NEI 13-02 [Rev. A3.2]

INDUSTRY GUIDANCE FOR COMPLIANCE WITH ORDER EA-13-109

BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions

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1 INTRODUCTION

The nuclear energy industry and the NRC share a common challenge of providing prevention and mitigation strategies to maintain safety in the face of unlikely and extreme events. An approach that focuses on diverse and flexible mitigation capability will provide additional defense-in-depth safety enhancement against a range of extremes, some of which cannot be forecasted.

The importance of reliable operation of hardened vents during conditions involving loss of containment heat removal capability is well established and this understanding has been reinforced by the lessons learned from the accident at Fukushima Dai-ichi. Hardened vents have been in place in U.S. plants with BWR Mark I containments for many years but variance exists with regard to the capability of the vents for a broad spectrum of events. Generally, BWR Mark II containments do not currently have hardened vent paths. The NTTF 90-day report indicated hardened vent designs that were AC independent to operate with limited operator actions from the control room are necessary. Therefore, hardened containment venting systems in BWR facilities with Mark I and Mark II containments are being required by the NRC on the basis that they are needed to ensure protection of public health and safety.

Prompted by Fukushima Dai-ichi accident, the NRC issued Order EA-12-050 requiring installation of a reliable hardened vents for Mark I and Mark II containments. As directed by the NRC Commission th,e original Order was rescinded and replaced with a new order to address severe accidents. Order EA-13-109 was issued to maintain the same set of design and quality requirements originally imposed by EA-12-050 and included additional requirements to ensure that venting functions are available during postulated severe accident conditions. Because EA-12-050 has been rescinded and its requirements are now reflected in Order EA-13-109, licensees are no longer expected to comply with the requirements of Order EA-12-050, including any applicable time lines for submission of integrated plans, or for complete implementation.

The new severe accident Hardened Containment Venting System (HCVS) Order contains historical information and decision making insights in sections I, II and III that provide useful information, but do not contain the legally binding actions which licensees are required to comply with, which are in sections IV and Attachment 2.

1.1 Purpose

The purpose of this guidance is to assist nuclear power reactor licensees with the identification of measures needed to comply with the requirements of Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accidents" [Ref. X]. This guidance provides an acceptable method for satisfying those requirements; however, licensees may propose other methods for satisfying these requirements.

Incorporation of the lessons learned and results from the Fukushima 2011 Accident is a key element in the foundation of requirements and guidance associated with the scope of work required in response to Order EA-13-109:

> *"The events at the Fukushima Dai-ichi nuclear power plant following the March 2011 earthquake and tsunami highlight the possibility that events such as rare natural phenomena could challenge the traditional defense-in-depth protections related to preventing accidents, mitigating accidents to prevent the release of radioactive materials, and taking actions to protect the public should a release occur. At Fukushima Dai-ichi, limitations in time and unpredictable conditions associated with the accident significantly hindered attempts by the operators to prevent core damage and containment failure. In particular, the operators were unable to successfully operate the containment venting system. These problems, with venting the containments under the challenging conditions following the tsunami, contributed to the progression of the accident from inadequate cooling of the core leading to core damage, to compromising containment functions from overpressure and over-temperature conditions… of three of the Fukushima Dai-ichi units. …The events at Fukushima reinforced the importance of reliable operation of hardened containment vents during emergency conditions…"*

To address this event with the rest of the nuclear industry, there are many regulatory and industry recommendations and changes to be considered. Among these currently are the following:

- NRC Near Term Task Force 90 Day Report
- NRC SRM/SECY 11-0124 - Recommended Actions to be taken Without Delay From The Near-Term Task Force Report
- NRC – SRM/SECY 11-0137 - Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned

The primary objectives of the scope of work derived from these documents resulted in the Industry response to NRC Order EA-12-049, Mitigation Strategies for Beyond-Design-Basis External Events (FLEX). Many of these cornerstones will be utilized in this guidance document for addressing NRC Order EA-13-109.

