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U.S. NUCLEAR REGULATORY COMMISSION

Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions

JLD-ISG-2013-02

Draft for Public Comment
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COMPLIANCE WITH ORDER EA-13-109, ORDER MODIFYING LICENSES WITH REGARD TO RELIABLE HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS

JLD-ISG-2013-02

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC or Commission) staff is providing this interim staff guidance (ISG) to assist nuclear power reactor licensees with the identification of methods needed to comply with requirements to mitigate challenges to key safety functions. These requirements are contained in Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Performing under Severe Accident Conditions" (Reference 1). This ISG is applicable to all operating boiling-water reactor (BWR) licensees with Mark I and Mark II containments issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." This ISG endorses, with exceptions and clarifications, the methodologies described in the industry guidance document Nuclear Energy Institute (NEI) 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision C2 (Reference 2). This ISG provides one acceptable approach for satisfying those requirements. Licensees may propose other methods for satisfying the requirements. The NRC staff will review such methods and determine their acceptability on a case-by-case basis.

BACKGROUND

The accident at the Fukushima Dai-ichi nuclear power station in Japan reinforced the importance of reliable operation of hardened containment vents for plants with Mark I and Mark II containments. As part of its response to the lessons learned from the accident, the NRC issued Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents" (Reference 3), which requires licensees to install a reliable hardened containment venting system (HCVS) for Mark I and Mark II containments. While developing the requirements for Order EA-12-050, the NRC acknowledged that questions remained about maintaining containment integrity and limiting the release of radioactive materials if the venting systems were used during severe accident conditions. The NRC staff presented options to address these issues for Commission consideration in SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments." (Reference 4). In the staff requirements memorandum (SRM) for SECY-12-0157 (Reference 5), the Commission directed the staff to issue a modification to Order EA-12-050, requiring licensees with Mark I and Mark II containments to "upgrade or replace the reliable hardened vents required by Order EA-12-050 with a containment venting system designed and installed to remain functional during severe accident conditions." The NRC staff held a series of public meetings following issuance of this SRM to

engage stakeholders on revising the order. The modified Order EA-13-109 was issued on June 6, 2013. This order requires installation of reliable hardened wetwell vents that will not only assist in preventing core damage when containment heat-removal capability is lost, but will also function in severe accident conditions (i.e., when core damage has occurred). Severe accident conditions include the elevated temperatures, pressures, radiation levels, and concentrations of combustible gases such as hydrogen and carbon monoxide associated with accidents involving extensive core damage, including accidents involving a breach of the reactor vessel by molten core debris. The safety improvements to Mark I and Mark II containment venting systems required by this order are intended to increase confidence in the ability to maintain the containment function following core-damage events. Although venting the containment during severe accident conditions could result in the release of radioactive materials, venting could also prevent containment structural and gross penetration leakage failures caused by overpressurization that would hamper accident management (e.g., continuing efforts to cool core debris) and ultimately result in larger, uncontrolled releases of radioactive material. A hardened vent system would provide a path to the outside environment that would minimize release of containment atmosphere into the reactor building and avoid the associated potential loss of operator access or other hindrance of efforts to bring the core debris to a controlled and cooled condition in a timely fashion.

This order also requires licensees with Mark I and Mark II containments to either install a severe-accident-capable drywell venting system or develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions. In recognition of the relative potential for retention of radioactivity between venting from the wetwell or drywell, a phased approach to implementation is being used to minimize delays in implementing the requirements originally imposed by Order EA-12-050. Phase 1 involves upgrading the venting capabilities from the containment wetwell to provide reliable, severe-accident-capable hardened vents to assist in preventing core damage and, if necessary, to provide venting capability during severe accident conditions. Phase 2 involves providing additional protections for severe accident conditions through installation of a reliable, severe-accident-capable drywell vent capability that allows for flooding the wetwell or the development of a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions. The focus of this ISG is to provide guidance for implementing Phase 1 of the order. Although not addressed by this ISG, licensees may propose and request NRC approval of alternative methods for complying with the requirements in Order EA-13-109. An example could be the installation of a drywell vent with an engineered filter as an alternate to the current requirements in Phase 1 and Phase 2 of Order EA-13-109.

