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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 ensuring prevention and mitigation strategies are available 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 extreme events, some of which cannot be forecasted.

The importance of reliable operation of hardened vents during conditions involving loss of active containment heat removal 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 design variances exist across the industry 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 [Ref. 6] indicated hardened vent designs that were AC independent to operate with limited operator actions from the control room are necessary. Therefore, Order EA-12-050 [Ref. 2] required hardened containment venting systems in BWR facilities with Mark I and Mark II containments on the basis that they are needed to provide reasonable assurance of adequate protection of public health and safety.

Subsequently the original Order was rescinded and replaced with a new order to require a severe accident capable containment vent on the basis that it provides a cost-justified substantial safety improvement beyond what is needed to provide reasonable assurance of adequate protection of public health and safety. Order EA-13-109 [Ref. 1] was issued to expand the set of design and quality requirements originally imposed by EA-12-050 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 Because EA-12-050 has been rescinded and its requirements are now reflected in Order EA-13-109, licensees are no longer expected to comply with the requirements of Order EA-12-050, including any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 completion dates for implementation.

The 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 Accident Conditions” [Ref. 1]. 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 from the March 11, 2011 Fukushima Dai-ichi 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, which is prefaced by the following statement:

> *"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, and to the hydrogen explosions that destroyed the reactor buildings (secondary containments) 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, particularly for smaller containments such as the Mark I and Mark II designs …"*

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

- NRC Near Term Task Force 90 Day Report, [Ref. 6]
- NRC SRM/SECY 11-0124 - Recommended Actions to be taken Without Delay From The Near-Term Task Force Report, [Ref. 7]
- NRC – SRM/SECY 11-0137 - Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned, [Ref. 8]

The primary objectives of the industry response scope of work derived from these documents resulted in NEI 12-06, revision 0, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide [Ref. 20], for implementation of NRC Order EA-12-049, Mitigation Strategies for Beyond-Design-Basis External Events (FLEX), [Ref. 4. Many of these cornerstones will be utilized in this guidance document for addressing NRC Order EA-13-109 even though they did not originally extend to venting capabilities under severe accident conditions.

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 revise 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 Emergency Operating Procedures (EOPs), Severe Accident Management Guidelines (SAMGs), Abnormal Operating Instructions (AOIs), Extreme Damage Mitigation Guidelines (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, etc.

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

g) Establish response centers with multiple sets of site response equipment and long term coping equipment for preventing fuel damage from an Extended Loss of AC Power (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 were required by the NRC (Order EA-12-050) 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 to be capable of operation during severe accident conditions. The new order is applicable to all operating 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 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 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 requirements relating to severe accident service for the hardened containment venting system (HCVS); rather, the HCVS was only required to be able to support strategies related to the prevention of core damage under a wide range of plant conditions. JLD-ISG-2012-02, “Compliance with Order EA-12-050, Reliable Hardened Containment Vents” [Ref. 5] provided the Interim Staff Guidance (ISG) for implementation of 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, “Staff Requirements - SECY-12-0157, ”Consideration Of Additional Requirements For Containment Venting Systems For Boiling Water Reactors With Mark I And Mark II Containments” [Ref. 3], the Commissioners 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 in addition to pre-core damage venting capability, 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. However, EA-13-109 also allows a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell as an acceptable alternate to the drywell vent. The severe accident capable HCVS is intended to keep the originally required function of the HCVS, which is to help prevent severe accidents from occurring, and to add the capability of operating during a severe accident conditions. 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 involves either installing a containment drywell venting system or developing a reliable strategy to limit the possible need to vent from the containment drywell during severe accident conditions. Thus the second phase will not be required to be installed concurrently with the first phase.

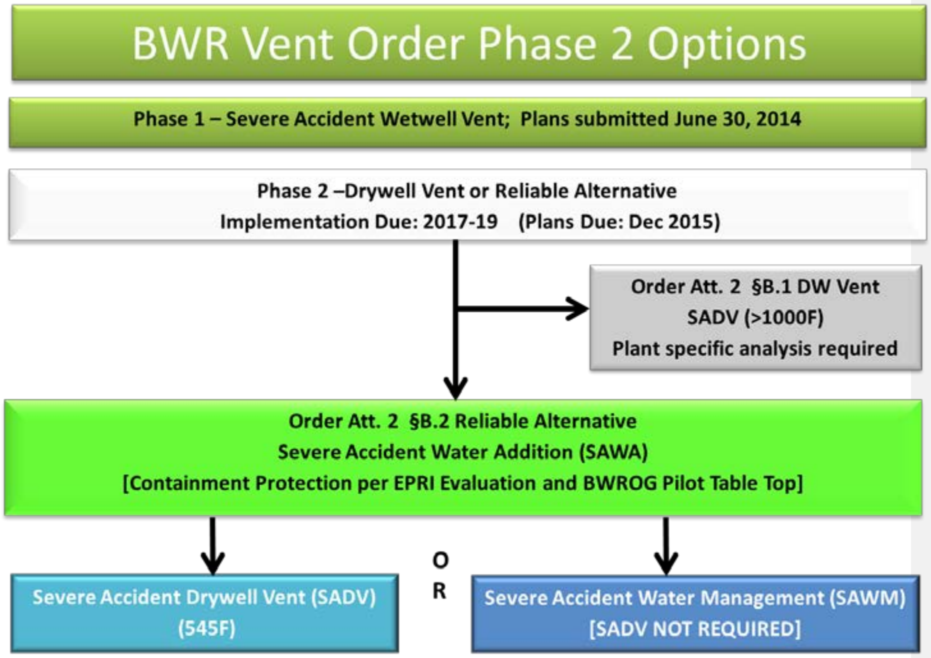
Comment [N1]: Suggested rewrite: The second phase involves either expanding the HCVS capability to vent directly from the drywell, or developing a reliable strategy that eliminates the vent directly from the drywell during severe accident conditions. The second phase is not required to be implemented concurrently with the first phase.

Analysis and calculations performed in conjunction with participation **support of**in the Containment Protection and Release Reduction Rulemaking, as documented in EPRI Technical Report XXXXXX, has identified that venting in conjunction with water addition to the drywell **which can be accomplished** under severe accident conditions involving extensive core damage and reactor vessel breach, provides substantially more safety benefit than venting alone. The safety benefit comes from the cooling effect of the added water on the containment temperatures. The reduction in containment temperature provides reasonable assurance that the probability of gross containment leakage due to temperature related effects is minimized. Water addition that can be provided to the Reactor Pressure Vessel (RPV) or Drywell under severe accident conditions has been termed Severe Accident Water Addition (SAWA). The primary benefits of SAWA include the reduction of containment temperatures with ex-vessel core debris and having a reliable source of water addition that can be used to implement a water management strategy that preserves the wetwell vent path until other means of accident coping are available. The preservation of the wetwell vent path would be **which is** accomplished by managing the water addition flow rate to the extent that the wetwell vent line remains available until other means of accident coping are available is termed Severe Accident Water Management (SAWM).

Comment [N2]: Until containment venting is no longer needed for pressure/temperature control ??? What else is meant by "accident coping"?

Comment [N3]: Same as above

The order provides two (2) compliance methods (B.1 and B.2) for phase 2 of the order, The first method is described in B.1 of attachment 2 of the order and **does** it requires a high temperature drywell vent supported by plant specific analysis. Those licensees that desire to pursue this option will work directly with the NRC for acceptable guidance.**not require further guidance.** For the other method of compliance (B.2) there are two (2) options that include Severe Accident Water Addition as a common element for implementing Phase 2 strategies of the Order, as shown in the following figure.



These options are informed by the currently ongoing Containment Protection and Radiological Release Reduction Rulemaking, which demonstrates a significant safety benefit from water addition in conjunction with venting. The key elements of water addition need to be defined to ensure the intent of B.2 is met (SAWA guidance is contained in Appendix I).

Option 1 – Utilization of the wetwell vent as long as available SAWA to either the RPV or Drywell and then transition to a severe accident capable drywell vent (SADV) meeting the requirements of Section B.1 (545°F SADV) and B.2 (SAWA) of Order EA-13-109. Use of SAWA and SADV should be maintained until alternate reliable decay heat removal and pressure control is established. (Guidance for SADV is contained in Section 2.)

Option 2 – Utilization of the wetwell vent with severe accident water addition (SAWA) to either the RPV or Drywell as part of the Order implementation meeting the requirements of Section A (SAWM) and B.2 (SAWA) of Order EA-13-109. Capability to vent directly from **Preservation of** the wetwell is to be preserved **vent should be maintained** until alternate reliable decay heat removal and pressure control is established (SAWM). This strategy includes both SAWA and SAWM but does not require the installation of a severe accident capable drywell **vent** vent (Guidance for SAWM is contained in Appendix C). The table below clarifies the scope of the elements used to implement a successful containment venting strategy needed to meet Section B.2 requirements of Phase 2 of the Order.

Comment [N4]: This is stated in B (2) of the order. In principle, what is stated here is acceptable. However, it is important to note that order requirement B (1) works with B 1.1 and 1.2, while B (2) works with B 2.1, 2.2, and 2.3. "Alternate reliable containment heat removal and pressure control" in B (2) refers to the pressure control benefit provided by a reliable containment heat removal system. If venting were required after placing the containment heat removal system in operation, the SADV is the only reliable drywell vent that can be used, for as long as leftover severe accident conditions exist in containment (e.g. combustible gases).

Comment [N5]: See comment above. Also, see further comments in the later portions of this guidance.

Comment [N6]: Summarizes?

Severe Accident Water Addition (SAWA)
- Water addition path – RPV or Drywell
- Mitigate drywell temperature extremes
- Utilization (Motive force, Instrumentation)
- Severe accident deployment considerations (Temperature, Radiation)

Severe Accident Water Management (SAWM)
- Sustained operational strategy using SAWA/WW vent (48 hrs.)
- Preserve wetwell vent path until personnel and equipment resources are available to establish alternate decay heat removal and pressure control

Comment [N7]: See comments in the later portions of this guidance.

Severe Accident Drywell Vent (SADV)
- Design Temperature 545 F (after 2nd Containment Isolation)
- Utilization (Motive force, Instrumentation)
- Severe accident deployment considerations (Temperature, Radiation)

1.3 Procedure Interface

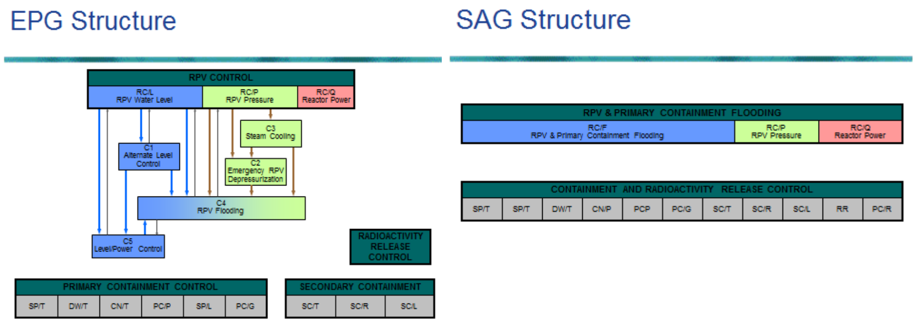
This section is intended to provide information on the accident management features of the suite of procedures needed to respond to symptoms present in a Beyond Design Basis Event (BDBE). Inclusion of this information does not intend to provide any express or implied endorsement of Emergency Procedure Guidelines/Severe Accident Guidelines (EPG/SAG) or other details presented in this section. If any conflicts arise between the discussion in this section and the criteria stated in Order EA-13-109, then the criteria in the Order takes precedence over the direction in EPGs/SAGs.

Command and Control for accident response is governed by the suite of Emergency Preparedness guidelines and procedures. Containment heat removal and pressure control functions are, and have always been, manually initiated at BWR facilities. Therefore, the use of procedures to direct the use of installed systems has existed well before the development of either order. The HCVS is also initiated manually and therefore requires procedural direction to initiate venting for containment heat removal and containment pressure control.

Use of the HCVS is governed by the plant specific Emergency Operating Procedures (EOPs), severe accident management guidelines (SAMGs), and Emergency Preparedness procedures. The EOPs provide direction, based on symptomatic containment conditions, to initiate use of installed vent paths from containment to assure adequate core cooling has been maintained for prevention of fuel damage. The SAMGs provide direction for use of hardened vents for the purpose of containment pressure control after adequate core cooling has been lost.

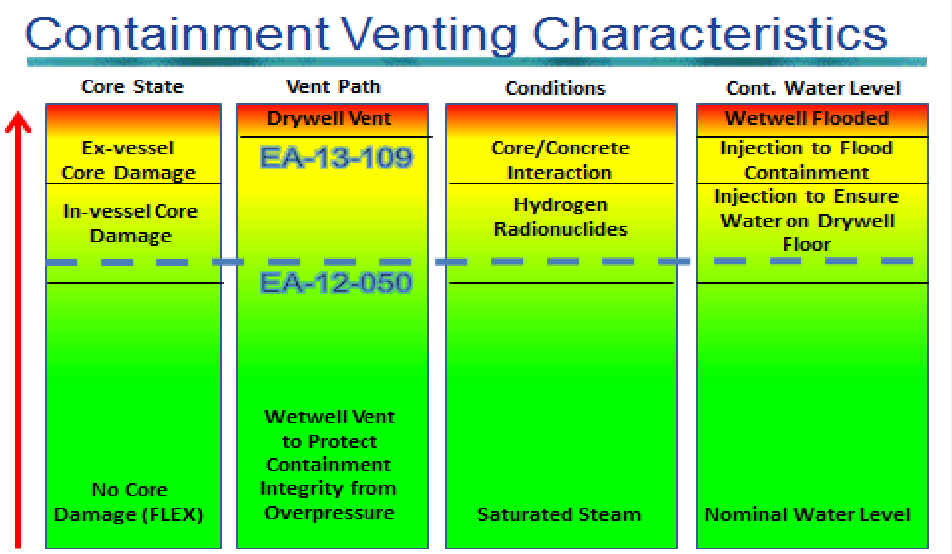
HCVS reliability does not only depend upon the design of the HCVS, but also the procedural guidance directing use based on containment parameters. The importance of reliable operation of hardened vents during conditions involving loss of containment heat removal capability is well established and this understanding has been reinforced by the lessons learned from the accident at Fukushima Dai-ichi. Understanding the procedural interface and direction in determining HCVS design criteria is essential

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



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 procedure guidelines and severe accident guides (EPG/SAGs) (Revision 2 and 3) both provide direction for BWR Mark I and II plants to leave EPG/SAGs flowcharts (into recovery actions) 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 EPG/SAGs 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.

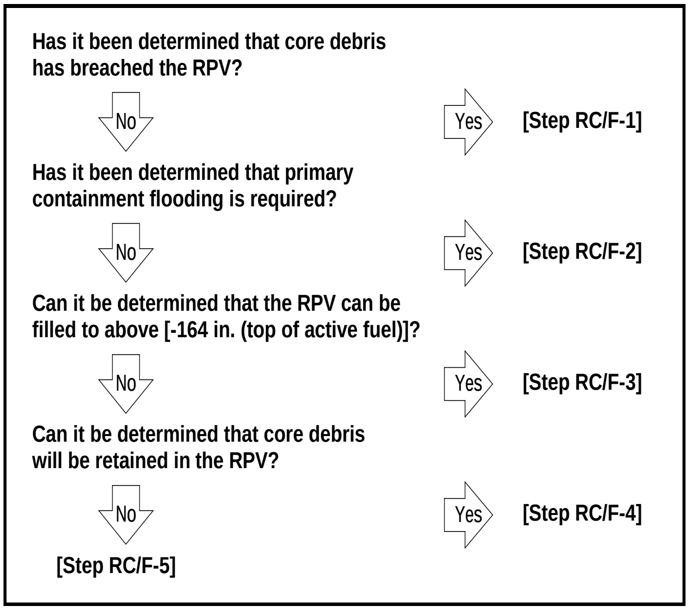
Containment venting per the procedures and guidelines should be coordinated with evacuation procedures and timed to take advantage of favorable meteorological conditions. It should be coordinated to take advantage of suppression pool scrubbing as much as possible.

For venting using 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 may occur.

Once adequate core cooling can no longer be assured **fuel damage occurs** and transfer to plant specific SAMGs is made, containment venting will depend on other plant conditions. 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 prior to RPV breach). Containment venting could be used to restore Pressure Suppression Capability by lowering containment pressure. The SAMGs**S** do not mandate Drywell venting for all conditions.

Comment [N8]: But they do indicate direct drywell venting when venting is needed and a suitable wetwell vent is not available.

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. Maintain Pressure Suppression Capability.

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 any pending procedure changes that could influence the design, such as the EPG/SAG Revision 3 directions for use of containment vents. SAGs currently provide guidance on water addition and management based on plant accident symptoms. The benefit of SAWA (SAWM) will be evaluated for inclusion in future revisions of the SAGs.

Comment [N9]: This can be construed as the current SAGs do not provide adequate water addition/management guidance. Suggested rewrite: The water addition (SAWA) and water management (SAWM) provisions in the SAGs will be evaluated for changes consistent with the Phase II option guidance and the CPRRR rulemaking.

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 “Order Modifying Licenses with

	Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events," [Ref. 4].
Section 3:	Drywell vent design per B.1 of the Order.
Section 4:	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 5:	Guidance on meeting the programmatic requirements associated with the order.
Section 6:	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. 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:	Appendices are provided to elaborate on specific aspects of the guidance including:

- Glossary of key terms and cross-reference roadmap of order requirements,
- Phase 2 containment venting strategy that makes it unlikely that a Severe Accident drywell vent is needed and Water addition to the RPV/DW during severe accidents,
- Generic letter 89-16 and FLEX interfaces,
- Methods for defining plant-specific severe accident operator doses and source terms and design approaches to address control of flammable gases,
- OIP Templates and Frequently Asked Questions from OIP development.

Licensees may propose other methods for satisfying the requirements of Order EA-13-109. The NRC staff can review such methods and determine their acceptability on a case-by-case basis.

2. HCVS BOUNDARY CONDITIONS FOR VENT DESIGN AND OPERATION (ONLY DRYWELL CONDITIONS ASSUMINGE SAWA)

Boiling-Water Reactors (BWRs) with Mark I and Mark II containments shall have a reliable, severe accident capable hardened containment venting system (HCVS). The HCVS includes a severe accident capable wetwell venting system, and may also, depending on the approach taken for Phase 2 of Order EA-13-109, include a severe accident capable drywell venting system. The implementation of the order can be in two phases, but the interaction of the phases needs to be coordinated since the containment conditions that exist at the initiation of venting from the wetwell and drywell may be different. Boundary conditions used in design of HCVS shared components, instrumentation and piping is included in this Section and in Section 4.1.

Under Phase 1 of Order EA-13-109, Licensees with BWR Mark I and Mark II containments shall design and install a HCVS, using a vent path from the wetwell to remove decay heat, vent the containment atmosphere (including steam, hydrogen, carbon monoxide, non-condensable gases, aerosols, and fission products), and control containment pressure within acceptable limits. The HCVS shall be designed for those accident conditions (before and after core damage) for which containment venting is relied upon to reduce the probability of containment failure, including accident sequences that result in the loss of active containment heat removal capability during an extended loss of alternating current (AC) power (ELAP). The HCVS shall meet the requirements of Sections 4, 5, and 6 of this document.