The industry is committed to continuous improvement of nuclear safety. Some applicable continuous improvement work items from lessons learned from the Fukushima Daiichi event are listed below:

a) Confirm or establish effective coping measures to address the vulnerability of onsite and offsite AC power systems to common mode failures resulting from external and internal events, including beyond design basis events.

b) Confirm the external events that formed the basis for plant designs exceed credible hazards based on historical data and current models (floods, high winds, seismic events, etc.) or raise the design bases and change the plants, as necessary to accomplish the revised design bases.

c) Confirm or establish effective primary containment protective strategies that can manage post-accident conditions, including such factors as elevated pressures and hydrogen generation from fuel damage more extensive than original design bases, including use of hardened venting, etc. as appropriate.

d) Confirm or establish effective integrated strategies to provide for system based response for events and/or severe accidents involving multiple reactors at a site (i.e., integrate EOPs, SAMGs, AOIs, EDMGs, etc.).

e) Provide for support during extended emergencies involving infrastructure loss, including fuel supplies, coordination of offsite resources, communications, near site living requirements and transportation, and etc.

f) Share and participate with other stakeholders to co-develop responses, improve acceptance and consensus, and minimize development costs.

g) Establish Regional Response Centers with multiple sets of site response equipment and long term coping equipment for mitigating fuel damage from an ELAP event.

1.2 HCVS Guiding Principles

Hardened vents have been in place in U.S. plants with BWR Mark I containments for many years but a variance exists with regard to the capability of the vents for a broad spectrum of events. BWR Mark II containments have containment venting capability but they typically are not hardened vent paths. Therefore, hardened containment venting systems in BWR facilities with Mark I and Mark II containments are being required by the NRC on the basis that they are needed to enhance protection of public health and safety.

On June 6, 2013, the US NRC rescinded Order EA-12-050 and issued a new order, EA-13-109, expanding the requirements of the original order to include requirements for the reliable hardened vent for severe accident conditions. The new Order 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."

The original Order EA-12-050 [Ref. X] required that all boiling water reactor (BWR) Mark I and Mark II containments have a reliable hardened vent to remove decay heat from the containment and maintain control of containment pressure within acceptable limits following events that result in the loss of active containment heat removal capability or prolonged station blackout (SBO), i.e., Extended Loss of AC Power (ELAP). The original order did not include explicit requirements relating to severe accident service for the hardened containment venting system (HCVS); rather, the focus of the HCVS was to support strategies related to the prevention of core damage under a wide range of plant conditions. JLD-ISG-2012-02 provided the Interim Staff Guidance (ISG) to drive compliance to Order EA-12-050.

All licensees subject to Order EA-12-050 provided integrated plans for the design and implementation of reliable hardened containment vents by February 28, 2013. In SRM-SECY-12-0157 [Ref. 3], the Commission directed the staff to revise Order EA-12-050 to require the upgrade or replacement of 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.

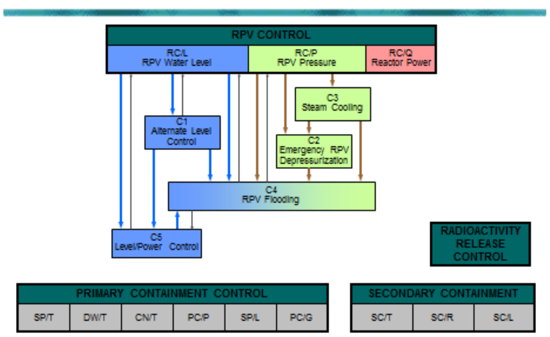
EA-13-109 requires that BWRs with Mark I or Mark II containments ensure that the HCVS also provides a reliable hardened venting capability from the wetwell and drywell under severe accident conditions, including those involving a breach of the reactor vessel by molten core debris. A drywell strategy for alternate heat removal instead of the drywell vent requirement is acceptable. The severe accident capable HCVS is intended to keep the original function of the HCVS, which is to help prevent severe accidents from occurring, and to add the capability of helping to mitigate the consequences of a severe accident should one occur. The wetwell and drywell vent pathways are not required to be in operation at the same time. The development and implementation of the severe accident capable HCVS consists of two phases. The first phase consists of providing a venting system from the containment wetwell that meets the functional, quality, and programmatic requirements listed in subsequent sections of this guide. The second phase is associated with capabilities to vent from the drywell during severe accident conditions and involves either installing a venting system or developing a reliable strategy to limit the possible need to vent from the containment drywell during severe accident conditions. Thus the wetwell and drywell vent pathways will not be required to be installed concurrently. Appendix C outlines the methodology licensees can use to evaluate the viability of a drywell vent path.