An industry working group under NEI auspices volunteered to develop a guidance document for the implementation of Order EA-13-109 for NRC staff review and endorsement. The NRC staff held several public meetings and provided its own comments on the proposed guidance. On August 28, 2013, NEI submitted NEI 13-02, “Industry Guidance for Compliance with Order EA-13-109,” Revision C2, incorporating many of the NRC staff comments. The NRC staff has reviewed the guidance document and has endorsed the methodology, with exceptions and clarifications as noted in Attachment 1.

RATIONALE

1. Order EA-13-109 provides a two-phased approach to implement requirements identified in the order. Under Phase 1, licensees of BWR facilities with Mark I and Mark II containment designs shall install a wetwell venting system that remains functional during severe accident conditions. Under Phase 2, licensees of BWR facilities with Mark I and Mark II containment designs either install a severe-accident-capable drywell venting system or develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during a severe accident. The installed venting system must meet prescribed quality standards. Generally, the system must be of a "seismically rugged design" and meet the plant's existing design basis where more stringent requirements apply.

2. The order requires that licensees develop the necessary procedures and conduct appropriate training of personnel who may be required to operate the system.

APPLICABILITY

This ISG shall remain in effect until it has been superseded, withdrawn, or incorporated into a regulatory guide or the Standard Review Plan (SRP).

PROPOSED GUIDANCE

As discussed above, this ISG is applicable to all operating BWR licensees with Mark I and Mark II containment designs. The NRC staff considers that the implementation of the methods described in Attachment 1 to this ISG is an acceptable means of meeting the requirements of Order EA-13-109 subject to the clarifications in Attachment 1 to this ISG. Endorsement of the methods described in NEI 13-02 does not imply endorsement of references listed in NEI 13-02.

IMPLEMENTATION

Except in those cases in which a licensee proposes an acceptable alternative method for complying with Order EA-13-109, the NRC staff will use the methods described in this ISG to evaluate licensee compliance as presented in submittals required in Order EA-13-109.

BACKFITTING DISCUSSION

Licensees may use the guidance in this document to demonstrate compliance with Order EA-13-109. Accordingly, the NRC staff issuance of this ISG is not considered backfitting, as defined in 10 CFR 50.109(a)(1), nor is it deemed to be in conflict with any of the issue finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

FINAL RESOLUTION

The contents of this ISG may subsequently be incorporated into a regulatory guide, the SRP, or other guidance documents, as appropriate.

ATTACHMENT

1. Guidance for Developing, Implementing, and Maintaining Reliable Hardened Containment Venting Systems at Boiling-Water Reactor Facilities with Mark I and Mark II Containment Designs.

REFERENCES

1. U.S. Nuclear Regulatory Commission, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions,” Order EA-13-109, June 6, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13130A067).

2. Nuclear Energy Institute, “Industry Guidance for Compliance with Order EA-13-109,” NEI 13-02, Revision C2, Washington, DC, August 28, 2013 (ADAMS Accession No. ML13247A403).

3. U.S. Nuclear Regulatory Commission, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents,” Order EA-12-050, March 12, 2012 (ADAMS Accession No. ML12054A696).

4. U.S. Nuclear Regulatory Commission, “Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments,” SECY-12-0157, November 26, 2012 (ADAMS Accession No. ML12325A704).

5. U.S. Nuclear Regulatory Commission,“Staff Requirements - SECY-12-0157 – Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments,” SRM-SECY-12-0157, March 19, 2013 (ADAMS Accession No. ML13078A017).

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Guidance for Developing, Implementing, and Maintaining Reliable Hardened Containment Venting Systems at Boiling-Water Reactor Facilities with Mark I and Mark II Containment Designs

1.0 Phased Approach

Order EA-13-109 requires boiling-water reactors (BWRs) with Mark I and Mark II containments to have a reliable, severe-accident-capable hardened containment venting system (HCVS). The order allows implementation of HCVS in two phases. In Phase 1, the subject licensees are required to design and install a venting system that provides venting capability from the wetwell during severe accident conditions. In Phase 2, licensees for BWRs with Mark I and Mark II containments are required to design and install a venting capability from the drywell under severe accident conditions or, alternatively, develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions.