Under Phase 2 of Order EA-13-109, Licensees with BWR Mark I and Mark II containments shall either, (1) design and install a HCVS, using a vent path from the containment drywell, that meet the requirements in Sections 2 or 3 and 4 through 6 or, (2) develop and implement a reliable containment pressure control and cooling strategy using the guidance provided in Appendix C of this document that demonstrates it is unlikely that a licensee would need to vent from the containment drywell before alternate reliable containment heat removal and pressure control is reestablished to meet the requirements in Section B.2 of the Order.

The requirements of Order EA-12-050 addressed the use of the HCVS for both prevention of core damage and protection of the containment from overpressure failure during a Beyond Design Basis Event (BDBE) that do not progress to core damage and severe accident conditions. Unlike conditions resulting from postulated plant events, severe accidents, by their very nature, are an effectively unbounded class of events. Although reactors licensed under 10CFR52 have certain regulatory requirements related to severe accident capabilities, the extension of regulatory requirements to design features required for severe accident conditions is unique for existing reactors licensed under Part 50. This unique aspect of Order EA-13-109 calls for very clear definition of the boundary conditions to be applied to the design and operational considerations required to implement the HCVS. The purpose of this section is to clearly outline these boundary conditions and the key terms used in relation to the conditions associated with a severe accident capable vent.

Two key functional aspects of the HCVS involve the prevention of containment over-pressurization for events that do not result in core damage and for events where severe accident conditions exist.

A key guiding principle regarding the design of the HCVS is defining conditions that are consistent with the capability of the containment to withstand severe accidents. This document will define the design parameters of the HCVS equipment, including that of a drywell vent, with the understanding that the HCVS design parameters should provide margin to meet the EA-13-109 order language of "The design is not required to exceed the current capability of the limiting containment components".

2.1. HCVS Use for Design Basis

Use of the HCVS during design basis accident or other events (DBE) is not assumed nor required.

2.2. HCVS Use for Beyond Design Basis External Events (BDBEEs)

A spectrum of Beyond Design Basis Events (BDBE) or Beyond Design Basis External Events (BDBEE) may be postulated; however, in the context of the HCVS, the design and operation in response to such events is not intended to be constrained to a specific set of scenarios or timelines. Rather, the considerations for the HCVS are defined to provide a broad functional capability for the prevention of containment over-pressurization prior to core damage and mitigation of containment over-pressure conditions that may exist after core damage.

2.2.1. BDBE are events that involve assumptions and failures that exceed those associated with DBEs but may not be considered severe accidents.

2.2.2. Certain beyond design basis events such as an extended loss of AC power (ELAP) can result in the loss of active containment heat removal capability.

2.2.2.1. Plant actions to address an ELAP are contained in the plants response to NRC Order EA-12-049, commonly referred to as FLEX. An ELAP itself is not considered a severe accident since use of FLEX may well prevent**s** core damage. However, if ELAP is not mitigated a severe accident with core damage and vessel breach may evolve.

2.2.3. The primary design objective of the HCVS is to provide sufficient venting capacity to prevent a long-term overpressure failure of the containment by restoration and maintenance of containment pressure below the primary containment design pressure and the primary containment pressure limit (PCPL).

2.2.4. The HCVS venting pressure for a BDBE may be driven by conditions created during BDBEs, such as to lower pressure to use a low pressure portable pump or to control containment conditions to allow continued use of installed equipment such as installed steam-driven equipment that discharges to the Suppression Pool/Torus during loss of containment cooling and may be using the suppression pool as a water source and thus also the cooling medium for pump components.

2.3. HCVS Use during Applicable Severe Accident Conditions

The primary severe accident use of the HCVS is to protect the containment from over-pressure failure caused by the increase in containment pressure from steam, non-condensable gases, and elevated containment temperature following severe core damage. For the purposes of this order, the severe accident is caused by loss of active containment heat removal capability or failure to mitigate an ELAP. The conditions include both scenarios in which all core debris is cooled in-vessel (similar to the accident at TMI-2) and scenarios in which core debris breaches the reactor coolant boundary and relocates into containment, with some of the core debris remaining within the reactor vessel. Increased temperature resulting from severe accidents may impact the pressure retention capability of containment penetration seals, particularly the drywell head gasket. The performance of the HCVS in response to a severe accident is intended to minimize, as far as reasonably practicable, uncontrolled releases of radionuclides and combustible gases to the environment external to the containment by preventing containment over-pressure failure.

The HCVS would also be used as an element of the Plant procedures to maintain the Pressure Suppression Pressure function of the containment prior to RPV breach by controlling suppression pool/torus pressure and level. Additionally, venting of non-condensable gases from containment can reduce the challenge to containment integrity from stratified gas temperature effects on the drywell head gasket.

2.3.1. Realistic assumptions (i.e. not bounding) may be used to determine the initial conditions for design of the HCVS, e.g., Suppression Pool initial temperature, DW initial temperature, use of heat sinks in analysis models. These initial condition assumptions are consistent with the starting point for order EA-12-049, in response to an ELAP.

2.4. Vent Design Boundary Conditions

The potential scope of possible severe accident conditions is essentially unbounded. In some scenarios, severe accident containment conditions can compromise containment integrity for reasons other than over-pressurization, (e.g., drywell shell melt-through in Mark Is, extremely high temperature effects on drywell head seal leakage or other postulated containment failure modes). The unbounded nature of severe accident conditions calls for a more reasonable design philosophy; the HCVS capability should exceed the current capability of the limiting containment components or meet the conditions under which it is required to operate. Four primary parameters are defined for use in defining the HCVS component capability; Pressure, Temperature, Radiation and Hydrogen/CO Concentration.

Order Reference: 1.2.10 – The HCVS shall be designed to withstand and remain functional during severe accident conditions, including containment pressure, temperature, and radiation while venting steam, hydrogen, and other non-condensable gases and aerosols. The design is not required to exceed the current capability of the limiting containment components.

2.4.1. Depending on the HCVS design, the HCVS may have three distinct portions.

2.4.1.1. a portion that only supports wetwell venting,

2.4.1.2. a portion that only supports drywell venting, and

2.4.1.3. a portion that is shared by both.

2.4.1.3.1. The temperature boundary conditions for the drywell vent are impacted by other conditions that may exist at the time the vent is needed. EPRI Technical Report XXXXXX{CPRR Related} demonstrates that water addition during severe accident conditions provides a substantial safety benefit by reducing containment temperatures. The temperature boundary conditions with water addition will be described in this section

2.4.2. The use of the HCVS is provided in Industry Guidance and adopted on a plant-specific basis through the use of flowcharts and procedures.

2.4.2.1. In the plant procedures, the highest pressure used for venting to control (restore and maintain) pressure is based on the plant-specific Primary Containment Pressure Limit (PCPL).

2.4.2.1.1. When designated herein, the most bounding PCPL for design of components is PCPL, which is based on the pressure capability of containment.

2.4.2.1.2. PCPL is selected as the boundary condition for the design pressure of the HCVS components, instrumentation and piping. It is expected that the capability of HCVS components and piping will be greater than the design boundary conditions.

2.4.3. During a severe accident, temperature of gases in the wetwell and drywell will differ but this is expected based on the physical configuration of the plant.

2.4.3.1. The suppression pool/wetwell of a BWR Mark I/II containment can be considered to be in a saturated condition.

2.4.3.2. The plant-specific PCPL determination provides a temperature range for the suppression pool of 70ºF to 350ºF.

2.4.3.3. Therefore, the design temperature for the wetwell vent portions of the HCVS are recommended to be based on the 350ºF upper bound of the EPG/SAG bases document which is above the saturation temperature corresponding to typical PCPL values.

2.4.4. For the drywell vent path, the plant-specific PCPL is within a drywell temperature range of 100ºF - 545ºF.

2.4.4.1. The PCPL and 545ºF, is recommended as the design pressure and temperature for the drywell vent system and any common and shared portions of the vent line if Severe Accident Water Addition as described in Appendix I is also implemented as part of Phase 2 of the Order. For portions of the vent line past the 1st primary containment isolation valve (PCIV) an auditable analysis may justify lower values. (This guidance is providing design pressure and temperature for the drywell vent system to address the possibility that the wetwell vent system associated with Phase I may share piping and components with the drywell vent portion associated with Phase 2.)

2.4.4.1.1. The postulated boundary of severe accident conditions could exceed the recommended design envelope of the drywell vent as evidenced by the Fukushima events and supported by various studies prior to Fukushima. In that event, the HCVS should have the capability to continue to perform its function at more extreme conditions. Inherent margins above design of the components, such as higher plastic failure temperatures provide assurance of this capability (reference Figure 2.1.)

2.4.4.1.2. The HCVS capability at extreme conditions should consider all potential aspects of vent usage and operation under severe accident conditions, including but not limited to drywell floodup and protection of drywell head seal from over-pressure and associated over-temperature induced gross leakage; which is accomplished by maintaining containment pressure below the lower of containment design pressure or PCPL.

Notes:
- The Switzerland Regulator imposed a vent design pressure of 150% of containment design pressure or 66% of failure pressure via HSK-AN-2026.
    - A European BWR uses 150°C (302°F) as the design temperature for its vent system.
- Not all BWR Containment, Drywell Sprays and Suppression Pools are sized and/or configured similarly depending on NSSS provider and construction timeline.
- These vent design parameters are associated with a particular configuration and severe accident mitigation strategy that is intended to protect the containment pressure retaining capability.

2.4.4.2. As pictorialized in Figure 2-1, which illustrates the representative margin of the containment based on the design envelope, extending the DW HCVS vent design values to PCPL and 545°F (from point 1 to point 2 on the diagram) provides an assurance that margin is maintained in the DW head region by selecting this design point for the DW vent.

Selection of this design point (PCPL and 545°F) should provide margin to avoid gross drywell head seal leakage (as illustrated by comparing point 2 to point 4 on the diagram).

The basis of Figure 2.1 is a compilation of various test and engineering evaluations that are publically available on the integrity of containment, e.g., SOARCA, NUREG/CR-2442, NUREG/CR-5334, NUREG/CR-3234, NUREG/CR-4064, DE-ACO4-76DP00789 [Ref. 9, 11 – 15].

The HCVS operational procedures should provide direction such that containment pressures are controlled. This capability of pressure control should be shown to provide containment pressure and associated temperature margin below the ultimate failure prediction for gross drywell head seal leakage.

2.4.4.2.1. The green, blue and light blue highlighted regions of the diagram show the dominant items contributing to loss of containment for that range of temperatures and pressures based on the containment design bases grey box.

2.4.4.2.2. The red area of the diagram shows the region where there is high likelihood that significant containment compromise will occur based on the containment design values (point 1).

2.4.4.2.3. The failure predictions for gross drywell head seal leakage from over-pressure/over-temperature, individually or in combination, shall be based on Figure 2.1 compilation basis and any other available data and research on the subject matter.

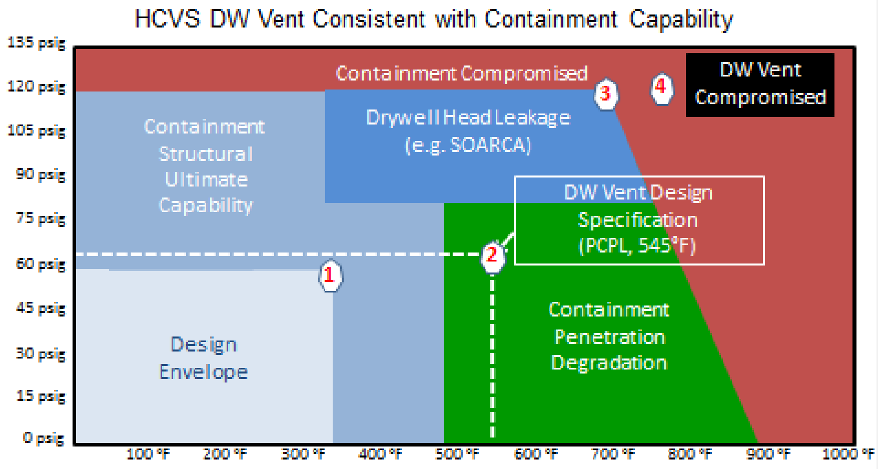


Figure 2-1

2.4.4.3. The selection of the DW HCVS vent design values to PCPL and 545°F (with SAWA) does not imply that the containment vent should be operated at this value since elevated temperatures and pressures increase the probability of DW head gasket compromise, which should be avoided.

2.4.4.4 A severe accident capable drywell vent meeting the requirements of Section B.1 of Order EA-13-109 with SAWA to either the RPV or Drywell as part of the Order implementation justifies a temperature design boundary condition of 545°F.

2.4.4.4.1 The recommended design temperature boundary condition for this option is 545°F. As shown in Figure 2-2, containment maximum temperatures remain at or below 545°F in 95% of all frequency weighted end states with water addition evaluated in conjunction with CPRRR**support of** rulemaking (reference EPRI Technical Report XXXXXX). Figure 2-3 shows that there is little difference in temperature benefit if the water addition occurs directly to the RPV or to the drywell.

Comment [N10]: This is for a particular plant and particular water injection rate (plant characteristics determine potential water depth on DW floor prior to containment flooding to that elevation, and decay heat and injection rate affect how much superheat is experienced in the DW.

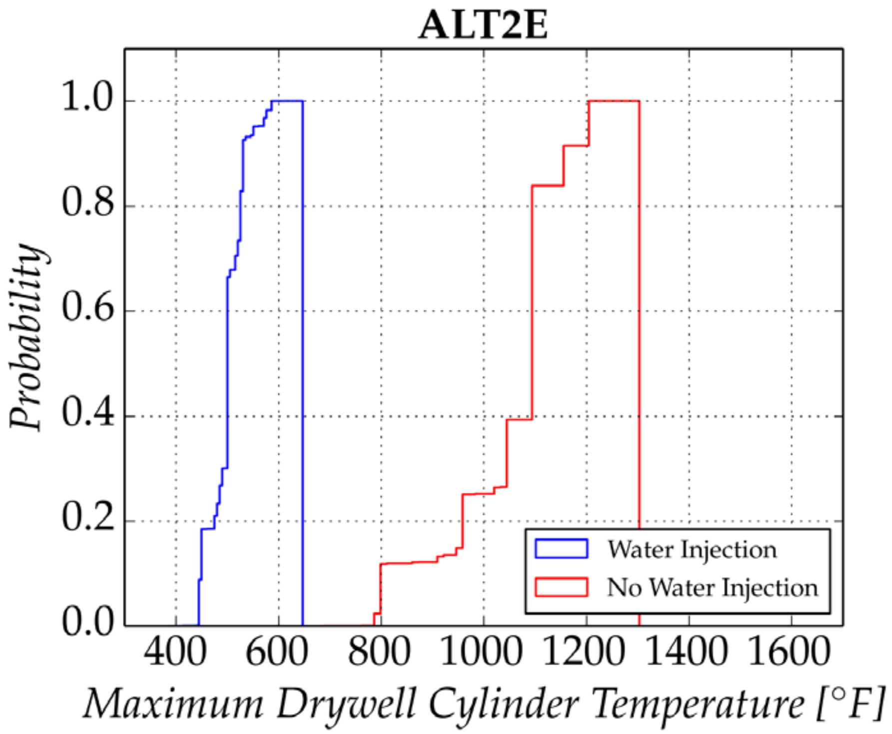
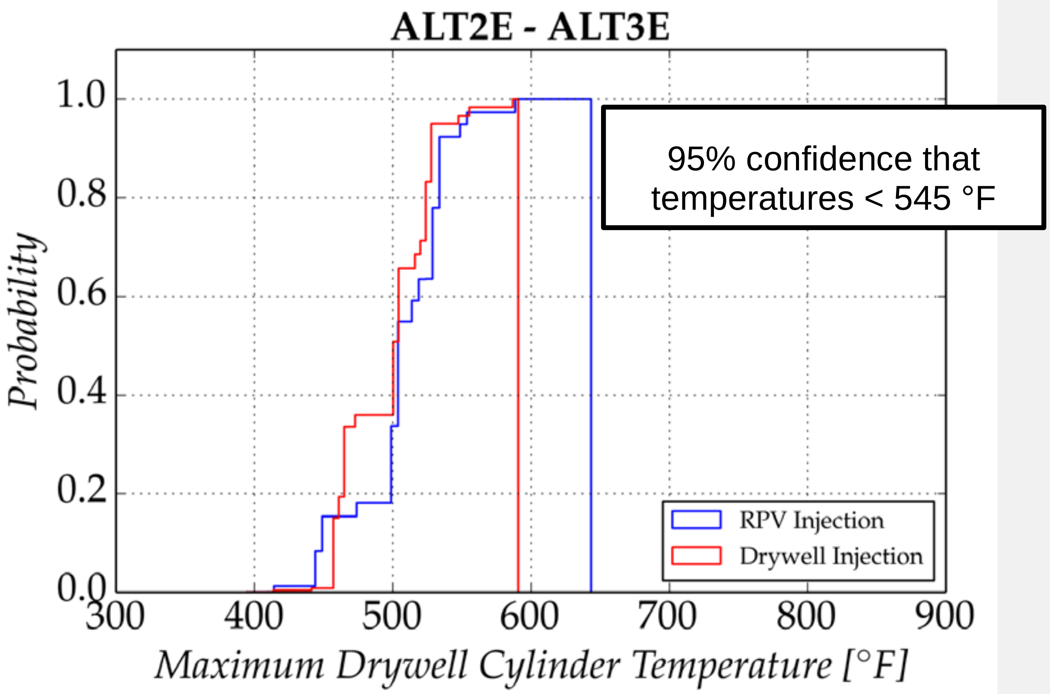


Figure 2-2 Probability of Maximum Containment Heat Sink Temperature under Various Severe Accident Sequences, Water Addition vs. No Water Addition (Reference EPRI Technical Report XXXXXX)

Comment [N11]: Would there be anything lost if "Heat Sink" were replaced with the word "drywell".



95% confidence that temperatures < 545 °F

Figure 2-3 Probability of Maximum Containment Heat Sink Temperature under Various Severe Accident Sequences, water addition to RPV vs. water addition to Drywell (from EPRI Technical Report XXXXXX)

Comment [N12]: Same as comment N11.

2.4.4.4.2 Maintaining the containment below PCPL and 545°F provides reasonable assurance that the potential for gross leakage from the drywell head seal is minimized. This is shown in Figure 2-2 and further supported in Section 2.2

2.4.4.4.3 Licensees choosing this option must also implement Severe Accident Water Addition (SAWA) as described in Appendix I.

2.4.4.5 Additional supporting information for a drywell vent design temperature boundary condition of 545°F as described in Section 2.4.4.4.

2.4.4.5.1 Analysis has been performed by NRC **Research** using MELCOR and EPRI using MAAP. The MAAP analysis produced the results shown in Figures 2-2 and 2-3.

2.4.4.5.2 MELCOR analysis shows that with water addition and containment venting, the maximum upper drywell gas temperatures for most of the dominant sequences would range from **3**400°F to 600°F, except for short durations when the temperature in the drywell pedestal region/elevation has a significant spike.

2.4.4.5.3 The information in this item is for less than a large Drywell head diameter seal testing, but it is expected that the information is representative and can be used as defense in depth supporting data. Sandia National Laboratories performed testing of compression seals and gaskets commonly used for DW head seals for the NRC in the early 1990s. Materials tested include EPDM, Silicone Rubber and Neoprene. Temperatures at which significant leakage could occur range from 460°F to 670°F. The pressures applied during the test are significantly higher (143 to 160 psig) than typical PCPL values (38 to 62 psig). The test pressures are more than twice the containment design pressure. (NUREG/CR-4944, SAND87-7118 R1, Containment Penetration Elastomer Seal Leak Rate Tests (Reference 15))

Comment [N13]: from laboratory setting testing of 14 inch and 18 inch standard piping system flanges machined for double elastomeric seals and is probably more applicable to other containment penetration flanges with elastomeric gaskets much smaller than a 30 foot plus diameter DW head flange. Also, testing was with nitrogen and not steam or hydrogen and gaskets were thermally aged and not radiation aged.