1.3 PROCEDURE INTERFACE

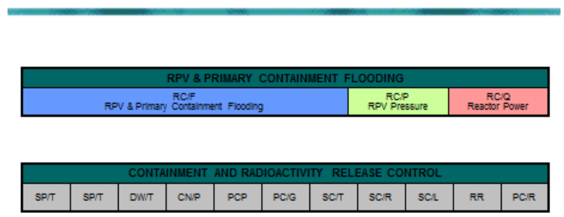
Command and Control for accident response is governed by the suite of Emergency Preparedness guidelines and procedures. Accident response is controlled by the plant specific Emergency Operating Procedures (EOPs), severe accident management guidelines (SAMGs), and Emergency Preparedness procedures. The EOPs provide direction to Operators for use of hardened vents (as well as other available venting) when adequate core cooling has been maintained for prevention of fuel damage. The SAMGs provide direction for use of hardened vents for the purpose of mitigation after adequate core cooling has been lost. The importance of reliable operation of hardened vents during conditions involving loss of containment heat removal capability is well established and this understanding has been reinforced by the lessons learned from the accident at Fukushima Dai-ichi. Understanding the procedural interface and direction is essential given the influence that severe accident conditions have on the design and operational use of the vent paths.

The plant specific procedures are based upon the BWROG generic Emergency Procedure Guidelines/Severe Accident Guidelines (EPGs/SAGs), whose organizational structure is diagramed below:

EPG Structure

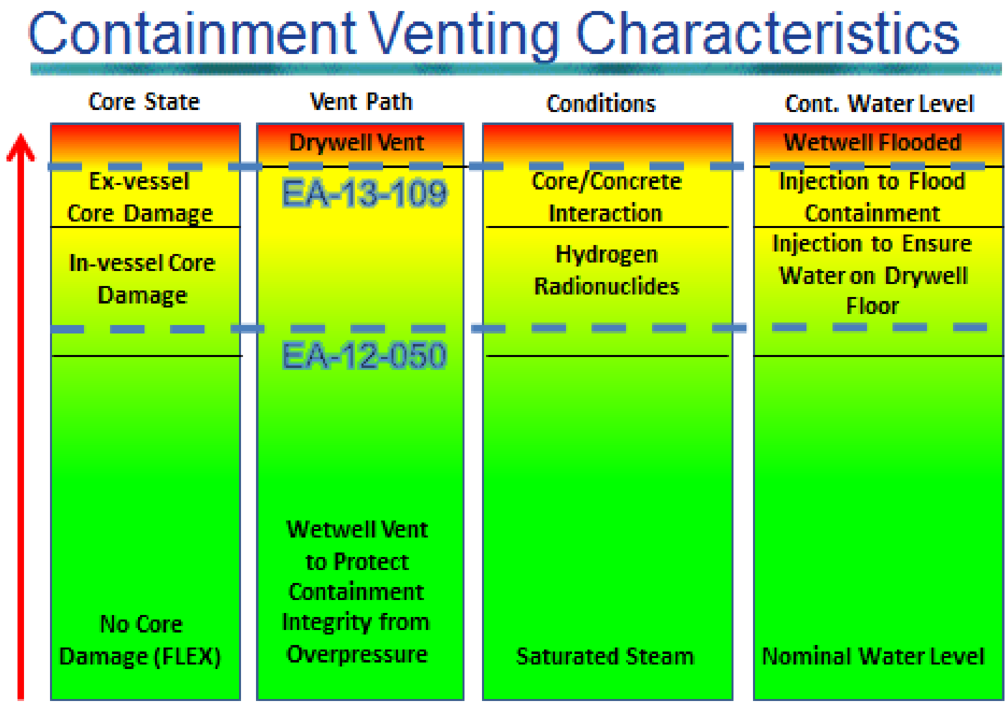


SAG Structure



Utilities currently have implemented Revision 2 of the EPG/SAGs, but Revision 3 has been published and includes the lessons learned from Fukushima Dai-ichi.

The BWROG standard emergency operating procedures and severe accident guides (EOP/SAG) (revision 2 and 3) both provide direction for BWR Mark I and II plants to leave EOP/SAG flowcharts at any point where adequate containment heat removal methods are in effect as on the following illustration of containment venting characteristics, i.e., they are not predisposed to have to use drywell venting.



Revision 3 of the EOP/SAG enhanced the flow of information from revision 2 using lessons learned from the Fukushima event. The information presented is representative of the structure in revision 3.

From the plant specific EOPs developed from the EPGs, use of a hardened vent is directed:

- before primary containment pressure reaches the primary containment overpressure limit defined by the Primary Containment Pressure Limit (PCPL),
- if lower containment pressure is necessary to provide RPV injection; if suppression pool approaches saturation conditions and can no longer effectively condense steam discharged from RCIC; or
- to limit total offsite dose by venting steam prior to experiencing fuel damage.

From the plant specific SAMGS developed from the SAGs, use of a hardened vent is directed:

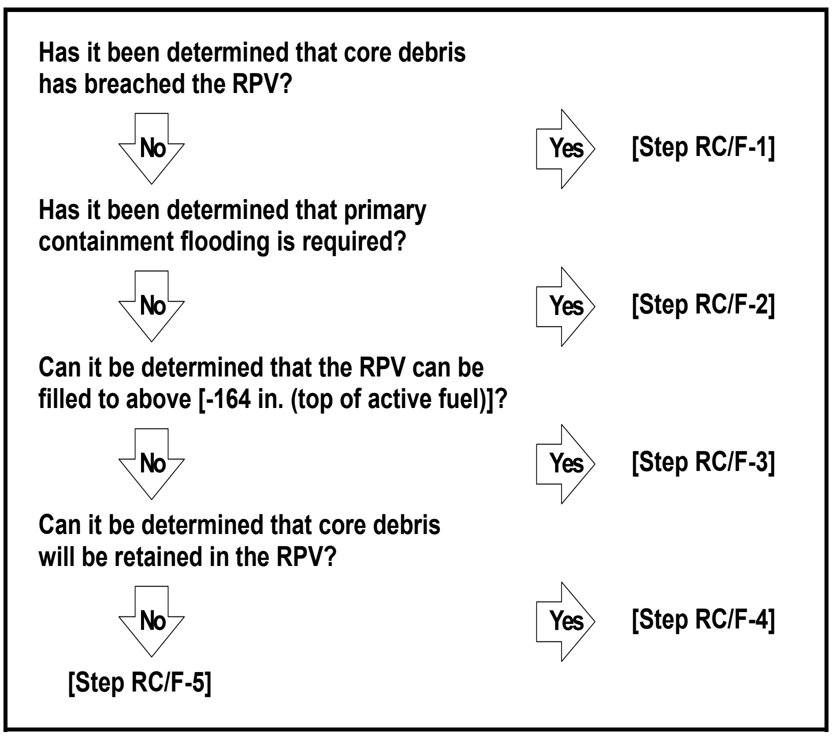
- Before primary containment pressure reaches the primary containment overpressure condition defined by (PCPL);
- To facilitate RPV injection or containment injection; or
- To remove combustible gases from primary and secondary containment.