The timeline for issuing the interim staff guidance (ISG) and for complying with the implementation of Order EA-13-109 are different for Phase 1 and Phase 2. The U.S. Nuclear Regulatory Commission anticipates that it will issue the Phase 1 ISG in October 2013, approximately 1-1/2 years earlier than the Phase 2 ISG. Similarly, the Phase 1 implementation (i.e., of a wetwell vent) is required approximately 1 year earlier than the Phase 2 implementation (i.e., of a drywell vent or alternate venting strategy). Because of the nexus between Phase 2 of Order EA-13-109 and NRC rulemaking addressing the broader severe-accident management and filtering strategies, the extended timeline would allow for appropriate consideration and coordination of common issues between Phase 2 and rulemaking. Therefore, Revision 0 of Nuclear Energy Institute (NEI) 13-02 will provide guidance information for Phase 1, but only overview information for Phase 2, with placeholders in Section 3, “Dry Well Vent Boundary Conditions for Vent Design and Operation,” and Appendix C, “Assessment of Need for Dry Well Vent,” which will be completed in a later revision for Phase 2.

Staff Position: NEI 13-02 provides an acceptable approach for complying with the Phase 1 portion of Order EA-13-109. Phase 2 of Order EA-13-109 will be addressed in future revisions of NEI-13-02 and this ISG.

2.0 HCVS Performance Objectives

The performance objectives to be considered in the design of the HCVS are provided under Section 1.1 of Attachment 2 to Order EA-13-109. Essentially, Section 1.1 requires that HCVS shall be designed to minimize the reliance on operator actions, minimize plant operators’ exposure to occupational hazards, account for radiological conditions that would impede personnel actions needed for event response, and have accessible and functional controls and indications under a range of severe accident conditions. These requirements are addressed in Sections 4.1, 4.2, and 6.1 and Appendices F and G of NEI 13-02.

Staff Position: NEI 13-02 provides acceptable method(s) for satisfying the performance objectives in Section 1.1 of Attachment 2 to Order EA-13-109.

3.0 HCVS Design Features

Section 1.2 of Attachment 2 to Order EA-13-109 requires an array of design features that should be included in the design of the HCVS.

The requirement for the HCVS capacity to vent steam and energy is addressed in Section 4.1.1 of NEI 13-02.

The requirement for discharging the HCVS effluent to an acceptable release point is addressed in Section 4.1.5 of NEI 13-02.

The requirement to minimize unintended cross-flow of vented fluids within a unit and between units on the site is addressed in Sections 4.1.2, 4.1.4, and 4.1.6 of NEI 13-02.

The requirements for the capability to operate the HCVS during sustained operations from a control panel in the main control room or a remote but readily accessible location, as well as for manual operation, are addressed in Sections 4.2.2 and 4.2.3 of NEI 13-02.

The requirement for the capability to operate the HCVS for at least 24 hours by dedicated and permanently installed equipment is addressed in Sections 2.3, 2.4, 4.1.1, and 5.1 of NEI 13-02.

The requirement for means to prevent inadvertent actuation is addressed in Section 4.2.1 of NEI 13-02.

The requirement for means to monitor the status of the vent system is addressed in Section 4.2.2 of NEI 13-02.

The requirement to monitor effluent discharge for radioactivity is addressed in Section 4.2.4 of NEI 13-02.

The requirement for the HCVS to withstand, and remain functional during, severe accident conditions is addressed in Sections 2.4, 4.1.1, and 5.1 of NEI 13-02.

The requirements to ensure that the lower flammability limits of gases passing through HCVS are not reached or that the vent system is designed to withstand hydrogen deflagration and detonation loading, and to minimize the potential for hydrogen gas migration and ingress into other buildings, are addressed in Sections 4.1.6 and 4.1.7 and Appendix H of NEI 13-02.