Comment [N14]: Provide some insight as to the limits of DW head seal performance

2.4.4.5.4 The use of the containment vent to maintain Containment pressure below PCPL will help maintain continuity of the metal-to-metal contact between drywell head flanges **ensure that metal to metal contact is maintained at the drywell head seal flange** so that only minor leakage is expected if some seal degradation occurs due to the elevated temperature and radiation. This is based on NUREG/CR 7110, Volume 1, Peach Bottom Integrated Analysis, Section 4.6, Containment Failure Model (Reference 26), description of Containment over-pressure failure mechanism for the drywell head seal flange.

2.4.5. The order drives two options regarding design of the HCVS for flammable mixtures; ensure that the flammability limits of gases passing through the system are not reached or to design for detonation.

2.4.5.1. Designing for detonation is addressed in Appendix H.

2.4.5.2. The exclusion of oxygen is an acceptable method to ensure that flammability limits are not reached.

2.4.5.3. Hydrogen gas (and other combustible gases) is a product of the core damage process as a result of chemical reactions involving zirconium and steam (or steel and steam) and Molten Corium Concrete Interaction (MCCI).

2.4.5.3.1. Depending on the scenario, vent operating cycles and the timing of vent use, the volume fraction of hydrogen can vary widely.

2.4.5.3.2. Based on information in Appendix H, consideration of a hydrogen concentration range of 0% to 6% is recommended (see NUREG C/R-2475/NUREG C/R-6524, GE SIL 643) [Ref. 17, 18 and 19].

2.4.5.3.3. Hydrogen is flammable at above 8% in many references and as low as 4% in other references.

2.4.5.3.4. Purging is an acceptable method for keeping the flammable concentration below 8%

2.4.6. The recommended boundary conditions for the severe accident capable vent are summarized in Table 2-1 below:

Severe Accident Capable Vent Design Parameter Boundary Conditions

Boundary Parameter	**Wetwell Vent Path**	**Drywell Vent/ Shared Paths**[1]
Containment Design Pressure	For Sizing Design use the **Lesser** of Design Pressure or PCPL For Pressure Rating use the **Higher** of Design Pressure or PCPL	
Containment Design Temperature	350 ºF	545ºF with SAWA

[1] The 545°F design temperature for shared paths only applies when a drywell vent designed to 545°F is installed as part of Phase 2 of the Order. If Order option B.2 is implemented, the design temperature of the shared path with any existing drywell vent may be limited to 350°F.

Table 2-1

2.4.6.1. Selection of values that are more conservative than the above recommended values is acceptable (i.e., higher design pressures and temperatures).

2.4.6.2. Less restrictive bases than the above recommended values require a plant-specific technical justification.

2.4.7. The piping, valves, and the valve actuators should be designed to withstand the dynamic loading resulting from the actuation of the system, including piping reaction loads from valve opening, resultant loads from SRV operation, potential for water hammer from accumulation of steam condensation, and hydrogen detonation, if applicable, during multiple venting cycles.

2.5. Vent Operation Assumptions

The vent must be capable of operation during an extended loss of AC power (ELAP) and under conditions that may exist during a severe accident.

Order Reference: 1.2.6 – The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power.

2.5.1. Severe accident conditions within the containment require consideration of accessibility and stay time issues using the methodologies in Appendix F and G. Sections 4.2.5 and 4.2.6 provide the requirements for design.

2.5.2. The 24 hour dedicated and permanently installed equipment requirement does not apply to non-HCVS equipment (e.g., SAWA pumps, valves and instrumentation) needed to support strategies implemented for B.2 of the Order for a Containment venting strategy using SAWA and/or SAWM. Refer to Appendix I for additional requirements for SAWA. (HCVS-FAQ-02: While the above components need not be dedicated, they need to be available to support HCVS function when containment venting using the HCVS system is required.)

3. DRY WELL VENT TEMPERATURE BOUNDARY CONDITIONS WITHOUT SAWA

3.1. Drywell Vent Design Boundary Conditions without SAWA

If SAWA is not provided during severe accident conditions, EPRI Technical Report XXXXXX (Reference ##) shows that containment temperatures with ex-vessel core debris may significantly exceed the 545°F temperature boundary condition identified in Section 2. The requirements for this method of compliance are defined in part B.1 of the Order.

If this option is selected, the Licensee will need to submit plant specific analysis and detailed design for NRC approval.

4. DESIGN CONSIDERATIONS

The purpose of the reliable HCVS is to enhance the capability of BWRs with Mark I and II containments to preserve containment capability in a wide spectrum of possible beyond design basis accident conditions including the presence of ex-vessel core debris, controlling containment pressure within acceptable limits by venting the containment atmosphere including steam, hydrogen, non-condensable gases, aerosols, and fission products. As described in Section 2, the HCVS will be designed for those accident conditions for which containment venting is relied upon to prevent containment failure; including accident sequences that result in the loss of active containment heat removal capability or extended loss of AC power (ELAP). This section describes the design considerations applicable to the design and implementation of a plant-specific HCVS.

4.1. Vent Design Criteria

4.1.1. Vent Thermal Design and Capacity

The primary design objective of the HCVS is to provide sufficient venting capacity to prevent a long-term overpressure failure of the containment by keeping the containment pressure below the lower value of either PCPL or containment design pressure, and maintaining Pressure Suppression Capability such that the safety relief valves (SRVs) can be opened and closed as required by plant conditions. Operational functionality of these valves will ensure the capability to depressurize the RPV to permit injection of low head injection systems and to maintain the containment pressure boundary.

Order Reference: 1.2.10 – The HCVS shall be designed consistent with containment pressures and temperatures during severe accident conditions as well as dynamic loading resulting from system actuation. The design is not required to exceed the current capability of the limiting containment components.

Order Reference: 1.2.1 – The HCVS shall have the capacity to vent the steam/energy equivalent of 1 percent of licensed/rated thermal power (unless a lower value is justified by analyses), and be able to maintain containment pressure below the primary containment design pressure and the primary containment pressure limit (PCPL).

4.1.1.1. Key issues to be addressed in the Vent Thermal Design and Capacity requirements are:

- 4.1.1.1.1. Consideration of containment venting to support mitigation strategies for BDBEE including ELAP conditions.
- 4.1.1.1.2. Ability of the vent system to operate under the expected pressures and temperatures of the containment.

4.1.1.1.2.1. The key consideration would be design temperature of the drywell vent components and instrumentation.

4.1.1.1.3. Sizing considerations for the wetwell and drywell vent.

4.1.1.1.3.1. A wet well vent sized under conditions of constant heat input at a rate equal to 1 percent of rated thermal power and containment pressure equal to the lesser of the PCPL or containment design pressure, the exhaust-flow through the wetwell vent would be sufficient to prevent the containment pressure from increasing.

4.1.1.1.3.2. The suppression pool/torus suppression capacity is typically sufficient to absorb the decay heat generated during at least the first three hours following the shutdown of the reactor with the suppression pool as the source of cooling. The decay heat is typically less than 1 percent of rated thermal power following this three hour period and continues to decrease to well under 1 percent thereafter.

4.1.1.1.3.2.1 Licensees shall have an auditable engineering basis for the decay heat absorbing capacity of their suppression pools, venting pressure and associated decay heat value.

4.1.1.1.3.2.2. Licensees may justify use of decay heat rates of less than 1 percent for purposes of vent sizing capability if analyses demonstrate that containment pressure can be maintained below the lower of design pressure or PCPL (Wetwell or drywell).

4.1.1.1.3.3. In cases where plants were granted, have applied, or plan to apply for power uprates, the decay heat value selected should correspond to the uprated thermal power.

4.1.1.1.3.4. The basis for the venting capacity should give appropriate consideration of where venting is being performed from (i.e., wetwell or drywell) and the difference in pressure between the drywell and the suppression chamber.

4.1.1.1.3.5. Vent sizing for multi-unit sites must take into consideration simultaneous venting from all the units, and ensure that venting on one unit does not negatively impact the ability to vent on the other units. This includes ensuring any shared portions of the vent can pass the cumulative flow requirements

4.1.2. Multipurpose Penetration Use

Order Reference: 1.2.3 – The HCVS shall include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site.

Order Reference: 2.1 – The HCVS vent path up to and including the second containment isolation barrier shall be designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components.

4.1.2.1. Key issues to be addressed regarding multipurpose penetration and containment isolation barriers use are:

4.1.2.1.1. Exception to GDC 56, 10 CFR 50.12 submittal.

4.1.2.1.1.1. Each HCVS containment penetration must have two in-series PCIVs as required by GDC 56.

4.1.2.1.1.1.1. Although GDC 56 stipulates that one valve should be inside containment and the other outside containment, both PCIVs on each HCVS containment penetration may be installed outside containment and as close as reasonably possible to the penetration.

4.1.2.1.1.1.2. Locating a power operated valve inside containment that must open and remain operable following a beyond design basis severe accident decreases the reliability of any valve and operator (including motive air and DC instrumentation and controls) located inside the containment.

4.1.2.1.2. The rational for locating the PCIVs as close as reasonably possible to the containment penetration is to comply with the applicable GDCs.

4.1.2.1.2.1. It limits the amount of the HCVS flow path that is part of the containment penetration boundary.

4.1.2.1.2.2. Minimizing the amount of new containment penetration piping limits the risks to containment integrity. Any piping that is part of the containment penetration boundary must be designed to the appropriate criteria (typically, protected from pipe whip, jet impingement, missiles, and be designed to ASME Section III class 2 with the added requirement for low stresses during design basis operation of the plant to preclude having to postulate pipe break or pipe cracks).

4.1.2.1.2.2.1. New piping and valves should be evaluated for both Design Basis events and Beyond Design Basis Events as separate evaluations.

4.1.2.1.2.2.2. Boundary conditions and loads associated with the Beyond Design Basis event do not have to be included or considered in Design Basis Calculations.

4.1.2.1.2.2.3. Qualification for piping/valves associated with the BDBE may include both different loading combinations and allowed stresses.

4.1.2.1.2.3. Locating the PCIVs close to the containment penetration restricts the possibility for practical local-manual operation; Section 4.2 discusses design features that will increase remote-manual operation.

4.1.2.1.3. GDC 56 stipulates that the valves must be either locked-closed or have automatic closure.

4.1.2.1.3.1. The intent of automatic isolation is to ensure that penetrations that may be open to the containment atmosphere during normal operation (e.g., nitrogen inerting, nitrogen purging) are closed when containment integrity is required.

4.1.2.1.3.2. Automatic isolation of the HCVS valves on a containment isolation signal is possible, but it would be redundant since these valves are required to be closed during all anticipated modes of operation that could require containment isolation. (Except during the period required for operation when the containment isolation signals are to be defeated to allow HCVS operation)

4.1.2.1.3.3. Also, automatic isolation would unnecessarily complicate valve opening if HCVS is required.

4.1.2.1.3.4. To support not providing locked-closed valves or automatic isolation, an option is new PCIVs that are normally-closed valves that have a fail-closed mode (i.e., AOVs).

4.1.2.1.3.5. These valves shall have remote-manual operation, but with a key-lock on the control switch to prevent inadvertent opening.

4.1.2.1.4. As required by GDC 54, these penetrations “shall be designed with a capability to test periodically the operability of the isolation valves and associated apparatus and to determine if valve leakage is within acceptable limits.”

4.1.2.1.4.1. The periodic PCIV testing frequency is dictated by the unit’s Technical Specifications.

4.1.2.1.4.2. Periodic rupture diaphragm testing frequency shall be based on manufacturer recommendations, if the rupture diaphragm is used as a relied upon penetration barrier

4.1.2.1.4.3. However, testing at any time may be required if a valve or rupture diaphragm reliability issue arises.

4.1.2.1.4.4. Therefore, the HCVS flow path can be credited for being closed and remaining closed during all design basis transients and accidents.

4.1.3. Routing Considerations

Order Reference: 1.1.4 – The HCVS controls and indications shall be accessible and functional under a range of plant conditions, including a severe accident environment, extended loss of AC power**,** and inadequate containment cooling.

4.1.3.1. Key issues to be addressed regarding routing considerations are listed in Appendices F & G on source term and dose considerations and Section 4.2 for operator “residence time”.

4.1.4. Multi-Unit Interfaces

System cross-connections or shared Unit vent exhaust flow paths present a potential for steam, hydrogen, and airborne radioactivity leakage to other areas of the plant and to adjacent units at multi-unit sites if the units are equipped with common vent piping. At Fukushima, an explosion occurred in Unit 4, which was in a maintenance outage at the time of the event. Although the facts have not been fully established, a likely cause of the explosion in Unit 4 is that hydrogen leaked from Unit 3 to Unit 4 through a common venting system.

Order Reference: 1.2.3 – The HCVS shall include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site.”

4.1.4.1. HCVS design should provide design features to minimize the cross flow of vented fluids and migration to other areas within the plant or to adjacent units at multi-unit sites.

4.1.4.1.1. A design that is free of physical and control interfaces with other systems eliminates the potential for any cross-flow is one way to satisfy this requirement.

4.1.4.1.2. Examples of acceptable means for minimizing cross flow are the use of valves, “leak-tight” dampers, and check valves.

4.1.4.1.3. Pressurizing with inert gas between system boundary valves could also be used (provided sufficient gas exists to support this during the required sustained operation period).

4.1.4.1.4. Other means are acceptable with a site specific justification based on the component parameters.

4.1.4.1.5. Any HCVS flow path interface should be designed to remain closed or automatically close upon the initiation of the HCVS and remain closed for as long as the HCVS is in operation.

4.1.4.1.5.1. If Operator actions are required for confirming/changing state of interfacing valves, then validation of the action using normal plant validation methods should be included in the HCVS plant procedures.

4.1.4.1.6. The environmental conditions (e.g. pressure, temperature) at the flow path interface locations during venting operations should be evaluated to ensure that the interface will remain sufficiently leak-tight.

4.1.4.1.7. If power is required for the interfacing valves to move to isolation position, it should be from power sources meeting the same standards and qualifications as the vent valves.

4.1.4.1.8. Leak tightness of any such barriers should be periodically verified by testing as described in Section 6 of this document.

4.1.5. Release Point

The HCVS release to outside atmosphere should be at an elevation higher than adjacent plant structures. (Refer to Section 5 for discussion of qualification details)

Order Reference: 1.2.2 – The HCVS shall discharge the effluent to a release point above main plant structures.

4.1.5.1. Release through existing plant meteorological stack(s) is acceptable.

4.1.5.2. If the release from HCVS is through a stack different than the plant meteorological stack, the elevation of the stack should meet the following criteria:

4.1.5.2.1. Be higher than the nearest power block building or structure.

4.1.5.2.2. The release point should be situated away from ventilation system intake and exhaust openings or other openings that may be used as natural circulation ventilation intake flow paths during a BDBEE (e.g., to prevent recirculation of the releases back into the buildings.)

4.1.5.2.3. The release stack or structure exposed to outside should be designed or protected to withstand missiles that could be generated by the external events that screen in for the plant site using the guidance in NEI 12-06 as endorsed by JLD-ISG-12-01 [Ref. 21] (See Section 5 for details).

4.1.6. Leakage Criteria

The HCVS design should address the reduction of Hydrogen Gas flammability in the vent pipe through the use of steam suppression (Reference Appendix H and reference NUREG C/R-2475/NUREG C/R-6524, GE SIL 643 [Ref 17, 18 and 19],) nitrogen inerting or the exclusion of oxygen.

Order Reference: 1.2.3 – The HCVS shall include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site.

Order Reference: 1.2.12 – The HCVS shall be designed to minimize the potential for hydrogen gas migration and ingress into the reactor building or other buildings.

4.1.6.1. Design for Leakage during HCVS Operation:

4.1.6.1.1. HCVS line inerting

4.1.6.1.1.1. The HCVS up to the second containment isolation valve should be either nitrogen inerted or be “steam inerted” such that any hydrogen gases within the containment or vent pipe remain below the hydrogen gas flammability limit (See NUREG/CR-2475).

4.1.6.1.1.2. The HCVS pipe beyond the final isolation valve used to initiate/cease venting should be designed for deflagration/detonation due to potential for oxygen intrusion resulting from steam condensation following HCVS vent closure or have the capability of being purged prior to the vent drawing in oxygen.

4.1.6.1.2. HCVS line oxygen exclusion

4.1.6.1.2.1. The exclusion of oxygen as an acceptable alternative to either inerting with steam or nitrogen or making the piping detonation/deflagration proof. An example of this approach is maintaining the line pressure above atmosphere to the last discharge isolation valve.

4.1.6.1.2.2. The HCVS pipe beyond the isolation valves should be able to tolerate a detonation/deflagration or have a purge system that would either keep oxygen out of the system or reduce hydrogen concentration below flammability limits following vent cycles.

4.1.6.2. Design for Leakage in interfacing piping to HCVS:

The HCVS pipe beyond the interfacing piping isolation valve should meet the provisions of Section 4.1.4.1.

4.1.7. Protection from Flammable Gas Ignition

Protection from flammable gas ignition should utilize principles found in NUREG/CR-2475. Additional information is provided in Appendix H of this document. The evaluation of gas ignition is to document the capability of the HCVS piping to maintain integrity should deflagration or detonations occur. Deformation of the pipe is acceptable given the integrity and continued functional capability of the vent system is shown to be maintained.

Order Reference: 1.2.11 – The HCVS shall be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation.

4.1.7.1. Design for Deflagration/Detonation

Most plants have a UFSAR evaluation of the Offgas flow path for detonation potential that evaluates piping for this issue. This method can be similarly used to evaluate the HCVS design. Methods of designing the HCVS piping/components/ instrumentation against flammable gas detonation/deflagration are discussed in Appendix H. Susceptible portions of the piping should be determined based on where oxygen can be drawn into the piping/interfacing piping.

4.1.7.2. Purge systems to reduce gas concentrations below flammability limits.

Use of a purge system in sections of pipe susceptible to air intrusion from intermittent HCVS operation can also be used to minimize detonation/deflagration potential.

4.1.7.3. Design Systems to Prevent Detonation/Deflagration

Design of the HVCS may include features that prevent air/oxygen backflow into the discharge piping. Use of design features in sections of pipe susceptible to air intrusion from intermittent HCVS operation can also be used to minimize detonation/deflagration potential.

4.1.7.4. Combination of loads

The design of the HCVS may require that it withstand the dynamic loading resulting from hydrogen deflagration/detonation. For design purposes, the HCVS is not required to consider assumed simultaneous loads that would not be present or occur during the venting of hydrogen (e.g. seismic loads).

4.1.8. Combined Drywell/Wetwell Vent pipe Design considerations

4.1.8.1. Depending on the HCVS design, the HCVS may have three distinct portions or flow paths;

4.1.8.1.1. A portion that only supports wetwell venting,

4.1.8.1.2. A portion that only supports drywell venting, and

4.1.8.1.3. A portion that is shared by both.

4.1.8.2. The drywell generally has the most limiting boundary conditions, so the drywell boundary condition parameters described in Sections 2.4.4 are recommended for the shared portions of the HCVS, unless lower values are justified.