Containment venting per the procedures and guidelines should be coordinated with evacuation procedures and timed to take advantage of favorable meteorological conditions. It should be coordinated to take advantage of suppression pool scrubbing as much as possible.

For venting from EOPs the wetwell vent is expected to be used to protect containment and will be venting mostly saturated steam, while Primary Containment Water level and pressure will be maintained to preserve the Pressure Suppression Capability of the Containment. This could include venting to protect steam driven systems being used to provide adequate core cooling or to limit the total offsite dose if it is expected that fuel damage has occurred.

Once fuel damage occurs and transfer to plant specific SAMGs is made containment venting will depend on what other plant conditions exist. Only two steps in plant specific SAMGs require containment flooding, steps RC/F-1 and RC/F-2. The remaining steps seek to maintain Pressure Suppression Capability (which means suppression pool water is maintained in an extended range but not flooding containment). Containment venting could be used to restore Pressure Suppression Capability by lowering containment pressure. The SAMGS do not mandate Drywell venting for all conditions.

The following graphic shows the SAMG decision block and briefly describes the conditions each step implements:



RC/F-1 RPV breached. Submerge debris and flood containment.

RC/F-2 Pressure Suppression Capability not maintained or Primary system break. Cool debris and flood containment.

RC/F-3 Re-flood RPV above TAF. Maintain Pressure Suppression Capability.

RC/F-4 Debris expected to remain in RPV. Cool debris and maintain Pressure Suppression Capability.

RC/F-5 Debris may melt through RPV. Containment may fail. Maximize RPV injection.

To summarize, containment venting is addressed in plant specific EOPs for prevention of core damage. After core damage cannot be prevented, plant specific SAMGs address mitigation of core damage. The basis for these actions is documented in the BWROG EPG/SAG Rev. 3 Appendix B, Technical Basis, and the Technical Support

Guidelines, Rev. 0. Hardened containment vent designs should include a review of the EPG/SAG Revision 3 directions for use of containment vents.

1.4 OVERVIEW

This industry guidance has been developed to provide an integrated set of considerations for the design and implementation of a severe accident capable hardened containment venting system (HCVS). This guidance is organized in the following manner:

- Section 2: Description of the boundary conditions to be applied to the design of HCVS including the applicable severe accident conditions, the design boundary conditions and operational assumptions, and the role of mitigation strategy capabilities implemented under EA-12-049 [Ref. X]
- Section 3: Guidance on the design considerations for the HCVS including vent path design, vent operation and monitoring, support systems for sustained operations, protection from flammable gas ignition, other design requirements such as environmental qualification, seismic and external hazard design and quality requirements.
- Section 4: Guidance on the operational considerations for the HCVS including procedural guidance and training related to the operator actions required for use of the HCVS and the testing and inspection of the HCVS and associated components.
- Section 5: Guidance on meeting the programmatic requirements associated with the revised order.
- Section 6: Operations consideration for the HCVS including environmental considerations, procedures, allowed out of service time, and testing.
- Section 7: Template for Overall Integrated Plan Submittal and six month status updates
- Section 8: References
- Appendices: Are provided to elaborate on specific aspects of the guidance including a glossary of key terms, a cross-reference roadmap of order requirements, FLEX interfaces, generic letter 89-16 interfaces, calculation methods for defining plant-specific severe accident operator doses and source terms, and design approaches to address control of flammable gases.

This industry guidance provides an acceptable method for satisfying those requirements. Licensees may propose other methods for satisfying these requirements. The NRC staff can review such methods and determine their acceptability on a case-by-case basis.