valve(s) in their sketches or operating scheme descriptions.   In cases, where vent pipes are routed to the RB roof line, provide the approach or combination of approaches that will be used in the design with respect to prevention of hydrogen detonations or capable of withstanding hydrogen detonations.

Temperature Requirements for Drywell Vent

- NEI 13-02 (Rev. 0) states that 545°F is the recommended temperature for the drywell vent system.

- NEI 13-02 also states that the vent system designed for the above temperature will have margin to perform its function at more extreme conditions.

- Analyses has been performed by NRC RES using MELCOR and EPRI (MAAP)

Temperature Requirements for Drywell Vent

- Results have indicated that with no water addition, drywell gas temperature can far exceed the current capability of drywell penetrations, as did the previous evaluations including the ones performed for SECY-12-0157.

- MELCOR analysis shows that with water addition and WW/DW venting, drywell gas temperatures for most of the dominant sequences would range from 300°F to 600°F, except for a short duration when the temperature in the drywell pedestal region/elevation has a significant spike.
- MELCOR analyses indicate that DW venting (vise WW venting) could provide a reduction in drywell gas temperature of ~40°F compared to WW venting.

Temperature Requirements for Drywell Vent

- MAAP analyses suggest a somewhat a lesser DW temperature difference between DW and WW venting.
- Sandia National Laboratories performed testing of typical compression seals and gaskets for the NRC in the early 1990s. Materials tested are EPDM, Silicone, and Neoprene.
- Temperatures at which significant leakage could occur range from 460°F to 670°F. The pressures applied during the tests are very high (143 or 160 psig), at least twice the containment design pressure. Range of failure temperatures are the lowest for Neoprene, highest for EPDM.

United States Nuclear Regulatory Commission

Protecting People and the Environment

Filtering Strategies Rulemaking Discussion of Alternatives

Japan Lessons Learned

Purpose

- Provide updated alternatives for rulemaking based on failure mode

Previous Alternatives

1. Status Quo
   – EA-13-109, FLEX, EA-12-049, EPG/SAG Rev. 3
2. Water addition via RPV
   A. Water addition
   B. Water addition + WW/DW vent cycling
   C. Water management + WW/DW vent cycling
   D. Water management
3. Water addition via DW
   1. Water addition
   2. Water addition + WW/DW vent cycling
   3. Water management + WW/DW vent cycling
   4. Water management

Previous Alternatives (cont'd)

4. Small Filter
   - 3A. Water addition via DW + small filter
   - 2A. Water addition via RPV + small filter
5. Large Filter
   - 3A. Water addition via DW + large filter
   - 2A. Water addition via RPV + large filter

Previous Alternatives (cont'd)

6. Additional filter options (SECY-12-0157)
   - A. Water addition via DW + passive DWF pre-CD + post-CD
   - B. Water addition via DW + manual WWF pre-CD and passive DWF post-CD
   - C. Water addition via DW + manual WWF pre-CD and manual DWF post-CD

New Alternatives

1. No Action/Base Case
   – EA-13-109, FLEX, EPG/SAG Rev. 3
2. Overpressurization Prevention Measures
   – Codify EA-13-109 in rulemaking
3. Containment Failure Prevention Measures
   A. Water addition via RPV
   B. Water addition via DW

New Alternatives (cont'd)

4. Release Reduction + Containment Failure Prevention Measures
   - A. Filtration Strategies
     - i. WW/DW cycling
       1. Water addition via RPV
       2. Water addition via DW
     - ii. Water management
       1. Water addition via RPV
       2. Water addition via DW
     - iii. WW/DW Cycling + water management
       1. Water addition via RPV
       2. Water addition via DW
   - B. Small Filter
     - i. Manual Wetwell First (WWF) pre-CD + manual WWF post-CD
       1. Water addition via RPV
       2. Water addition via DW
     - ii. Manual WWF pre-CD + manual drywell first (DWF) post-CD
     - iii. Manual WWF pre-CD + passive DWF post-CD
     - iv. Passive DWF pre-CD + passive DWF post-CD

New Alternatives (cont'd)

4. Release Reduction + Containment Failure Prevention Measures
   C. Large Filter
      i. Manual WWF pre-CD + manual WWF post-CD
         1. Water addition via RPV
         2. Water addition via DW
      ii. Manual WWF pre-CD + manual DWF post-CD
      iii. Manual WWF pre-CD + passive DWF post-CD
      iv. Passive DWF pre-CD + passive DWF post-CD

Mapping of Alternatives

New Alternatives	Previous Alternatives
1	1
2A	1
3A	2A
3B	3A
4Ai(1)	2B
4Ai(2)	3B
4Aii(1)	2D
4Aii(2)	3D
4Aiii(1)	2C
4Aiii(2)	3C
4Bi(1)	4-2A
4Bi(2)	4-3A
4Bii	New - similar to 6C, but with small filter; only water addition to DW
4Biii	New - similar to 6B, but with small filter; only water addition to DW
4Biv	New - similar to 6A, but with small filter; only water addition to DW
4Ci(1)	5-2A
4Ci(2)	5-3A
4Cii	6C; only water addition to DW
4Ciii	6B; only water addition to DW
4Civ	6A; only water addition to DW

Contact Information

- Aaron L. Szabo, Cost Analyst
  - Office of Nuclear Reactor Regulation, Division of Policy and Rulemaking, Rulemaking Branch
  - 301-415-1985
  - Aaron.Szabo@NRC.gov

Questions & Discussion