4.1.8.3. Examples of reasons for lower temperature values include heat loss through piping and dead-legged piping (for example, WW vent piping when DW vent is being used)

4.1.9. Fault/Failure Evaluations

The table below provides an example of a Failure Evaluation that will be included in the Overall Integrated Plan. The table details the HCVS system interactions with design and operation for potential failures and alternate actions. It should not be construed from inclusion of this table in this guide, that the HCVS should be designed as a single failure proof system due to the low probability of a Severe Accident BDBEE. However, licensees should give consideration for low cost measures to provide enhanced reliability of the vent system.

SAMPLE: Failure Evaluation Table

Functional Failure Mode	Failure Cause	Alternate Action*	Failure with Alternate Action Impact on Containment Venting?
Fail to Vent (Open) on Demand	Valves fail to open/close due to loss of normal AC power	Switch power supply to inverter backed AC power	No
	Valves fail to open/close due to loss of one train of inverter backed AC power	Align power supply to alternate inverter	No
	Valves fail to open/close due to complete loss of DC batteries (long term)	Recharge batteries with FLEX provided generators considering severe accident conditions	No
	Valves fail to open/close due to loss of normal pneumatic air supply	No action needed, valves are provided with accumulator tanks which are sufficient for up to 5 actuations in a 24 hour period	No
	Valves fail to open/close due to loss of alternate pneumatic air supply (long term)	Recharge accumulator tanks with N_2 bottles and/or portable air compressors. Replace bottles as needed.	No
	Valve fails to open/close due to SOV failure	Heroic Action needed	Yes

4.2 Vent Operation and Monitoring

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. This sub-section describes the design considerations relative to the HCVS operation and monitoring.

By nature, some BDBEEs create a need to initially operate the vent manually (either locally or from remote stations) and the design concepts espoused in this document protect that operational capability. Due to the multiple functions provided by the vent path, a single set of passive features (e.g., Rupture Diaphragms) cannot achieve all of the operational functions, therefore operator actions are required. The challenges found in operating the vents at Fukushima have been addressed by this guidance as have the required actions to complete multiple functions (e.g. FLEX heat removal venting, normal plant venting, intermittent venting in severe accidents, post severe accident venting for combustible gas control). Based on this, the design elements proposed by this guidance (as listed below) do not require specific new requirements to minimize operator actions to address the ability to operate vents as required for ELAP and severe accident conditions.

Comment [N15]: Where was "normal plant venting" capability in either EA-12-049 or EA-13-109?

4.2.1 Protection from Inadvertent Actuation

The design of the HCVS should incorporate features, such as control panel key-locked switches, locking systems, rupture diaphragms, or administrative controls to prevent the inadvertent opening of the vent.

a. The system should be designed to preclude inadvertent actuation of the HCVS due to any single active failure.

b. The design should consider general guidelines such as single point vulnerability and spurious operations of any plant installed equipment associated with HCVS.

c. Use of Administrative controls on energizing the HCVS controls can also be a part of the acceptable plan to minimize impact on Current Licensing Basis (CLB) controls.

Order Reference: 1.2.7 - The HCVS shall include means to prevent inadvertent actuation.

4.2.1.1 One or more of the following criteria are acceptable approaches for inadvertent actuation features of the HCVS.

4.2.1.1.1 Rupture diaphragm in the HCVS flow path

4.2.1.1.2 Key lock for HCVS valve switches

4.2.1.1.3 Administrative Controls for energizing HCVS components/controls

4.2.1.1.4 Interface with Technical Specification Components (such as current primary containment isolation valve (PCIV) controls).

4.2.1.2 Meeting design features and the above criteria will show compliance with separation of controls from negative impact on CLB equipment and methods to demonstrate reasonable prevention of inadvertent actuation of the system.

4.2.1.3 Prevention of inadvertent actuation, while important for all plants, is essential for plants relying on containment accident pressure (CAP) to provide adequate net positive suction head to the emergency core cooling system (ECCS) pumps. Plants that rely on CAP should have an evaluation that specifically addresses the design considerations for minimizing inadvertent actuation interaction. This evaluation may include a combination of design features and administrative controls.

4.2.2 Required HCVS Controls Primary Control and Monitoring Location

The preferred location for remote operation and control of the HCVS is from the main control room. However, alternate locations to the control room are also acceptable.

Order Reference: 1.2.4 - The HCVS shall be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location.

Order Reference: 1.2.8 - The HCVS shall include means to monitor the status of the vent system (e.g., valve position indication) from the control panel required by 1.2.4. The monitoring system shall be designed for sustained operation during an extended loss of AC power.

4.2.2.1 The control location should take into consideration the following:

4.2.2.1.1 The ability to open/close the valves multiple times during the event, i.e., sustained operations.

4.2.2.1.1.1 Licensees should determine the number of open/close cycles necessary during the first 24 hours of operation and provide supporting basis consistent with the plant-specific containment venting strategy.

4.2.2.1.1.2 Sustained operational requirements may continue beyond the capacity of the installed HCVS system motive force (air/nitrogen) make-up, power supply changes or both, i.e., beyond the first 24 hours.

4.2.2.1.1.3 Sustained operations provisions should continue until 7 days or a shorter period of time if an alternative method of containment heat removal is put in place by using installed or portable equipment (e.g., a means of shutdown cooling aligned directly to the RPV, drywell or suppression pool.) The alternate method of containment heat removal should not rely on the HCVS (i.e., the HCVS isolation valves should be able to remain closed such that releases and cross unit or system interface leakages are no longer a concern.)

4.2.2.1.1.4 During Sustained Operation, the containment barrier is initially manually controlled by the plant staff/ERO during containment heat removal operations (either by containment venting or alternative measures) to prevent further fuel damage. This manual containment heat removal allows RPV injection by use of RCIC or external water supplies (reduced containment pressure may be required.)

4.2.2.1.1.5 Severe accident venting to remove containment heat should be stopped as soon as possible to fully restore the containment function so that the containment source term barrier is available (i.e., no substantial leakage through containment components.) Thus allowing design barriers to be maintained for potential degrading core conditions.

4.2.2.1.2 The temperature and radiological conditions that operating personnel may encounter both in transit and locally at the controls.

4.2.2.1.2.1 This should include the impacts on initial release of post severe accident source term and impacts of vent piping related heat up in areas with little or no ventilation on the controls/controlling station. Alternatives may be used, such as providing features to facilitate manual operation of valves from remote locations or relocating/reorienting containment vent valves.

4.2.2.1.3 Availability of permanently installed HCVS equipment, including any connections required to supplement the HCVS operation during an ELAP (e.g., electric power, N_2/air) should be consistent with the staff's guidance in JLD-ISG-2012-01 for Order EA-12-049 with consideration of severe accident conditions.

4.2.2.1.4 The controls/control location design should preclude the need for operators to move temporary ladders or operate from atop scaffolding to access the HCVS valves or remote operating locations.

4.2.2.1.5 HCVS valve position indication should be available at the primary controlling location.

4.2.2.1.6 HCVS valve position indicators should be capable of operating under the temperature/radiation conditions existing at the valve locations.

4.2.2.1.7 HCVS valve position indicators and indications should be powered from sources that will be available during the appropriate mission time of the HCVS system. The mission time may vary by component but the cumulative mission time for credited components and instrumentation performing a required installed plant HCVS equipment function should be no less than the first 24 hours post event.

4.2.2.1.8 HCVS system should include indications of effluent temperature. Permanently installed gauges that are at, or nearby, the HCVS control panel is an acceptable method to address this item.

4.2.2.1.9 The HCVS system should include indications for the Containment Pressure and Wetwell level for determination of vent operation. These indications may be either at the primary controlling location (order criteria 1.2.4) for the HCVS or at another location with communication to the HCVS controlling location. Use of existing control room indications is adequate and these instruments do not need to be powered by the HCVS battery system.

4.2.2.1.10 Considerations for alternative approaches for system status instrumentation must provide sufficient information and justification for alternative approaches and be submitted to the NRC for approval.

4.2.2.2 The following criteria are acceptable approaches for HCVS Primary Controls and Monitoring location:

4.2.2.2.1 Requirement for sustained operation of the HCVS

4.2.2.2.2 Requirements for assessment of temperature and radiological condition

4.2.2.2.3 Reasonable protection of required equipment

4.2.2.2.4 Required design criteria for indications

4.2.2.3 Meeting design features and the above criteria will show compliance with Primary Controls and Monitoring location requirements (including instrumentation).

4.2.3 Alternate Remote Operation {Alternate/Local Valve Control Location}

During an ELAP, manual operation/action from alternate control locations may become necessary to operate the HCVS. As demonstrated during the Fukushima event, the valves lost motive force including electric power and pneumatic air supply to the valve operators, and control power to solenoid valves.

a. If direct access and local operation of the valves is not feasible due to temperature or radiological hazards, licensees should include design features to facilitate remote manual operation of the HCVS valves. This could include means such as reach rods, chain links, hand wheels, alternative control locations, and portable equipment to provide motive force as needed (e.g., air/N_2 bottles, diesel powered compressors, and DC batteries).

   Note, throughout this section portable equipment will not be relied upon until 24 hours after event initiation.

Order Reference: 1.2.5 - The HCVS shall, in addition to the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations.

4.2.3.1 The HCVS design should consider the following elements to facilitate remote manual operation:

4.2.3.1.1 An assessment of temperature and radiological conditions that operating personnel may encounter both in transit and locally at the local or alternate control location.

4.2.3.1.1.1 Include radiological conditions associated with post severe accident source terms and impacts of vent piping related heat up in areas with little or no ventilation on the local or alternate control location.

4.2.3.1.1.2 Alternatives such as providing features to facilitate manual operation of valves from remote locations or relocating/reorienting the valves may be used.

4.2.3.1.1.3 Consider that local-manual access to PCIVs for an ELAP event may not be feasible due to high temperature or radiation levels in the Reactor Building since they will be located near a containment penetration.

4.2.3.1.1.4 The connections between the valves and portable equipment should be designed for quick deployment.

4.2.3.1.1.5 If a portable motive force (e.g., air or N_2 bottles, DC power supplies) is used in the design strategy, licensees should provide reasonable protection of that equipment consistent with the staff's guidance in JLD-ISG-2012-01 for Order EA-12-049 considering severe accident conditions.

4.2.3.1.1.6 The Local Controls/Alternate Valve Control Location design should preclude the need for operators to move temporary ladders or operate from atop scaffolding to access the HCVS valves or remote operating locations.

4.2.3.2 The following criteria are acceptable approaches for HCVS Local Controls/Alternate Valve Control Location:

4.2.3.2.1 Supply an alternate method of HCVS valve operation

4.2.3.2.2 Assessment of temperature and radiological conditions

4.2.3.2.3 Reasonable protection of required equipment

4.2.3.2.4 Required design criteria for indications

4.2.3.2.5 Criteria for manual opening of HCVS and Interfacing AOVs

4.2.3.2.6 Criteria for operation of HCVS and Interfacing MOVs

4.2.3.3 Meeting design features and the above criteria will show compliance with local controls/alternate control location requirements (including instrumentation).

4.2.4 Vent Monitoring

Plant operators must be able to readily monitor the radiological conditions that exist during venting operations of the HCVS at all times.

Order Reference: 1.2.9 - The HCVS shall include a means to monitor the effluent discharge for radioactivity that may be released from operation of the HCVS. The monitoring system shall provide indication from the control panel required by 1.2.4 and shall be designed for sustained operation during an extended loss of AC power.

4.2.4.1 The HCVS design should provide a means to allow plant operators to readily determine, or have knowledge of, the following system parameters:

4.2.4.1.1 HCVS vent valves position (open and closed).

4.2.4.1.2 HCVS vent pipe radiation levels. The range of the instrument should be consistent with the dose rates anticipated during severe accident venting. The use of a multi-range instrument that will span the expected dose rates is acceptable.

4.2.4.1.2.1 The effluent discharge radiation monitor is required to provide additional knowledge of HCVS operation not as a required change for Emergency Preparedness off-site dose functions.

4.2.4.1.3 Other important information includes the status of supporting systems, such as availability of electrical power and pneumatic supply pressure.

4.2.4.1.3.1 Monitoring by means of permanently installed gauges or meters that are at, or nearby, the HCVS control panel or in the Control Room with communication to the HCVS control panel is acceptable.

4.2.4.1.4 The HCVS system should include indications for the Containment Pressure and Wetwell level for determination of vent operation. These indications may be either at the local controls/alternate control location for the HCVS systems or at another location with communication to the Primary Controls location or local controls/alternate control location.

4.2.4.1.5 Alternative approaches for system status instrumentation may be considered with appropriate justification provided for alternative approaches.

4.2.4.2 The means to monitor system status should support sustained operations during an ELAP, and be designed to operate under environmental conditions that would be expected following a loss of containment heat removal capability and an ELAP. “Sustained operations” beyond the first 24 hours may include the use of portable equipment to provide an alternate source of motive force to components used to monitor HCVS status.

Note: Additional instrumentation required to comply with Order EA-12-049 as discussed in NEI 12-06 may be useful in support of HCVS operation, but are not required for HCVS functionality.

4.2.4.3 Instrument reliability should be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of HCVS components for the conditions described in Section 2 of this guide.

4.2.4.3.1 Selection of HCVS components should consider ease and simplicity of design so that maintenance and calibration during system operation is not necessary. This design consideration should avoid the need for intrinsically safe instruments.

4.2.4.4 The following criteria are acceptable approaches for HCVS monitoring:

4.2.4.4.1 Requirements to monitor HCVS vent pipe conditions including radiological releases, vent pipe pressure and temperature.

4.2.4.4.2 Sustained operation of HCVS vent pipe condition instrumentation and other required indications during an ELAP condition (limiting analysis).

4.2.4.4.3 Requirements for assessment of radiological, temperature and pressure conditions in the area of HCVS monitoring instruments.

4.2.4.5 Meeting design features and the above criteria will show compliance with HCVS monitoring.

4.2.5 Operational Hazards

Order Reference: 1.1.2 - The HCVS shall be designed to minimize plant operators’ exposure to occupational hazards, such as extreme heat stress, while operating the HCVS system.

Order Reference: 1.1.3 - The HCVS shall also be designed to account for radiological conditions that would impede personnel actions needed for event response.

4.2.5.1 HCVS controls should be located in areas where sustained operation is possible accounting for expected temperatures and radiological conditions in the HCVS vent pipe and attached components without extreme heat stress or radiological over exposure to the operators.

4.2.5.1.1 HCVS operation must be possible without placing the operators in dose fields above those allowed by the ERO guidance to conduct local equipment operation. The use of shielding and other radiological dose control actions may provide acceptable radiation levels for operator access

4.2.5.1.2 HCVS operating locations (Primary/Alternate) must account for the expected lack of ventilation that is encountered during an ELAP event.

4.2.5.1.3 HCVS operating locations should not place the operators in areas above the maximum safe entry points in the applicable plant safety manual/guidance.

4.2.5.1.4 HCVS controls should be located in areas where sustained operation is possible accounting for radiological conditions in the HCVS vent pipe and attached components (instrumentation) within allowed doses per the ERO guidance to the operators for non-heroic actions. These conditions should include estimation of the impact during an ELAP event and following core damage required vent operations.

4.2.5.1.5 The HCVS vent pipe routing and shielding must be considered for other actions required of the plant staff/ERO during the event should venting be required during severe accident conditions. Guidance for the allowable dose fields/dose during required actions with the source term in the HCVS vent pipe would be the limits prescribed in the ERO guidance.

Note: Any deviation from the above can be considered provided justification is submitted.

4.2.5.2 The following criteria are acceptable approaches for HCVS operational hazards at local controls/primary and alternate control locations:

4.2.5.2.1 Temperature conditions at the HCVS proposed operating stations meet plant safety manual/guidance or justification is provided to the Staff.

4.2.5.2.2 Radiological conditions at the HCVS proposed operating stations meets ERO allowable dose guidance or justification is provided.

4.2.5.2.3 Other plant actions required by the plant staff/ERO should account for the expected radiological conditions caused by HCVS vent pipe routing with severe accident source term release through the HCVS vent pipe. The expected limits imposed on the dose/dose field from the ERO guidance should be used for these actions.

4.2.5.3 Meeting design features and the above criteria will show compliance with HCVS operational hazards at Primary Controls and Local/Alternate Valve Control Locations.

4.2.6 Designed to minimize Operator Actions

HCVS system should be designed to maximize the probability of successful operator action to operate vents when required.

Order Reference: 1.1.1 - The HCVS shall be designed to minimize the reliance on operator actions.

4.2.6.1 Design features consistent with this approach include:

- 4.2.6.1.1 Environmental considerations
  - 4.2.6.1.1.1 Heat stress impact on ability to vent
  - 4.2.6.1.1.2 Radiological condition impact on ability to vent
- 4.2.6.1.2 Sustained operational capability
  - 4.2.6.1.2.1 Independent 24 hour electrical and pneumatic supplies.
  - 4.2.6.1.2.2 The system will be capable of multiple valve cycles during the first 24 hour period without the need to recharge pneumatic or electrical power supplies.
- 4.2.6.1.3 Ease of vent valve operation
  - 4.2.6.1.3.1 Readily accessible under all operational conditions (e.g., accessible location without need for ladders or scaffolds)
  - 4.2.6.1.3.2 Operation achievable at a localized location.
  - 4.2.6.1.3.3 Operation does not require the use of jumpers or lifted leads to defeat valve interlocks.
  - 4.2.6.1.3.4 System comprised of installed equipment. No need for system or component disassembly/reassembly.

4.2.6.2 The following criteria are acceptable approaches for HCVS minimize operator actions that could prevent vent operations when required:

- 4.2.6.2.1 Compliance with other sections of this guidance as listed above.

4.2.6.3 Meeting design features and the above criteria will show compliance with HCVS to minimize operator actions that could prevent vent operations when required.

5. PROGRAMMATIC CONTROLS

5.1. Environmental Conditions

The HVCS is required to be capable of functioning during severe accidents in which the containment function is not compromised by the severe accident conditions. The HCVS equipment is designed to provide reasonable assurance of operation in the severe accident environment for which it is intended to function and over the time span for which it is needed. However, the environmental requirements of 10CFR50.49 are design basis regulatory requirements and as such are not applicable under severe accident conditions.

Order Reference: 1.2.10 – The HCVS shall be designed consistent with containment pressures and temperatures during severe accident conditions as well as dynamic loading resulting from system actuation. The design is not required to exceed the current capability of the limiting containment components.

5.1.1. The resultant design conditions for the HCVS equipment to provide reasonable protection to assure functionality may be different for the wetwell vent and/or the drywell vent, thus the following environmental conditions should be considered in the design of the system:

5.1.1.1. The limiting wetwell conditions are assumed to be 350°F and 80 psig based on the saturation temperature at the drywell failure pressure.

5.1.1.2. The drywell conditions are assumed to be 545°F and 80 psig corresponding to the temperature and pressure at which the drywell head may exhibit some leakage. Although some range of temperatures above this may be encountered due to stratification in areas of the drywell, the HCVS equipment should be designed using a temperature of 545°F consistent with the boundary conditions as detailed in Section 2 of this document.

5.1.1.3. Drywell radiological conditions should be consistent with the conditions assumed in the plant's current licensing basis (CLB) for a major accident. (i.e., the most severe design basis accident during or following which the equipment is required to remain functional, including the radiation resulting from recirculating fluids for equipment located near the recirculating lines and including dose-rate effects.)