The requirements for operation, testing, inspection, and maintenance of the HCVS are addressed in Sections 5.4 and 6.2 of NEI 13-02.

Staff Position: NEI 13-02 provides acceptable method(s) for satisfying the requirements imposed on design features for the HCVS.

4.0 HCVS Quality Standards

The quality standards required for the HCVS are provided in Section 2 of Attachment 2 to Order EA-13-109.

The quality standards for the containment isolation barrier and beyond, including seismic design requirements, that involve the HCVS components are addressed in Sections 5.2 and 5.3 of NEI 13-02.

Staff Position: NEI 13-02 provides acceptable method(s) for satisfying the quality standards for the HCVS.

5.0 HCVS Programmatic Requirements

The programmatic requirements for the HCVS are provided in Section 3 of Attachment 2 to Order EA-13-109.

The requirements to develop, implement, and maintain procedures, and train appropriate personnel, for reliable and safe operation of HCVS are addressed in Sections 6.1.2 and 6.1.3 of NEI 13-02.

Staff Position: NEI 13-02 provides acceptable method(s) for satisfying the programmatic requirements for the HCVS.

6.0 Staff Clarifications and Exceptions to NEI 13-02

The NRC staff's endorsement of NEI 13-02 is subject to the following exceptions and clarifications.

6.1 Emergency Operating Procedures, Severe Accident Management Guidelines, and Emergency Preparedness Procedures

NEI 13-02 contains references to the Boiling Water Reactor Owners Group (BWROG) generic Emergency Procedure Guidelines/Severe Accident Guidelines (EPGs/SAGs) and plant-specific Emergency Operation Procedures (EOPS), Severe Accident Management Guidelines (SAMGs), and Emergency Preparedness procedures. A substantial portion of these references occur in Section 1.3, "Procedure Interface," of NEI 13-02. The discussion in this section extends beyond the scope of Order EA-13-109 and the staff's endorsment of the technical and quality requirements of severe-accident-capable vents. The discussion pertains to the use of a drywell vent when plant-specific EPGs/SAMGs are revised to incorporate post-Fukushima revisions recommended by the BWROG EPGs/SAGs. This discussion is informational and the NRC staff is not providing a general endorsement for all of that section's contents. The procedural requirements on how to operate and make use of the HCVS including whether a drywell vent is needed during severe accident conditions, will depend on Phase 2 evaluations and the related rulemaking.

Therefore, staff endorsement of NEI 13-02 is not an endorsement, explicit or implicit, of the BWROG generic EPGs/SAGs or plant-specific EOPs/SAMGs.

6.2 Anticipatory Venting

NEI 13-02 makes references to the possibility of using HCVS to vent containment at a lower pressure to enable use of a low-pressure portable pump or to control containment conditions to allow continued use of installed steam-driven equipment. Section 2.2.3 of NEI 13-02 is an example of such a statement. This concept, also referred to as "anticipatory venting," is currently being reviewed by staff as part of licensee submittals under Order EA-12-049. As this issue is being reviewed as part of other licensee submittals, it will not be addressed in this version of the ISG.

6.3 Appendix E - Interface with the Requirements of Generic Letter 89-16, "Installation of a Hardened Wetwell Vent"

The stated purpose of Appendix E to NEI 13-02 is to provide a clear understanding of the interface between Generic Letter 89-16, "Installation of a Hardened Wetwell Vent," and Order EA-13-109, "Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions." Appendix E also clarifies administrative housekeeping, in that it provides a basis for the licensee use of changing commitments to Guidelines (GL) 89-16 in accordance with NEI 99-04, "Guidelines for Managing NRC Commitment Changes." The appendix contains no information on the guidance related to the design and implementation of the HCVS required by Order EA-13-109. Therefore, the staff did not review Appendix E of NEI 13-02, and it is not within the scope of this ISG.