5.1.1.3.1. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products (e.g., Technical Information Document (TID) 14844, "Calculation of Distance Factors for Power and Test Reactor Sites (March 1962)," or NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants" consistent with the current design basis of the plant.) Refer to Appendix G for further details.

5.1.1.3.2. The evaluation of HCVS functionality should consider the potential conditions resulting from accidental events, whether postulated, hypothesized or otherwise identified, which do not exceed the conditions resulting from any credible accident as identified in the plant's CLB.

5.1.1.4. If the drywell vent and wetwell vent are interconnected, interaction between the two vent flow paths should be considered although only one flow path is required to be operated at any one time.

5.1.1.5. Environmental effects of the areas traversed by the system should be considered in both standby and operating conditions.

5.1.1.6. Tornado and wind loading and missile impacts are required to be considered for portions of the HCVS.

5.1.1.6.1. Current design of the structure is acceptable regarding wind and missile protection for portions of the HCVS enclosed within a seismic category 1 (or equivalent) building/enclosure or through the plants existing elevated release point (e.g., meteorological stack)

5.1.1.6.2. Reasonable protection evaluations per the guidance in NEI 12-06 as endorsed by JLD-ISG-12-001 for Order EA-12-049 should be performed for portions of the HCVS not covered in 5.1.1.6.1 above.

5.1.1.7. The system should be designed to provide reasonable assurance of operation for up to 7 days consistent with the sustained operation definition.

5.2. Seismic and External Hazard Conditions

Order Reference: 2.1 – The HCVS vent path up to and including the second containment isolation barrier shall be designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components.

Order Reference: 2.2 – All other HCVS components shall be designed for reliable and rugged performance that is capable of ensuring HCVS functionality following a seismic event. These items include electrical power supply, valve actuator pneumatic supply and instrumentation (local and remote) components.

5.2.1. HCVS components including instrumentation should be designed, as a minimum, to meet the seismic design requirements of the plant.

5.2.2. Components including instrumentation that are not required to be seismically designed by the design basis of the plant should be designed for reliable and rugged performance that is capable of ensuring HCVS functionality following a seismic event. (reference ISG-JLD-2012-01 and ISG-JLD-2012-03 [Ref. 22] for seismic details.)

5.2.3. The components including instrumentation external to a seismic category 1 (or equivalent building or enclosure should be designed to meet the external hazards that screen in for the plant as defined in guidance NEI 12-06 as endorsed by JLD-ISG-12-01 for Order EA-12-049.

5.3. Quality Requirements

Order Reference: 2.1 – The HCVS vent path up to and including the second containment isolation barrier shall be designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components.

Order Reference: 2.2 – All other HCVS components shall be designed for reliable and rugged performance that is capable of ensuring HCVS functionality following a seismic event. These items include electrical power supply, valve actuator pneumatic supply and instrumentation (local and remote) components.

5.3.1. HCVS components including instrumentation should, as minimum, meet the quality design requirements of the plant, ensuring HCVS functionality.

5.3.1.1. The HCVS up to and including the second isolation valve is designed to the same quality requirements of the connected system.

5.3.1.2. HCVS elements that are not covered by 5.3.1.1 should be reliable and rugged to ensure HCVS functionality following a seismic event

5.3.1.3. Additionally, non-safety equipment installed to meet the requirements of Order EA-13-109 must be implemented so that they do not degrade the existing safety-related systems

5.3.1.4. Design quality requirements and supporting analysis documentation should be auditable, consistent with generally accepted engineering principles and practices, and controlled within the configuration document control system

5.4. Maintenance Requirements

Order Reference: 1.2.13 – The HCVS shall include features and provision for the operation, testing, inspection and maintenance adequate to ensure that reliable function and capability are maintained.

5.4.1. HCVS equipment should be initially tested or other reasonable means used to verify performance conforms to the design and operational requirements.

5.4.2. Validation of source manufacturer quality is not required.

5.4.3. The HCVS maintenance program should ensure that the HCVS equipment reliability is being achieved in a manner similar to that required for FLEX equipment. Standard industry templates (e.g., EPRI) and associated bases may be developed to define specific maintenance and testing.

5.4.3.1. Periodic testing and frequency should be determined based on equipment type and expected use (further details are provided in Section 6 of this document).

5.4.3.2. Testing should be done to verify design requirements and/or basis. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.

5.4.3.3. Preventive maintenance should be determined based on equipment type and expected use. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.

5.4.3.4. Existing work control processes may be used to control maintenance and testing.

5.4.4. HCVS permanent installed equipment should be maintained in a manner that is consistent with assuring that it performs its function when required.

5.4.4.1. HCVS permanently installed equipment should be subject to maintenance and testing guidance provided to verify proper function.

5.4.5. HCVS non-installed equipment should be stored and maintained in a manner that is consistent with assuring that it does not degrade over long periods of storage and that it is accessible for periodic maintenance and testing.

6. OPERATIONAL CONSIDERATIONS

6.1. Operator Actions

During the extended loss of AC power condition at the Fukushima Dai-ichi units, operators faced many challenges while attempting to restore adequate core cooling in addition to complications associated with controlling containment pressure via the containment venting system. The difficulties faced by the operators related to operation of the containment venting system included the location of their vent valves, ambient temperatures and radiological conditions, loss of all alternating current electrical power, loss of motive force to open the vent valves, and exhausting DC battery power. The use of a hardened containment vent provides an important method of containment heat removal which can become necessary for an ELAP/loss of Ultimate Heat Sink (UHS) event. Indirectly, an elevated containment pressure may prevent the injection from a low head water supply to the RPV. Operator actions are a vital part of normal and off-normal plant activities and are expected to play an important role in mitigation of beyond design basis external events. It is fully recognized that operator actions will be needed to implement the EA-13-109 severe accident capable HCVS; however, the licensees should consider design features for the system that will minimize the need and reliance on operator actions to the extent possible during a variety of plant conditions, as further discussed in this guidance. Actions should be simple and easily accomplished with direct feedback to indicate when the action is successfully accomplished.

The HCVS should be designed to be operated from a control panel located in the main control room or a remote but readily accessible location. The HCVS should be designed to be fully functional and self-sufficient with permanently installed equipment in the plant, without the need for portable equipment or connecting thereto, until such time that on-site or off-site personnel and portable equipment become available. At least one method of operation of the HCVS should be capable of operating with permanently installed equipment for at least 24 hours during the extended loss of AC power. The system should be designed to function in this mode with permanently installed equipment providing electrical power (e.g., DC power batteries or electrical or pneumatic operation) valve motive force (e.g., N_2/air cylinders). The HCVS operation in this mode depends on a variety of conditions, such as the cause for the extended loss of AC power (e.g., seismic event, flood, tornado, high winds), severity of the event, and time required for additional help to reach the plant, move portable equipment into place, and make connections to the HCVS. The system should be designed to function in this mode for a minimum duration of 24 hours with no operator actions required or credited to replenish electrical power and pneumatic supplies. Operator action is expected to perform system alignment and monitoring functions from either the primary (1.2.4) or alternate (1.2.5) locations as needed for event mitigation. To ensure continued operation of the HCVS beyond 24 hours, licensees may credit manual actions, such as moving portable equipment to supplement electrical power and valve motive power sources.

For the period of sustained operation beyond the initial 24 hours after event initiation, the licensee should consider the number and complexity of actions and the cumulative demand on personnel resources that are needed to maintain hardened vent functionality as a result of design limitations. The use of supplemental portable power or pneumatic sources may be acceptable if the supplemental power or pneumatic source is readily available, could be quickly and easily moved into place, and installed through the use of pre-engineered quick disconnects, and the necessary human actions were identified along with the time needed to complete those actions. Conversely, supplemental power sources that require a qualified electrician or mechanic to temporarily wire into the panel or connect to a piping system would not be considered acceptable because its installation requires a series of complex, time-consuming actions in order to achieve a successful outcome.

6.1.1. Feasibility and Accessibility

During an extended loss of AC power, the drywell, wetwell (torus or suppression pool), and nearby areas in the plant where HCVS components including instrumentation are expected to be located will likely experience elevated temperatures due to inadequate containment cooling combined with loss of normal and emergency building ventilation systems. In addition, installed normal and emergency lighting in the plant may not be available. Licensees should take into consideration plant conditions expected to be experienced during applicable beyond design basis external events when locating valves, instrument air supplies, and other components including instrumentation that will be required to safely operate the HCVS system. Components required for manual operation should be placed in areas that are readily accessible to plant operators, and not require additional actions, such as the installation of ladders or temporary scaffolding, to operate the system.

6.1.1.1. The design strategy should evaluate potential plant conditions and use acquired knowledge of these areas to provide input to system operating procedures, training, the choice of protective clothing, required tools and equipment, and portable lighting. The evaluation should include considerations such as, how temperatures would elevate due to extended loss of AC power conditions and the lighting that would be available following beyond design basis external events. Use of handheld or portable lighting is acceptable.

6.1.1.2. The design of the HCVS should account for radiological conditions resulting from the beyond design basis external event including dominant severe accident impacts. During the Fukushima event, personnel actions to manually operate the containment vent valves were impeded due to the location of the valves in the torus (suppression pool) rooms. The HCVS should be designed to be placed in operation by operator actions at a control panel, located in the main control room or in a suitable alternate location (Requirements 1.2.4 and 1.2.5). The design of the severe accident capable HCVS system will take into account the radiological conditions that may be encountered during system operation. The use of shielding and locating components having significant source term away from system control stations where the system will be operated are the primary means available to control operational dose. Additional means of minimizing potential radiological dose to the operators may include, but are not limited to:

6.1.1.2.1. Simplification of operator actions needed to initiate, control and isolate the system including replenishment of electrical power and pneumatics during the sustained operational period.

6.1.1.2.2. Use of rupture diaphragms are an acceptable component to address inadvertent actuation and leakage, but require operator action to initiate venting at lower pressures than the rupture diaphragm setting. Thus the ability to open the vent path by reasonable operator actions must be addressed if rupture diaphragms are installed in the HCVS.

6.1.1.2.3. Minimizing the time operators need to spend at the vent controls or monitoring locations during system operation under severe accident conditions.

6.1.1.2.4. Minimizing the number of operators needed to operate and maintain the system functional under severe accident conditions.

6.1.1.2.5. Developing a strategy to rotate operators through the various venting actions to minimize the dose received by any one operator.

6.1.1.3. In response to Generic Letter (GL) 89-16, a number of facilities with Mark I containments installed vent valves in the torus (suppression pool) room, near the drywell, or both. Licensees may continue to use these venting locations or select new locations, provided that the requirements of this guidance document are satisfied.

6.1.1.4. The HCVS improves the chances of mitigating a core damage accident by removing heat from containment and lowering containment pressure. Radiological and thermal impacts to the plant from the HCVS within the plant and at the location of the external release could impact the event response from on-site operators and off-site help arriving at the plant. An adequate strategy to minimize radiological consequences that could impede personnel actions should include the following:

6.1.1.4.1. Provide permanent radiation shielding where necessary to facilitate personnel access to valve controls that allow manual operation of the valves at a remote manual location. Other alternatives to facilitate personnel access besides radiation shielding can be utilized, such as:

6.1.1.4.1.1. Provide features to facilitate manual operation of valves from remote locations, as discussed further in this guidance.

6.1.1.4.1.2. Locate the vent valves in areas that are significantly less challenging to operator access/actions.

6.1.1.5. In accordance with Requirement 1.2.10 and 1.2.11, the HCVS should be designed for pressures that are consistent with the higher of the primary containment design pressure and the primary containment pressure limit (PCPL), for specification purposes, as well as including dynamic loading resulting from system actuation and hydrogen deflagration or detonation if the gases passing through the system cannot be maintained below flammability limits. The capacity for venting should be based on the lower pressure value because the flow characteristics are more limiting at the lower pressure. In addition, the system should minimize leakage. As such, ventilation duct work (i.e., sheet metal) should not be utilized in the design of the HCVS. Licensees should perform appropriate testing, such as hydrostatic or pneumatic testing, to establish the leak-tightness of the HCVS. System actuation should consider the dynamics of the driving force for the venting such as the pressure fluctuations from SRV actuations, etc.

6.1.1.6. The HCVS release to outside atmosphere should be at an elevation higher than adjacent power block plant structures. Release through existing plant metrological stacks is considered acceptable, provided the guidance under

Requirements 1.2.3 and 1.2.11 are satisfied. If the release from HCVS is through a vent stack different than the plant metrological stack, the elevation of the stack should be higher than the nearest power block building or structure. The routing should be such that radiological conditions resulting from operation of the HCVS would allow event response by the on-site operators and off-site help arriving at the plant without requiring heroic actions.

6.1.1.7. The required Operator actions to operate the HCVS under the design conditions required by Order items 1.1.2 and 1.1.3 at the plant specified operating locations need to be evaluated.

6.1.1.7.1. The operations should be feasible for the control locations for conducting the operations under the beyond design basis external event conditions. These expected conditions can be obtained from available generic or plant-specific accident analysis.

6.1.1.7.2. The timing of the operations should be taken into consideration (e.g., operation of the equipment during the worst source term release is not required if the station could be accessed prior to the release and after the release for control of radiological dose) for this accessibility/feasibility evaluation.

6.1.1.7.3. Guidance is supplied in Appendix D, F**,E**, E and G of this guide for this evaluation. Elements of the evaluations can utilize NUREG 1921/1852 [Ref. 23 and 24] guidance and/or procedural controls.

6.1.1.8. Environmental conditions and effects on operators need to be considered during event response and sustained operation timelines.

6.1.2. Procedural Guidance

6.1.2.1. Procedures to operate, test, and maintain the severe accident capable HCVS during ELAP conditions should include the following elements:

6.1.2.1.1. HCVS operation including system startup, shutdown and off-normal conditions.

6.1.2.1.2. HCVS standby status verification.

6.1.2.1.3. System out of service controls.

6.1.2.1.4. Location of system components and equipment lineups (may be part of other plant system procedures).

6.1.2.1.5. HCVS instrumentation available that supports HCVS operation.

6.1.2.1.6. Directions for sustained operation using portable equipment and supplies, which supports HCVS operation.

6.1.2.1.7. Storage location of portable equipment.

6.1.2.1.8. Equipment testing and maintenance.

6.1.2.1.9. CAP is credited by some (typically earlier) plants to meet RG 1.1 in a LOCA. Specifically CAP in a LOCA is credited to ensure that the ECCS pumps have adequate NPSH. LOCA is a DBE. If applicable, the nexus between containment accident pressure (CAP) and the ECCS and containment heat removal pump net positive suction head during a design basis LOCA (DBLOCA) and how an inadvertent opening of the vent valve could have an adverse impact on the operation of those pumps. For an ELAP event a LOCA is not considered and ECCS pumps are not available. The HCVS design should ensure that inadvertent opening of the vent path in a DBE is not credible. The procedures should also address the precautions that should be taken to assure adequate net positive suction head before restarting those pumps upon restoration of onsite or offsite power during an ELAP event.

6.1.2.2. HCVS procedures should be developed and implemented in the same manner as other plant procedures.

6.1.2.3. HCVS procedures for operation need to be validated for operator usability/accessibility and should address the following functional operations:

6.1.2.3.1. With power on normal power sources. [no ELAP]

6.1.2.3.2. With backup power and from local manual location/alternate remote location during conditions of ELAP/loss of UHS with no core damage for containment heat removal AND containment pressure control (PCPL). [FLEX]

6.1.2.3.3. With backup power and from local manual location/alternate remote location during conditions of ELAP/loss of UHS with core damage and vessel breach for containment heat removal AND containment pressure control (PCPL). [Severe Accident Capable Vent]

6.1.2.4. Coordination with guidance and procedures

The Licensee should verify that the procedures for HCVS operation are coordinated with other procedures. The following relationships should be evaluated to address this coordination:

6.1.2.4.1. Coordinate EOPs and SAGs with hardened containment vent operation on normal power sources (no ELAP)

6.1.2.4.2. Coordinate Abnormal Operating Procedures (AOPs), EOPs, SAGs and FLEX Support Guidelines (FSGs) with hardened containment vent operation on normal and backup power and from primary and alternate locations during conditions of ELAP/loss of UHS with no core damage. System use is for containment heat removal AND containment pressure control

6.1.2.4.3. Coordinate SAGs with HCVS operation on normal and backup power and from primary and alternate locations during conditions of ELAP/loss of UHS with core damage and vessel breach. System use is for containment heat removal AND containment pressure control (PCPL) with potential for combustible gases.

6.1.2.4.4. Coordinate administrative controls for FLEX and HCVS equipment allowed outage times and compensatory actions.

6.1.2.5. Demonstration with other Post Fukushima measures

The Licensee should demonstrate use in drills, tabletops, or exercises for HCVS operation as follows:

6.1.2.5.1. Hardened containment vent operation on normal power sources (no ELAP).

6.1.2.5.2. During FLEX demonstrations (as required by EA-12-049: Hardened containment vent operation on backup power and from primary or alternate location during conditions of ELAP/loss of UHS with no core damage. System use is for containment heat removal AND containment pressure control.

6.1.2.5.3. HCVS operation on backup power and from primary or alternate location during conditions of ELAP/loss of UHS with core damage. System use is for containment heat removal AND containment pressure control with potential for combustible gases (Demonstration may be in conjunction with SAG change).

6.1.3. Training

6.1.3.1. All personnel expected to operate the HVCS should receive initial and continuing training in the use of plant procedures developed for system operations when either normal or backup power is available and during ELAP/loss of UHS conditions consistent with the specific elements of the plant's training program.

6.1.3.2. The training should be refreshed on a periodic basis consistent with the procedure control process at the plant site or when procedural related changes occur to the HCVS.

6.1.3.3. Training should also ensure that specific guidance and procedures that direct HCVS Operation is referenced and used in formulation of the training (e.g., EOPs, FSGs, SAGs,).

6.1.3.4. When determining the required HCVS training a "task analysis" or similar site acceptable process should be used.

6.1.3.5. Training for use of any FLEX equipment in a support role will be governed by the actions developed for compliance with order EA-12-049.

6.1.3.5.1. The use of a Systematic Approach to Training (SAT) based training program to determine required training and frequency may be used to demonstrate compliance with the training requirements of Order EA-13-109 in lieu of the specific elements defined in 6.1.3.1 through 6.1.3.4.

6.2. Testing and Inspection of HCVS.

6.2.1. The HCVS design should provide a means (e.g., drain valves, pressure and temperature gauge connections) to periodically test system components including instrumentation, including exercising (opening and closing) the vent valve(s).

6.2.2. Primary and secondary containment required leakage testing is covered under existing design basis testing programs.

6.2.3. The HCVS outboard of the containment boundary should be tested to ensure that vent flow is released to the outside with minimal leakage, if any, through the interfacing boundaries with other systems or units.

6.2.3.1. The testing method can either individually leak test interfacing valves or test the overall leakage of the HCVS volume by conventional leak rate testing methods.

6.2.3.2. The test volume should envelope the HCVS between the outer primary containment isolation barrier and the last isolation point from the plant buildings, including the volume up to the interfacing valves.

6.2.3.3. The test pressure should be based on the HCVS design pressure. Methods for testing system boundary leakage should be consistent with the licensee's design basis for these tests (e.g., permissible leakage rates for the interfacing valves should be within the requirements of American Society of Mechanical Engineers Operation and Maintenance of Nuclear Power Plants Code (ASME OM) – 2009, Subsection ISTC – 3630 (e) (2) [Ref. 25], or later edition of the ASME OM Code.)

6.2.3.4. When testing the HCVS volume, allowed leakage should not exceed the sum of the interfacing valve leakages as determined by the licensee's test program (e.g., ASME OM Code).

6.2.3.5. For HCVS designs that contain interfacing valves between the HCVS and an isolated system, i.e. systems that do not vent to atmosphere. An assessment of the impact of cumulative leakage past interfacing valves into an isolated system should be performed. The results of the assessment should be used in establishing the leakage limits for interfacing valves between the HCVS and the isolated system(s).

6.2.3.5.1 When interfacing components including instrumentation are found to be degraded such that the HCVS function cannot be assured, then an entry into the plants Corrective Action Program shall be made to address the cause(s) of the non-functionality of the HCVS and prevent recurrence.

6.2.4. Licensees should implement the following operation, testing and inspection requirements for the HCVS to ensure reliable operation of the system.

Testing and Inspection Requirements

Description	Frequency
Cycle the HCVS valves and the interfacing system valves not used to maintain containment integrity during operations.	Once per operating cycle
Perform visual inspections and a walkdown of HCVS components.	Once per operating cycle
Test and calibrate the HCVS radiation monitors.	Once per operating cycle
Leak test the HCVS.	(1) Prior to first declaring the system functional; (2) Once every three operating cycles thereafter; and, (3) After restoration of any breach of system boundary within buildings.
Validate the HCVS operating procedures by conducting an open/close test of the HCVS control logic from its control panel and ensuring that all interfacing system valves move to their proper (intended) positions.	Once per every other operating cycle

6.3. Allowed out of service time for HCVS

6.3.1. The unavailability of equipment and applicable connection that directly performs an HCVS function should be managed such that HCVS functionality is maximized. The primary control and monitoring elements (1.2.4) and alternate valve control elements (1.2.5) of HCVS operation will normally be functional in Modes 1, 2 and 3. However the HCVS is not a single failure proof system, and as such the primary and alternate methods of HCVS operation do not imply system redundancy.

6.3.1.1. If the primary control and monitoring elements or alternate valve control elements of HCVS render operation of the HCVS non-functional, those elements may be out of service for periods of up to 90 consecutive days without any compensatory actions.

6.3.1.2. If the primary control and monitoring elements and alternate valve control elements of HCVS render operation of the HCVS non-functional, those elements may be out of service for periods of up to 30 consecutive days without any compensatory actions.

6.3.1.3. If the allowed out of service times described in 6.3.1.1 and/or 6.3.1.2 above are exceeded, then through the plant corrective action program determine:

6.3.1.3.1. The cause(s) of the non-functionality, 6.3.1.3.2. The actions to be taken and the schedule for restoring the system to functional status and prevent recurrence, and

6.3.1.3.3. Initiate action to implement appropriate compensatory actions.

6.3.2. The HCVS system is functional when piping, valves, instrumentation and controls including motive force necessary to support system operation are available. Since the system is designed to allow a primary control and monitoring or alternate valve control by Order criteria 1.2.4 or 1.2.5, allowing for a longer out of service time with either of the functional capabilities maintained is justified. A shorter length of time when both primary control and monitoring and alternate valve control are unavailable is needed to restore system functionality in a timely manner while at the same time allowing for component repair or replacement in a time frame consistent with most high priority maintenance scheduling and repair programs, not to exceed 30 days unless compensatory actions are established per 6.3.1.2.

6.3.3. The system functionality basis is for coping with beyond design basis events and therefore plant shutdown to address non-functional conditions is not warranted. However, such conditions should be addressed by the corrective action program and compensatory actions to address the non-functional condition should be established. These compensatory actions may include alternative containment venting strategies or other strategies needed to reduce the likelihood of loss of fission product cladding integrity during design basis and beyond design basis events even though the severe accident capability of the vent system is degraded or non-functional. Compensatory actions may include actions to reduce the likelihood of needing the vent but may not provide redundant vent capability.

6.3.4. Applicability for allowed out of service time for HCVS for system functional requirements is limited to startup, power operation and hot shutdown conditions when primary containment is required to be operable and containment integrity may be challenged by decay heat generation.

7. REPORTING REQUIREMENTS

Licensees shall promptly start implementation of the requirements in Attachment 2 to Order EA-13-109, *Order Modifying Licenses with regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions*, upon NRC issuance of the associated final interim staff guidance (ISG) for each Phase (reference section IV.B of Order EA-13-109). In accordance with NRC Order EA-13-109 the following reporting requirements are established.

7.1. Submittal Guidance

7.1.1. All Licensees shall notify the Commission if they are unable to comply with any of the Phase 1 requirements or if any of the Phase 1 (wetwell vent) requirements would adversely affect the safe and secure operation of the facility within twenty (20) days of the issuance date of the final ISG for Phase 1, The notification shall provide the Licensee's justification for seeking relief from or variation of any specific requirement. Reference EA-13-109 C.1 & 2.

7.1.2. All Licensees shall notify the Commission if they are unable to comply with any of the Phase 2 requirements or if any of the Phase 2 (drywell vent) requirements would adversely affect the safe and secure operation of the facility within twenty (20) days of the issuance date of the final ISG for Phase 2, The notification shall provide the Licensee's justification for seeking relief from or variation of any specific requirement. Reference EA-13-109 C.3 & 4.

7.1.3. All Licensees shall, by June 30, 2014, submit to the Commission for review an Overall Integrated Plan (OIP) including a description of how compliance with the Phase 1 (wetwell vent) requirements will be achieved. Reference EA-13-109 D.1.

7.1.4. All Licensees shall, by December 31, 2015, submit to the Commission for review an updated OIP including a description of how compliance with the Phase 2 (drywell vent) requirements will be achieved. Reference EA-13-109 D.2.

7.1.5. All Licensees shall provide status reports at six (6)-month intervals following submittal of the Phase 1 (wetwell vent) OIP which delineates progress made in implementing the requirements of Order EA-13-109. Reference EA-13-109 D.3.

7.1.5.1. The issuance of the revision to the OIP which includes Phase 2 scope from 7.1.4 can substitute for the six (6)-month status report due on December 31, 2015.

7.1.5.2. The six (6)-month status reports beginning in 2016 shall include both Phase 1 and 2 scope.

7.1.5.3. Once Phase 1 scope is complete the six (6)-month status reports will only update Phase 2 items and leave the Phase

1 items as historical until compliance with both Phase 1 and 2 scope is complete.

7.1.6. All Licensees shall report to the Commission when full compliance with the requirements for Phase 1 and Phase 2 are achieved. Reference EA-13-109 D.4.

7.2. Overall Integrated Plan Template

The Overall Integrated Plan should include a complete description of the HCVS strategies, including important operational characteristics. The level of detail generally considered adequate is consistent to the level of detail contained in the Licensee's Final Safety Analysis Report (FSAR).

7.2.1. The OIP should provide the following information:

7.2.1.1. Extent to which this guidance, NEI 13-02, is being followed including a description of any alternatives to the guidance

7.2.1.2. A milestone schedule of planned actions

7.2.1.3. Description of the strategies and guidance to be developed to meet the requirements contained in Attachment 2 of the Order

7.2.1.4. Operational characteristics contained in this document, NEI 13-02 are being met.

7.2.1.5. Description of how the design features contained in section 4 of this guide are being met for the appropriate phase

7.2.1.6. Description of major installed and portable components used in the strategies, the applicable reasonable protection for the portable equipment, and the applicable maintenance requirements for the HCVS equipment.

7.2.1.7. Description of major system components including instrumentation, including applicable quality requirements

7.2.1.8. Description of the steps for the development of the necessary procedures, guidance, and training for the HCVS strategies including modifications to meet the requirements contained in this document, NEI 13-02.

7.2.1.9. Conceptual sketches, as necessary to indicate equipment which is installed or equipment hookups necessary for the strategies.

7.2.1.9.1. A preliminary or draft piping and instrumentation diagram (P&ID) or a similar diagram that shows system components including instrumentation and interfaces with plant systems and structures is acceptable piping and instrumentation diagrams should be included in the OIP, while as-built

P&IDs will be available upon completion of plant modifications

7.2.1.9.2. A preliminary or draft electrical/air motive force functional connection sketch should be included in the OIP.

7.2.1.10. Description of how the portable HCVS equipment will be available to be operable during BDBEE and Severe Accident events as defined in this document, NEI 13-02.

7.2.2. Phase 1, wetwell vent OIP shall be submitted by June 30, 2014 that should include a description of how compliance with the “Phase 1” requirements described in Attachment 2 of the Order will be achieved within the required schedule.

7.2.2.1. The Phase 1 OIP should include the items delineated in section 7.1.1 as well as the following items:

7.2.2.1.1. A description of how the design objectives contained in section 2 of this guide, NEI 13-02 are met

7.2.2.1.2. When applicable to a specific Licensee, include details on how this issue will be addressed for all situations when CAP credit is required

7.2.2.2. An industry template will be provided that defines the essential information for this submittal.

7.2.3. By December 31, 2015, a revision of the Phase 1 OIP including a description of the approach to the Phase 2 requirements described in Attachment 2 of the Order will be achieved within the required schedule shall be submitted.

7.2.3.1. The Phase 2 OIP revision should address the items delineated in section 7.1.1 as it relates to Phase 2 as well as the following items:

7.2.3.1.1. A description of how the design objectives contained in section 3 of this guide, NEI 13-02 are met

7.2.3.1.2. When applicable to a specific Licensee, include details on how this issue will be addressed for all situations when CAP credit is required

7.2.3.2. A justification for meeting Phase 2 via conditions allowed in Phase 2 B.2 option from the Order and delineated in Appendix C of this guide can replace the criteria from 7.2.3.1 above

7.2.3.3. An industry template will be provided that defines the essential information for this submittal (revision).

7.3. Six (6)-Month Updates

7.3.1. The 6-month status submittal should delineate progress made in implementing the requirements of the Order and include the following information

7.3.1.1. An update of the milestone schedule from the OIP

7.3.1.2. A brief summary of the milestones from the OIP completed in the preceding six-month period

7.3.1.3. Changes to the compliance method as stated in the OIP or OIP revision

7.3.1.3.1. Revisions to the OIP detailed implementation details that follow the criteria of NEI 13-02 and comply with the Order requirements need not be submitted to the NRC, but should be documented for inspection after compliance is obtained.

7.3.1.4. Changes to the compliance schedule as required by the Order or revised in other NRC communication on this topic

7.3.1.5. Provide update of any open items from the OIP, RAIs or Draft SER.

7.3.2. The 6-month status submittal should not be a revised OIP except for the December 31, 2015 update which could be replaced with the Phase 2 OIP revision submittal.

7.3.3. An industry template will be provided that defines the essential information for the 6-month status submittal.

8. REFERENCES

1. USNRC, Order EA-13-109, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions,” June 6, 2013 (ADAMS Accession No. ML13143A321).
2. USNRC, Order EA-12-050, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents,” March 9, 2012 (ADAMS Accession No. ML12054A694).
3. USNRC, SRM SECY-12-0157, “Staff Requirements - SECY-12-0157, ”Consideration Of Additional Requirements For Containment Venting Systems For Boiling Water Reactors With Mark I And Mark II Containments”, March 19, 2013 (ADAMS Accession No. ML13078A017).
4. USNRC, Order EA-12-049, “Order Modifying Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events,” March 12, 2012 (ADAMS Accession No. ML12054A735).
5. USNRC, JLD-ISG-2012-02, Revision 0, “Compliance with Order EA-12-050, Reliable Hardened Containment Vents”, Interim Staff Guidance, September 29, 2012 (ADAMS Accession No. ML 12229A475).
6. USNRC – SECY-11-0093, “Near Term Task Force 90 Day Report”, (ADAMS Accession No. ML111861807).
7. USNRC – SRM SECY-11-0124, “Recommended Actions to be taken Without Delay From The Near-Term Task Force Report”, (ADAMS Accession No. ML112911571).
8. USNRC – SRM SECY-11-0137, “Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned”, (ADAMS Accession No. ML113490055).
9. NUREG-1935, State-of-the-Art-Reactor Consequence Analysis (SOARCA) Report (ADAMS Accession No. ML12332A057/ML12332A058)
10. "Mark I Containment Severe Accident Analysis." Prepared for the Mark I Owners Group, Chicago, IL: Chicago Bridge & Iron, NA-CON, April 1987
11. NUREG/CR-2442 U.S. Nuclear Regulatory Commission, Division of Technical Information & Document Control, “Reliability Analysis of Steel Containment Strength”, Grieman, L.G. et al., June 1982.
12. NUREG/CR-5334, “Severe Accident Testing of Electrical Penetration Assemblies”, Clauss, D.B., November 1989
13. NUREG/CR-3234; SAND83-0538, “The Potential for Containment Leak Paths Through Electrical Penetration Assemblies Under Severe Accident Conditions”, Wayne Sebrell, dated July 1983.
14. NUREG/CR-4064, "Structural Response of Large Penetrations and Closures for Containment Vessels Subjected to Loadings Beyond Design Basis," R.F. Kulak et al., February, 1985

15. NUREG/CR-4944, “Containment Penetration Elastomer Seal Leak Rate Tests”, Bridges T.L., July 1987.
16. DE-ACO4-76DP00789, "Performance of Seals and Gaskets Under Severe Accident Conditions," Koenig L., Sandia National Laboratory, pp. 174-180.
17. NUREG/CR-2475, Hydrogen Combustion Characteristics Related to Reactor Accidents (ADAMS Ascension No. ML071700446)
18. NUREG/CR-6524, The Effect of Lateral Venting on Deflagration-to-Detonation Transition in Hydrogen-Air-Steam Mixtures at Various Initial Temperatures (ADAMS Ascension No. ML071650492)
19. General Electric Nuclear Energy Services Information Letter, GE SIL 643, Potential for Radiolytic Gas Detonation, dated June 14, 2002
20. NEI 12-06 Rev 0, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide (ADAMS Ascension No. 12221A205)
21. USNRC, JLD-ISG-2012-01, Revision 0, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design-Bais External Events”, Interim Staff Guidance, August 29, 2012 (ADAMS Accession No. ML 12229A174)
22. USNRC, JLD-ISG-2012-03, Revision 0, “Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation”, Interim Staff Guidance, August 29, 2012 (ADAMS Accession No. ML 12221A339)
23. NUREG-1921, EPRI/NRC-RES Fire Human Reliability Analysis Guidelines (ADAMS Ascension No. ML093350494)
24. NUREG-1852, Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire (ADAMS Ascension No. ML073020676)
25. ASME OM-2009, Operation and Maintenance of Nuclear Power Plants
26. NUREG/CR-7110, Vol. 1, State-of-the-Art Reactor Consequence Analyses Project, Peach Bottom Integrated Analysis (ADAMS Ascension No. ML120260675)

APPENDIX A – GLOSSARY OF TERMS

This glossary provides definitions of key terms used in this guidance document and an acronym listing.

A.1 Definitions:

These definitions have been made consistent with other external definitions, to the degree possible, but the definitions herein represent the expressed intent of the terms as used in this guidance.

Active Function: A function that requires mechanical motion or a change of state (e.g., the closing of a valve or relay contacts or the change in state of a transistor

Beyond Design Basis Requirements: Provide reasonable confidence in a flexible operational capability for responding to an unbounded class of event conditions

Containment: For the purpose of this guidance, the principal enclosure that acts as a leak-tight barrier, to prevent the release of radioactive material from the structure, system, and component (SSC) containing the radioactive material under DBE conditions.

Current Design Basis Requirements: Provide a high level of assurance of design capability to address a defined set of event conditions

Elevated Release: Release of steam outside the reactor building and other critical buildings necessary for safe shutdown

Hardened Containment Vent System (HCVS): A group of physically interconnected components including instrumentation that together perform the specified design function as defined by Order EA-13-109 and this guide.

Hardened Pathway:

- Release of steam, hydrogen or radionuclides at an elevation above the reactor building roof.
- A vent pathway designed to withstand pressures consistent with existing containment design and avoid steam impacts within the Reactor Building.
- A vent pathway designed to withstand PCPL pressures and avoid hydrogen or radionuclide releases or re-entrainment within unacceptable locations such as the Reactor Building or Control Building.
- New venting capability should not change the design basis. The vent capability should be seismically and flooding informed, analogous to risk-informed. The containment function must be protected.

Mission Time: The operational or available time a component is required to perform its function. This time may vary by component but the cumulative mission time for credited components including instrumentation performing a required installed plant HCVS equipment function should be no less than the first 24 hours post event. Multiple pieces of equipment may be used to obtain the required time duration, such as two (2) half (1/2) size accumulators to obtain the required 24 hours of installed capacity.

Passive Function: A function that is not an active function (e.g., the pressure-retaining function of a valve, a structural element, pipe support, cable, etc. that is not required to change position in order to perform its design function).

Performance Based: Performance objectives for the design of hardened vents to ensure reliable operation and ease of use (both opening and closing) during a prolonged SBO, ELAP

Primary Containment Pressure Limit (PCPL): Defined in Rev 4 BWROG EPGs in order to maintain containment integrity

Public: For the purpose of this guidance, all individuals outside a geographic boundary within which public access is controlled and activities are governed by the operator of a reactor nuclear facility.

Redundant Equipment or System: Equipment or system that duplicates the essential function of another piece of equipment or system to the extent that either may perform the required function regardless of the state of operation or failure of the other.

Regulatory Requirement: For the purpose of this guidance, a requirement stemming directly, or indirectly, from a regulation established by a regulatory agency (e.g., the Code of Federal Regulations (CFR), or an NRC license).

Reliable: Capable of performing its required function in the desired manner under all the relevant conditions and on the occasions or during the time intervals when it is required so to perform. [Source: A.E. Green and A.J. Bourne, Reliability Technology, Wiley-Interscience, 1972.] The vent can be used when needed by procedures, and be usable across a spectrum of events to include both prevention and mitigation of severe core damage

Seismically Reliable and Rugged Performance: A term used to describe the design of components including instrumentation beyond the second containment isolation barrier to ensure that the HCVS is able to remain functional following a design basis seismic event. While the design and construction must meet the plant's design basis earthquake seismic requirements, licensees may use commercial grade components and materials beyond the second containment isolation barrier. Thus, licensees are not required to qualify piping, supports and other related components in accordance with NRC requirements for safety related structures, systems, and components, including Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," for this portion of the system.

Severe Accident: An accident that involves extensive core damage and fission product release into the reactor vessel and containment with potential release to the environment. Severe accidents include both scenarios in which all core debris is cooled in-vessel (similar to the accident at TMI-2) and scenarios in which core debris breaches the reactor coolant boundary and relocates into containment, with some of the core debris remaining within the reactor vessel.

Severe Accident Hardened Containment Vent System

- The containment venting function should presume the occurrence of significant core damage and the presence of hydrogen. (This is a defense-in-depth requirement and should be considered one of the missions of the hardened vent system)
- The vent should be capable of operation to limit pressure to the PCPL, and to permit depressurization at any time, for example, to enable low pressure coolant injection into the RPV
- Operators should be able to vent containment from the wetwell and drywell(if chosen as the Phase 2 option) using permanently installed equipment under prolonged SBO conditions, ELAP
- Venting system should minimize the use of common systems between units and not interfere with the operation of other safety and non-safety equipment

Single Failure: A random failure (e.g., single component failure or operator error) and its consequential effects, in addition to an initiating occurrence, which result in the loss of capability of a component to perform its intended function. Fluid and electrical systems are considered to be designed against an assumed single failure if neither (1) a single failure of any active component (assuming passive components function properly) nor (2) a single failure of any passive component (assuming active components function properly) results in a loss of capability of the system to perform its safety function(s).