6.4 Design Temperature of the HCVS

NEI 13-02 recommends 350 degrees Fahrenheit (F) (177 degrees Celsius (C)) as the upper design temperature for the wetwell HCVS. The wetwell HCVS would encounter saturation temperatures corresponding with vent opening pressure. Because the recommended temperature of 350 degrees F (177 degrees C) at saturation corresponds to approximately 120 pounds per square inch and the wetwell HCVS opening pressure is expected to be significantly below this, the staff endorses the wetwell vent design temperature.

The determination of the drywell HCVS design temperature would normally fall under the Phase 2 portion of this guidance. However, the likelihood that a portion of the vent pipe could provide a pathway for both wetwell- and drywell-vented fluids, though at different times rather than simultaneously, requires the design temperature of the shared vent pipe to be determined in Phase 1. Because the drywell atmosphere temperature could be higher, more so during severe accident conditions, the temperature of the drywell-vented gas dictates the design-temperature value for the shared portion of the vent pipe. NEI 13-02 recommends 545 degrees F (285 degrees C) as the upper design temperature for the drywell and the shared (wetwell and drywell) portion of the HCVS. NEI stated that the drywell temperature limit is taken from industry guidance obtained from BWROG and that it is above the current design-basis limits of containment penetrations.

The staff, while agreeing with NEIs assessment, also believes that further evaluation of this issue is necessary before agreement can be reached on a specific temperature value. The order contains a statement that the HCVS design is not required to exceed the current capability of the limiting containment components. In this context, the drywell head gasket is assumed by the NRC staff to be the limiting component because of its potential for higher leakage as a result of combined overpressure and overtemperature conditions at the drywell head region, as evidenced during the Fukushima accident. While the head gasket design values (specifications and environmental qualification) are known, its ultimate integrity capability values need to be ascertained. In addition, different accident management and filtration strategies are expected to impact the drywell temperatures experienced during an accident and alter the results of the analysis being performed in support of the rulemaking. The relationship between the venting system design and head gasket design is a matter of discussion. Therefore, the staff is not endorsing the drywell HCVS design temperature in NEI 13-02 until further evaluations are complete.

6.5 Instrumentation Design Features

NEI 13-02 provides several different references to instrumentation being used for monitoring the protection of personnel actions, the surveillance of environmental conditions to maintain leak tight conditions, and the main operations of the HCVS system. The instrumentation and controls require design features that as stated in Order EA-13-109, Item 1.2.10, can withstand and remain functional during a severe accident event, which includes the dynamic loading of hydrogen deflagration and detonation. Item 1.2.13 states that the HCVS shall include features and provisions for the operation, testing, inspection and maintenance adequate to ensure that reliable function and capability are maintained during a severe accident.

In a severe accident scenario, ignitable concentrations of flammable gas exist in the atmosphere including areas around the instrumentation and controls. The instrumentation must be able to show continued functionality during severe accidents including environmental effects from vibration, shock, temperature, humidity and pressure associated with the accident along with initiating event conditions. The instrumentation history for reliability and the operating performance of the HCVS needs to be demonstrated.

Because of the abnormal conditions during a severe accident, and in order to have confidence in the safety, function and reliability of the HCVS instrumentation and controls the guidance needs to include a sufficient discussion of:

- intrinsically safe system;
- a flame proof or explosion proof features for hazardous locations;
- effects of seismic, and vibration and shock performance during several open and close cycles, when under dynamic severe accident load on instrumentation and it's mounting; and
- training, procedure development, surveillance routines for testing and calibration.

With these above instrumentation considerations, the staff is not endorsing the HCVS design features in NEI 13-02, for example, Section 4.2.4.3.

6.6 References in NEI 13-02

In support of the guidance, NEI 13-02 and its appendices cite a number of other documents. The references are generally acceptable to the NRC staff when they are the source document for the information provided in NEI 13-02. However, the references, in some cases, also provide alternate methods and choices for designing the HCVS. The NRC staff is not providing a blanket endorsement of the references when they are intended to support methods for implementing the HCVS under Order EA-13-109. The staff will conduct such a review only after the licensee submittals provide details on the specific application and methods identified in the references that they are relying on for their implementation of Order EA-13-109.