Sustained Operation: The ability to operate 7 days or a shorter time if an alternative method of containment heat removal is put in place by using installed or portable equipment (e.g., a means of shutdown cooling aligned directly to the RPV, drywell or a means of suppression pool cooling). Use of the Hardened Containment vent should not be the means of containment heat removal after this time. Some containment source term control is inherent with the longer term (>7 day or alternate means) containment heat removal function; however, addressing site source term control functionality will be governed by the ERO Recovery actions versus activities associated with NEI 13-02 or Order EA-13-109. This definition does not apply to Order EA-12-049 phase 1, 2, or 3 equipment unless the equipment is repurposed under Order EA-13-109.

A.2 Acronyms and Abbreviations

Acronym	Description
AC	Alternating Current
AOP	Abnormal Operating Procedure
AOV	Air Operated Valve
ASME	American Society of Mechanical Engineers
BDBE	Beyond Design Basis Event
BDBEE	Beyond Design Basis External Event
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners' Group
CAP	Containment Accident Pressure
CLB	Current License Basis
CPRR	Containment Protection and Release Reduction
DBE	Design Basis Event
DBLOCA	Design Basis Loss of Coolant Accident
DC	Direct Current
DW	Drywell
ECCS	Emergency Core Cooling System
EDMG	Extreme Damage Mitigation Guideline
ELAP	Extended Loss of AC Power
EOP	Emergency Operating Procedure
EPGs	Emergency Procedure Guidelines
EPRI	Electric Power Research Institute
ERO	Emergency Response Organization
FSG	FLEX Support Guideline
GDC	General Design Criteria
GE	General Electric
HCVS	Hardened Containment Vent System
ISG	Interim Staff Guidance
LOCA	Loss of Coolant Accident
LUHS	Loss of Ultimate Heat Sink
MCCI	Molten Corium Concrete Interaction
MOV	Motor Operated Valve
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NTTF	Near Term Task Force
OIP	Overall Integrated Plan
P&ID	Piping and Instrumentation Diagram
PCIV	Primary Containment Isolation Valve
PCPL	Primary Containment Pressure Limit
PSP	Pressure Suppression Pressure
RAI	[NRC] Request for Additional Information
RCIC	Reactor Core Isolation Cooling

Acronym	Description
RPV	Reactor Pressure Vessel
SAGs	Severe Accident Guidelines
SAMG	Severe Accident Management Guidelines
SAT	Systematic Approach to Training
SAWA	Severe Accident Water Addition
SAWM	Severe Accident Water Management
SBO	Station Blackout
SER	[NRC] Safety Evaluation Report
SOV	Solenoid Operated Valve
SRV	Safety Relief Valve
TMI	Three Mile Island
TOC	Table of Contents
UFSAR	Updated Final Safety Analysis Report
UHS	Ultimate Heat Sink

APPENDIX B – ROADMAP OF ORDER REQUIREMENTS

The purpose of this appendix is to provide a cross-reference of the requirements contained in the revised Order EA-13-109 against the requirements of the original Order EA-12-050 and identifies where the requirements are addressed in this guidance document.

B.1 Structure of Roadmap

Table B-1 lists each requirement of Order EA-13-109, "Order Modifying Licenses With Regard To Reliable Hardened Containment Vents Capable Of Operation Under Severe Accident Conditions" [Ref. B-1] against the requirements of the original Order [Ref. B-2] and the appropriate section in this document.

B.2 Order EA-13-109 Attachment 2:

Boiling-Water Reactors (BWRs) with Mark I and Mark II containments shall have a reliable, severe accident capable hardened containment venting system (HCVS)[1]. This requirement shall be implemented in two phases. In Phase 1, licensees of BWRs with Mark I and Mark II containments shall design and install a venting system that provides venting capability from the wetwell during severe accident conditions. Severe accident conditions include the elevated temperatures, pressures, radiation levels, and combustible gas concentrations, 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. In Phase 2, licensees of BWRs with Mark I and Mark II containments shall design and install a venting system that provides venting capability from the drywell under severe accident conditions, or, alternatively, those licensees shall 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.

A. PHASE 1 (reliable, severe accident capable wetwell venting system)

The BWRs with Mark I and Mark II containments shall design and install a HCVS, using a vent path from the containment wetwell to remove decay heat, vent the containment atmosphere (including steam, hydrogen, carbon monoxide, non-condensable gases, aerosols, and fission products), and control containment pressure within acceptable limits. The HCVS shall be designed for those accident conditions (before and after core damage) for which containment venting is relied upon to reduce the probability of containment failure, including accident sequences that result in the loss of active containment heat removal capability or extended loss of alternating current (AC) power. The HCVS shall meet the requirements in Sections 1, 2, and 3, below.

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[1] Unless otherwise specified in this attachment, HCVS refers to a reliable, severe accident capable hardened containment venting system. The HCVS includes a severe accident capable containment wetwell venting system and may also, depending on the approach taken for Phase 2 include a severe accident capable containment drywell venting system.

1. HCVS Functional Requirements

1.1 The design of the HCVS shall consider the following performance objectives:

1.1.1 The HCVS shall be designed to minimize the reliance on operator actions.

1.1.2 The HCVS shall be designed to minimize plant operators' exposure to occupational hazards, such as extreme heat stress, while operating the HCVS system.

1.1.3 The HCVS shall also be designed to account for radiological conditions that would impede personnel actions needed for event response.

1.1.4 The HCVS controls and indications shall be accessible and functional under a range of plant conditions, including severe accident conditions, extended loss of AC power, and inadequate containment cooling.

1.2 The HCVS shall include the following design features:

1.2.1 The HCVS shall have the capacity to vent the steam/energy equivalent of one (1) percent of licensed/rated thermal power (unless a lower value is justified by analyses), and be able to restore and then maintain containment pressure below the primary containment design pressure and the primary containment pressure limit.

1.2.2 The HCVS shall discharge the effluent to a release point above main plant structures.

1.2.3 The HCVS shall include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site.

1.2.4 The HCVS shall be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location.[2]

1.2.5 The HCVS shall, in addition to meeting the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations.

1.2.6 The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power.

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[2] For the purposes of these technical requirements, "sustained operations" means until such time that alternate reliable containment heat removal and pressure control is reestablished, independent of the HCVS, (e.g.. suppression pool, torus. or shutdown cooling) using installed or portable equipment.

1.2.7 The HCVS shall include means to prevent inadvertent actuation.

1.2.8 The HCVS shall include means to monitor the status of the vent system (e.g., valve position indication) from the control panel required by 1.2.4. The monitoring system shall be designed for sustained operation during an extended loss of AC power.

1.2.9 The HCVS shall include a means to monitor the effluent discharge for radioactivity that may be released from operation of the HCVS. The monitoring system shall provide indication from the control panel required by 1.2.4 and shall be designed for sustained operation during an extended loss of AC power.

1.2.10 The HCVS shall be designed to withstand and remain functional during severe accident conditions, including containment pressure, temperature, and radiation while venting steam, hydrogen, and other non-condensable gases and aerosols. The design is not required to exceed the current capability of the limiting containment components.

1.2.11 The HCVS shall be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation.

1.2.12 The HCVS shall be designed to minimize the potential for hydrogen gas migration and ingress into the reactor building or other buildings.

1.2.13 The HCVS shall include features and provisions for the operation, testing, inspection and maintenance adequate to ensure that reliable function and capability are maintained.

2. HCVS Quality Standards

The HCVS shall meet the following quality standards:

2.1 The HCVS vent path up to and including the second containment isolation barrier shall be designed consistent with the design basis of the plant. Items in this path include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components.

2.2 All other HCVS components shall be designed for reliable and rugged performance that is capable of ensuring HCVS functionality following a seismic event. These items include electrical power supply, valve actuator pneumatic supply and instrumentation (local and remote) components.

3. HCVS Programmatic Requirements

3.1 The Licensee shall develop, implement, and maintain procedures necessary for the safe operation of the HCVS. Procedures shall be established for system operations when normal and backup power is available, and during an extended loss of AC power.

3.2 The Licensee shall train appropriate personnel in the use of the HCVS. The training curricula shall include system operations when normal and backup power is available, and during an extended loss of AC power.

B. PHASE 2 (reliable, severe accident capable drywell venting system)

Licensees with BWRs with Mark I and Mark II containments shall either:

(1) design and install a HCVS, using a vent path from the containment drywell, that meets the requirements in Section 8.1 below, or

(2) develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell before alternate reliable containment heat removal and pressure control is reestablished and meets the requirements in Section B.2 below.

1. HCVS Drywell Vent Functional Requirements

1.1 The drywell venting system shall be designed to vent the containment atmosphere (including steam, hydrogen, non-condensable gases, aerosols, and fission products), and control containment pressure within acceptable limits during severe accident conditions.

1.2 The same functional requirements (reflecting accident conditions in the drywell), quality requirements, and programmatic requirements defined in Section A of this Attachment for the wetwell venting system shall also apply to the drywell venting system.

2. Containment Venting Strategy Requirements

Licensees choosing to develop and implement a reliable containment venting strategy that does not require a reliable severe accident capable drywell venting system shall meet the following requirements:

2.1 The strategy making it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions shall be part of the overall accident management plan for Mark I and Mark II containments.

2.2 The licensee shall provide supporting documentation demonstrating that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions.

2.3 Implementation of the strategy shall include licensees preparing the necessary procedures, defining and fulfilling functional requirements for installed or portable equipment (e.g., pumps and valves), and installing the needed instrumentation.

B.3 References

B.3.1 USNRC, Order EA-13-109, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions,” June 6, 2013 (ADAMS Accession No. ML13143A321).

B.3.2 USNRC, Order EA-12-050, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents,” March 12, 2012 (ADAMS Accession No. ML12054A696).

Table B-1

Roadmap of Technical Requirements from Revised EA-12-050

EA-13-109 Order Requirement	Changes from EA-12-050	NEI 13-02 Applicable Guidance
HCVS Performance Objectives (Phase I)		
A.1.1.1 - Minimize the reliance on operator actions	No changes	4.2.6
A.1.1.2 - Minimize operators' exposure to occupational hazards	No changes	4.2.5, 6.1.1
A.1.1.3 – Account for radiological conditions that would impede event response	Wording change from “minimize radiological consequences” to “account for radiological consequences”	4.2.5, 6.1.1, Appendix F, Appendix G
A.1.1.4 – Accessible controls and indications	New Item, Specified in order item previously in ISG. “The HCVS shall be accessible and functional under a range of plant conditions, including a severe accident environment, extended loss of AC power and inadequate containment cooling”	4.1.3, Appendix F, Appendix G
HCVS Design Features		
A.1.2.1 - Capacity to vent 1 percent of thermal power	Added, “and the primary containment pressure limit (PCPL).” to end of sentence.	4.1.1, Appendix I
A.1.2.2 - Discharge the effluent to a release point above plant structures	No changes but renumbered (1.2.9 in EA-12-050)	4.1.5
A.1.2.3 - Design features to minimize cross flow	No changes but renumbered (1.2.6 in EA-12-050).	4.1.2, 4.1.4, 4.1.6
A.1.2.4 - Operation from control panel for sustained operations	Similar wording as 1.2.2 in EA-12-050, but included the definition of “sustained operation” in a footnote.	4.2.2

Table B-1

Roadmap of Technical Requirements from Revised EA-12-050

EA-13-109 Order Requirement	Changes from EA-12-050	NEI 13-02 Applicable Guidance
A.1.2.5 – Alternate manual operation capability	New Item, adds additional capability for system operation for defense in depth, not redundancy.	4.2.3
A.1.2.6 - Operation with permanently installed equipment for 24 hours	New Item, added prior ISG item. "The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power."	2.5, 4.2.2, 4.2.6, 6.1
A.1.2.7 – Prevention of inadvertent actuation	No changes but renumbered (1.2.3 in Order EA-12-050).	4.2.1
A.1.2.8 – Monitoring of vent status from control panel	No substantive changes but renumbered (1.2.4 in Order EA-12-050). Added, "from the control panel installed in accordance with requirement 1.2.4"	4.2.2
A.1.2.9 - Means to monitor the effluent discharge	No substantive changes but renumbered 1.2.5 in Order EA-12-050). Added, "from the control panel installed in accordance with requirement 1.2.4"	4.2.4

Table B-1

Roadmap of Technical Requirements from Revised EA-12-050

EA-13-109 Order Requirement	Changes from EA-12-050	NEI 13-02 Applicable Guidance
A.1.2.10 - Design for severe accident & dynamic conditions	Significant changes from 1.2.8 in Order EA-12-050. Added design conditions to account for severe accident service of the HCVS to include temperature, radiation and combustible gas. Design consistent with limiting containment components.	2.3, 2.4, 4.1.1, 5.1, Appendix I
A.1.2.11 - Flammability control	New item related to hydrogen control. “The HCVS shall be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation.”	4.1.7, 4.1.7.1, 4.1.7.2, Appendix H
A.1.2.12 - Designed to minimize hydrogen gas migration	New item related to hydrogen control programs. “The HCVS shall incorporate strategies for hydrogen control that minimizes the potential for hydrogen gas migration and ingress into the reactor building or other buildings.	4.1.6, Appendix H
A.1.2.13 - Operation, testing, inspection and maintenance	No changes, renumbered (1.2.7 in Order EA-12-050).	5.4, 6.2

Table B-1

Roadmap of Technical Requirements from Revised EA-12-050

EA-13-109 Order Requirement	Changes from EA-12-050	NEI 13-02 Applicable Guidance
Quality Standards		
A.2.1 – Design basis of containment isolation function	No changes.	5.3
A.2.2 - Reliable and rugged performance	No changes.	5.2, 5.3
Programmatic Requirements		
A.3.1 - Develop, implement, and maintain procedures	No significant changes. Changed prolonged SBO to extended loss of AC power.	6.1.2, 6.1.2.1
A.3.2 - Train appropriate personnel	No significant changes. Changed prolonged SBO to extended loss of AC power.	6.1.3
Drywell Vent Functional Requirements (Phase 2)		
B.1.1 Meet performance objectives, design features, quality requirements, and programmatic requirements	New guidance on Drywell venting.	2, 3 and Appendix I
B.1.2 Justify confidence drywell vent is not necessary	New guidance on Drywell venting.	Appendix C and I

APPENDIX C – SEVERE ACCIDENT WATER MANAGEMENT (SAWM)

The purpose of this appendix is to provide a description of the water management aspects of a strategy for complying with the requirements of B.2 of order EA-13-109.

C.1 Introduction

NRC Order EA-13-109 Section B requires Licensees with BWRs with Mark I and Mark II containments to either:

(1) Design and install a HCVS, using a vent path from the containment drywell, that meets the requirements in Section B.1,

(2) Develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell before alternate reliable containment heat removal and pressure control is reestablished and meets the requirements in Section B.2.

The purpose of this Appendix is to define guidance for implementation of water management for the second method. This guidance must address the following elements of the Order, Section B.2:

Licensees choosing to develop and implement a reliable containment venting strategy that does not require a reliable, severe accident capable drywell venting system shall meet the following requirements:

2.1 The strategy making it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions shall be part of the overall accident management plan for Mark I and Mark II containments.

2.2 The licensee shall provide supporting documentation demonstrating that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions.

2.3 Implementation of the strategy shall include licensees preparing the necessary procedures, defining and fulfilling functional requirements for installed or portable equipment (e.g., pumps and valves), and installing the needed instrumentation.

This Appendix recognizes the insights gained from EPRI Technical Report XXXXXX that water addition during severe accident conditions in conjunction with containment venting provides a substantial safety benefit by reducing containment temperatures. Any Phase 2 B.2 strategy should contain SAWA.

Comment [N16]: This needs to be defined with the concept of “stabilized” and what the difference is between “severe accident conditions” and “recovery phase” given that the DW will most likely be flooded with or without a severe accident capable DW vent. Is the severe accident “stabilized” and “recovery phase” entered before core debris in the DW is submerged (quench/cool core debris and greatly attenuate CCI and Zr-H2O combustible gas production.

Severe Accident Water Addition (SAWA) - water addition capability that can be implemented under the severe accident conditions required by the order, as defined in the definitions section of this document (SAWA requirements are addressed in Appendix I)

Comment [N17]: "required by the order" – this is yet to be determined pending the NRC response to the industry letter. Suggest changing to "for which the severe accident venting capability is required"

C.2 Severe Accident Water Management (SAWM) - management of wetwell water level such that the use of the wetwell vent path is preserved until "*alternate reliable containment heat removal and pressure control is reestablished*" (SAWM requirements are addressed in this Appendix).

Comment [N18]: The intent of this statement in the order is that adequate containment heat removal provides the benefit of pressure control, not that any venting method that is not in accordance with the order requirements (reliable, hardened, rugged, leak tight, etc.) is acceptable. The Order requires this if the option not to have a severe accident capable DW vent capability is pursued, not that it is required no matter what.

In addition, while the EPRI Technical Report XXXXXX analysis shows marginal safety benefit gained from water management strategies that delay or prevent the need for a drywell vent path, the Order requires that the containment venting strategy will make it unlikely that a drywell vent path is needed before "*alternate reliable containment heat removal and pressure control is reestablished*". (Section B.2.1 of the Order)

Comment [N19]: See comment above

Generic evaluations performed under (EPRI Technical Report XXXX) meet the required "*documentation demonstrating that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions*". (Section B.2.2 of the Order)

Comment [N20]: For how long? Is this where the 48 hours comes from? This was for the generic plant with its specific spillover height (maximum water level on the drywell floor without flooding WW), injection rate in excess of decay heat boil-off need and available "freeboard" (volume/level in WW where switch to DW vent needed).

Is there a need to vent from drywell after the wetwell vent is flooded? If so, how is venting accomplished without a reliable hardened vent that meets the requirements of the order, should severe accident conditions still exist in containment (e.g. combustible gases).

SAWM defines how to use the hardware (Section B.2.3 of the Order) provided by SAWA and will primarily be implemented through procedures and training. Under the water management strategy sufficient water flow must be supplied to reduce thermal challenges to the containment so that the containment function remains intact. SAWM Instrumentation requirements will be addressed in this appendix to fulfill the requirements of Section B.2.3 of the Order.

C.2.1 The following are aspects of the strategy supporting actions that may prolong use of the wetwell vent path (SAWM)

C.2.1.1 Plant characteristics influential in preserving the wetwell vent path

- Freeboard space, spillover height, Suppression Pool volume to Power ratio are characteristics that will be used as sensitivity elements to validate the generic evaluations against plant specific design configurations

C.2.1.2 Length of time that the wetwell vent path is to be preserved (e.g., 48 hours).

Comment [N21]: Is there a downside to an approach that may be good only for 48 hours rather than one that could continue for a much longer time if necessary? How about the "variability of the progression of a severe accident"?

- To transition to the alternate reliable containment heat removal and pressure control conditions sites may utilize a combination of installed and portable equipment.

- This section provides the rational for establishing 48 hours as a reasonable length of time for Phase 2 Order compliance criteria to remain in effect to meet the sustained operation requirement of the Order (Reference Appendix A). That is, "an alternative method of containment heat removal is put in place by using installed or portable equipment" within 48 hours, provides a reasonable length of time for transition to sustained operation for Phase 2 B.2 SAWA/SAWM based on the following characteristics, which provide margin to the selected time of 48 hours:
    - Decay heat is significantly reduced within the first hours of the event (SOARCA),
    - Significant heat is transferred to the SP within the first hours of the event and removed through the WW vent (EA-13-109 Phase 1 compliance)
    - The ERO will be at full staff at 24 hours (EA-12-049 compliance) so that Command and Control is established to enable effective deployment of the additional portable resources stored locally and arriving from the NSRC. This will enable effective SAWA/SAWM for sustained operation and until the transition to "alternate reliable containment heat removal and pressure control".
    - Due to the variability of the progression of a severe accident, it is not possible to identify specific recovery actions for the transition to the alternate reliable containment heat removal and pressure control. The Emergency Response Organization will determine the appropriate recovery actions based on the status of the plant and the equipment available at the time.
    - HCVS support equipment will be in-service and available (EA-13-109 Phase 1 compliance).

Comment [N22]: Only if there is adequate alternate containment heat removal established that also provides pressure control function. Alternate methods of venting that does not meet Order EA-13-109 requirements are not acceptable for as long as severe accident conditions exist in containment.

Comment [N23]: What is the basis for 48 hours? Given the dynamic nature of the event, this time should be based on the determination of the conditions in containment and if they can be called stable. Depending on how severe the initiating event is, accident progression, arrival of additional help and equipment, this may take less than 48 hours or significantly more than 48 hours.

Comment [N24]: All decay heat is not removed from the containment. A significant portion of that still remains in containment in the form of suppression pool capacity.

Comment [N25]: Sustained operation definition is already established in Phase 1, e.g. seven (7) days or s shorter time if an alternate method of containment removal is put in place that does not require containment venting.

Comment [N26]: So, establishing (not the subsequent continued operation of) the alternate reliable containment heat removal and pressure control capability is a "recovery phase" activity? What exactly marks the transition from severe accident to recovery phase?

Comment [N27]: Where additional dialogue is required is when does the plant become stable in terms of the requirements of Order EA-13-109. The staff believes that full staffing of ERO and equipment availability is not the criteria in the Order space, but it is the containment conditions that would no longer require a reliable, hardened, rugged, and functional containment vent.
In addition, Order requirement B (1).2.2 requires that licensee shall provide supporting documentation demonstrating that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions. The guidance should address that requirement generically and what individual plants may have to do if the generic application does not apply to their specific plant.

  - National SAFER Response Center (NSRC) initial equipment delivery within 24 hours after notification (EA-12-049 compliance)

- The following are examples of equipment that may be deployed for post-accident coping conditions.

  1. Low pressure high flow portable pump from the NSRC. This pump may be used to flood the containment and to provide cooling water flow to the installed Residual Heat Removal (RHR) heat exchangers.
  2. Medium voltage portable generators and associated distribution switchgear from the NSRC. These generators may be used to power on-site RHR pumps.
  3. The above items are considered generic equipment and available to any nuclear power plant site in the United States for the purpose of mitigating a beyond design basis event.

C.2.1.3 SAWA analyzed flow rates

Comment [N28]: Comments from RES to follow later.

- The water management strategy under Phase 2 of Order EA-13-109 is a means to preserve the wetwell vent path by providing sufficient water flow to remove heat generated by the core debris and venting that water, in the form of steam, to atmosphere using the Severe Accident capable wetwell vent installed under Phase 1 of the Order.

- The addition of water during ex-vessel core melt scenarios provides the additional benefit of reducing overall containment temperatures so that the pressure retaining function of the containment remains intact.

- Rather than a detailed breakdown of water addition requirements over time to address a specific accident progression sequence, a more generic strategy of water addition is appropriate given the unpredictable nature of the beyond design basis condition that results in severe accident conditions with ex-vessel core debris.

Argonne National Laboratory (ANL) Experimental Results

- Initial bulk cooling phase in the range of 1 Mw/m^2
  - With debris confined to pedestal floor – equivalent to boil-off rate of 217 gpm
  - Assuming spread to ¼ of the drywell floor – equivalent to 376 gpm
- After initial bulk cooling (approx. 60 min), crust begins to form, limiting the heat transfer to the water
  - With debris confined to pedestal floor – equivalent to boil-off rate of 54 gpm
  - Assuming spread to ¼ of the drywell floor – equivalent to 94 gpm

Comment [N29]: Where is the reference to the associated report. It is difficult to understand the applicability/usefulness of this information summary without a more complete description.

- The initial water addition rate should be the maximum addition rate possible given the capacity of the water addition source. In no case does the water addition rate have to exceed 500 GPM at the maximum containment pressure, consistent with the pressure limitations of Phase 1 of the Order.
  - This will provide for the initial removal of sensible heat and subsequent reduction in containment temperature.
  - Suppression Pool water level and containment pressure monitoring will indicate when the proper balance of water addition and containment heat removal by venting is achieved and should be used to determine when to reduce the SAWA flow rate.
    - Initially, the rate of containment pressure rise may increase due to the quenching action of the added water followed by a reduction in the rate of pressure rise which will indicate that the sensible heat and decay heat are being properly managed.
    - The wetwell vent size is sufficient to prevent containment failure as a result of overpressure until the wetwell vent becomes flooded.

Comment [N30]: If water addition flow is entering the in-pedestal area via a RPV bottom head breach, is this reduction in average DW temperature, reduction in average containment temperature or suppression of temperature rise throughout containment.

Comment [N31]: Are these parameter instruments essential for achieving the conditions that obviate the need for a severe accident capable DW vent?

  - Containment pressure and suppression pool level monitoring as described in C.2.4 should be used to indicate when increases or reductions in water addition flow should be made.

C.2.2 The initial source of water on the drywell floor comes from a combination of Reactor Recirculation pump seal leakage and condensation caused by containment heat sinks in contact with the steam environment.

- The water depth will be dependent upon the spillover height of the drywell to torus vent pipes (Mark I) or drywell to suppression chamber downcomers (Mark II), and will therefore range between nine inches and approximately three and a half feet, which bounds the BWR Mark I and II fleet.
- If not limited by the spillover height, the depth may be limited by the water accumulation rate and the time that core debris reaches the drywell floor.
  - Some Mark II containments also feature a sunken pedestal design which will limit water accumulation via the floor drain system piping to the under pedestal area. Since this is the most likely accumulation area for core debris, the configuration is not a limiting condition of or cause for a revision to the SAWA or SAWM strategies.

C.2.3 Licensees must determine an upper wetwell level indication that, including instrument uncertainties, allows steam and non-condensables to vent through the wetwell vent.

- Successful SAWM has three scenarios related to suppression pool level instrument related to functional use of the WW vent
  - Scenario 1 is when the instrument level useful range allows greater than the minimum preservation time per C.2.1 from the normal level using SAWA.
  - Scenario 2 is when the available instrument freeboard to the WW vent function allows greater than the minimum preservation time per C.2.1 from the normal SP level using SAWA.
  - Scenario 3 is when the time from the normal SP level to the need for a DW vent is greater than the minimum preservation time per C.2.1, using a WW vent as long as possible

Comment [N32]: Not sure if condensation provides additional source before vessel is breached and water starts to accumulate on the drywell floor. Until vessel breach, condensation if any, would come from the evaporated seal leakage.

Comment [N33]: Staff's understanding from previous meetings is that some plants have much lower spillover height, in the order of 3 inches.

Comment [N34]: Is the long standing assumption of DW floor breach and suppression pool bypass for Mark II plants no longer considered a possibility?

Comment [N35]: Not clear as to what the distinction is or how these would be functionally different, needs clarification as to what physically is being described and how it affects what strategy will be acceptable.
For staff's better understanding, please explain aided by a sketch in the next public meeting.

- Extension of this level is not required if the SAWM strategy can be implemented to preserve the wetwell vent for the minimum time per C.2.1,

- Licensees may make modifications (examples below) to the facility to improve the available wetwell freeboard volume in the containment in order to meet the minimum preservation time per C.2.1.

    - Re-span or replace the wetwell level instrument to increase the upper range of the instrument. This action will increase the available volume up to the level of the wetwell vent piping.

    - Relocate the wetwell level instrument tap to increase the upper range of the instrument. This action in combination with the re-span will increase the available volume up to the level of the wetwell vent piping.

    - Modify the wetwell vent piping to increase the available wetwell volume to support the SAWM strategy.

C.2.4 Instrumentation

Comment [N36]: Instrumentation comments to follow later.

- Instrumentation supporting the HCVS wetwell vent path is defined in Sections 4.2.2 and 4.2.4 of this document. These requirements will not be changed by this Appendix.

Comment [N37]: Are WW level and DW pressure essential for ensuring water addition scheme will result in a severe accident capable DW vent being needed?

- The instrumentation described in this document is part of the set of post-accident monitoring instruments and, for most plants, conforms to Regulatory Guide (RG) 1.97. (Pre RG 1.97 plants have similar qualification requirements for this set of instrumentation)

- Containment Pressure and Wetwell level are indications needed to support water addition and water management in the accident stabilization phase.

Comment [N38]: What conditions have to exist for "stabilization" to be complete and allow "recovery phase" entry? Is "accident stabilization phase" distinct from "severe accident conditions" and "recovery phase"?

    - These indications are addressed by Section 4.2.2.1.9 of this document and are adequate to support Phase 2 implementation.

- Licensees should also evaluate installed temperature instrumentation.

    - Many thermocouple and RTD instruments have a higher range than currently used based on DW design temperature.

        - Typically DW design temperature is below 400F, however many sites have thermocouples that have a greater nominal range

  - that likely will be available for manual readings of DW temperature.

- Containment temperature trends can also be used to confirm that the lower portion of the Drywell is not exceeding or approaching the thermal failure point of containment penetrations. This could be evaluated by installed containment temperature monitoring instrumentation.
  - The trends need to be evaluated due to the potential for individual instruments to be inaccurate due to local hot spots or thermal radiation impacts on the instruments.
- DW Temperature is not a requirement for compliance with Phase 2 of the order, but some knowledge of temperature characteristics provides information for the operation staff to evaluate plant conditions under a severe accident and provide confirmation to adjust SAWA flow rates.

Comment [N39]: Drywell temperature is a requirement within the context of the guidance in Section 2.4 and that is why SAWA and SAWM are being implemented even in the absence of any rulemaking requirements that may or may not come about in the future.

If a plant's SA mitigation strategy includes flooding up to some minimum level in the DW as quickly as prudently possible (avoiding DW pressures going too high or too low), then knowing the DW temperatures is not essential as everything that can be done to control those temperatures is being done. However, if water addition rate is being throttled to avoid a need to open a DW vent, then knowing DW temperatures could indicate a need to increase the addition rate to reduce the rise in temperatures.

C.2.5 Licensees may identify other similar actions to achieve a successful SAWM strategy. Actions taken by Licensees are subject to the review and approval of the NRC staff and should be identified in the Phase 2 Overall Integrated Plan (OIP).

APPENDIX D – INTERFACE WITH FLEX

Order EA-13-109 calls for very clear definition of the boundary conditions to be applied to the design and operational considerations required to implement the HCVS associated with a severe accident capable vent. Compliance with NRC Order EA-12-049, FLEX is clearly a mitigation strategy for a BDBEE without core damage.

D.1. Interaction Between Order EA-12-049 and EA-13-109

D.1.1. Complying with Order EA-13-109 using components allocated to FLEX do not change the compliance methods or requirements for all aspects of complying with Order EA-12-049 using FLEX.

D.1.2. References in this guidance to the criteria contained in NRC endorsed FLEX guidance, NEI 12-06, invoke those Order EA-12-049 criteria, such as the screened-in criteria for hazards for establishing boundary conditions applicable to compliance with Order EA-13-109 not the reverse.

D.1.3. Use of specific elements of FLEX to comply with Order EA-13-109 require only those specific elements to have additional criteria as defined in this guidance applied to ensure the credited function is available to meet the design, operational and maintenance criteria contained in this guide. The most likely FLEX functions that could be used for compliance to EA-13-109 are makeup air to the HCVS system connections (either primary or alternate control locations) and requisite power (either AC or DC) to either primary or alternate valve operating stations

Comment [N40]: And water addition/water management

D.1.3.1. Connections, staging and deployment for portable equipment and support functions must comply with Order EA-13-109 requirements as clarified in this guidance.

D.1.3.2. Connections, staging and deployment established for FLEX do not have to be applicable for compliance with Order EA-13-109. If this is the case then additional actions are required to provide compliance with Order EA-13-109 requirements as clarified in this guidance.

D.1.4. For ELAP and Loss of Ultimate Heat Sink (LUHS) BDBE that do not have core damage, FLEX analysis determines the timing for containment venting under Order EA-12-049 (ELAP/LUHS) conditions.

D.1.4.1. For ELAP and LUHS BDE that do not have core damage, FLEX will supply the analysis and method of water addition to the RPV. It also supplies AC/DC power and Key Parameter instrumentation, as defined in NRC endorsed guidance NEI 12-06 independent of HCVS

D.2. Onsite Portable Equipment Use

D.2.1. The HCVS may use on-site FLEX Phase 2 portable equipment as replenishment source for motive air

D.2.2. The HCVS may use on-site FLEX Phase 2 portable equipment as source of reliable DC power

D.2.3. The HCVS may use on-site FLEX Phase 2 portable equipment as source of AC power

D.2.4. The HCVS may use required FLEX Key Parameter instruments for monitoring Suppression Pool (Torus)/DW parameters such as those listed in section 4.2.2.1.9.

D.2.5. The HCVS may use FLEX Phase 1 or 2 Safety Support Functions strategies, as defined in the plant's FLEX OIP, for habitability in HCVS areas

D.3. Offsite Portable Equipment Use

D.3.1. The HCVS may use off-site FLEX Phase 3 portable equipment for any longer term actions which they are capable of addressing

D.3.2. The HCVS may use any available off-site portable equipment for any longer term actions which they are capable of addressing

D.3.3. These sets of off-site equipment will have to perform the functions identified in other sections of this document and only have to address the radiological, and habitability conditions expected to be present at the location and time of connection. With severe accident conditions other setup/connections may be necessary due to associated radiological and habitability concerns.

D.3.4. Accessibility and deployment conditions under the Order EA-13-109 conditions expected at the time of deployment and use should be addressed when determining the appropriate usability of portable equipment.

APPENDIX E – INTERFACE WITH GENERIC LETTER 89-16, INSTALLATION OF A HARDENED WETWELL VENT

The purpose of this appendix 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.

In 1989, the NRC issued Generic Letter 89-16, “Installation of a Hardened Wetwell Vent,” to all licensees of BWRs with Mark I containments to encourage licensees to voluntarily install a hardened wetwell vent. In response, licensees installed a hardened vent pipe from the wetwell to some point outside the secondary containment envelope (usually outside the reactor building). Some licensees also installed a hardened vent branch line from the drywell. Because the modifications to the plant were performed in accordance with 10 CFR 50.59, “Changes, tests and experiments,” detailed information regarding individual plant configurations was not submitted to the NRC staff for review. Subsequently, the NRC has issued orders to each plant via EA-13-109 to install reliable hardened containment vents capable of operation under severe accident conditions to be implemented in two phases; Phase 1 addresses the Wetwell vent path and Phase 2 the Drywell vent path. A review of the requirements of EA-13-109 phase 1 and Phase 2 concludes the requirements of this order bounds the previous requirements of GL 89-16. As such, licensees have a basis for changing commitments to GL 89-16 in accordance with NEI 99-04, Guidelines for Managing NRC Commitment Changes.

Design Elements of GL 89-16 (based on the Pilgrim design included in 89-16)	EA-13-109 requirement equivalent or greater
Provide venting capability equal to approximately 1% decay heat	Item 1.2.1
Vent the wetwell vapor space to a suitable release point (e.g. stack, reactor building or turbine building roof).	Item 1.2.2
Provide operability independent of AC power (note 1)	Item 1.1.4
Prevent inadvertent operation	Item 1.2.7
No single operator error can actuate the system	Item 1.2.7
Provide indication of valve position in the main control room	Item 1.2.8
Piping is safety related and supported as Class I up to the vent valve	Section 2
Class II items with potential to degrade the integrity of a Class I are analyzed.	Section 2

Note 1: It was proposed in the staff recommendation in SECY 89-17 that the hardened vent isolation valves be capable of being opened from the control room under station blackout conditions beyond the then-established coping time; however, the generic letter only requested that the licensee include costs for electrical modifications in a plant-specific basis for why the vent was not cost beneficial if a vent was not voluntarily installed. The installed vents in most cases were dependent on AC power.

References: SECY 89-17

APPENDIX F – METHOD TO EVALUATE OPERATOR DOSES

The purpose of this appendix is to provide a link to information on methods that are already established in response to regulatory dose considerations for fuel damage and core ex-vessel. The approach proposed to use to evaluate operator dose under the severe accident conditions that may be present under a EA-13-109 order scenario is the information from the well-established NUREG 0737. An example of this is the Direct Shine component for Main Control Room Habitability in the NUREG is an acceptable application for Order EA-13-109. The following information provides a general overview of some of those elements for personnel not readily familiar with the NUREG and its application.

While this appendix purports using the existing regulatory basis it is understood that the severe accident conditions that may be present under a EA-13-109 order scenario are beyond design basis conditions and there is no express or implied change in the regulatory position on other guidelines because of the use of that guidance in this document.

F.1 Methodology for Computation of Operator Doses

Personnel safety and accessibility will be important during the mitigation of a severe core damage accident. Opening of a containment vent with elevated radiation levels will pose some challenges to the operating staff. Various methods for routing the vent piping can reduce the impact on plant operations. Shielding of portions of the vent pipe can also be used to reduce exposure to plant personnel.

Attenuation coefficients can be obtained for various materials such as concrete (0.181 cm^{-1}) and lead (1.289 cm^{-1}) to allow for estimating the local radiation doses to plant personnel. More sophisticated analysis tools are available to assist the plant in evaluation of radiation doses expected during the venting operation for their specific routing. Whether using sophisticated analysis tools or hand calculations, multiple release pathways must be considered when evaluating possible sources of dose for plant personnel. While selectively routing vent pathways may assist in the mitigation of radiation effects on plant personnel, the vent paths themselves must be properly shielded in order to prevent shine through the walls of the vent paths (pipe walls). Furthermore, fission products and aerosols released from the containment have the potential to escape the reactor building through a stack or other pathways, depending upon vent path routing preferences. Any radiation released from the reactor building has the potential to shine back into various compartments of the reactor building, such as the main control room. Thus, it is also important to evaluate the effects of fission products and aerosols that could have potentially been released from the reactor building. While such effects are partially dependent upon scrubbing capabilities prior to the release of any trace gases beyond the boundary of the reactor building walls, meteorological effects, such as wind patterns and precipitation, may also affect overall dose to plant personnel. Wind patterns that force fission products and aerosols to hover over the reactor building increase the amount of risk to plant personnel. Additionally, any precipitation can force airborne sources of radiation to settle on the roof of the reactor building or main control room. As previously mentioned, sophisticated analysis tools are available for calculating such effects.

F.2 Example Plant-specific Dose Calculation

Appendix G provides estimates for containment radiation levels during postulated severe core damage accidents. The above attenuation characterization can be used to estimate radiation levels due to shielding by new or existing structures to demonstrate an acceptable environment for plant staff.

For example, using the attenuation above for a one (1) foot concrete shield, a factor of 1000 reduction in the radiation level can be achieved.

F.3 References

F.3.1 Accident Source terms for Light-Water Nuclear Power Plants, NUREG-1465, February 1995

F.3.2 Clarification of TMI Action Plan Requirements, NUREG 0737, November 1980.

APPENDIX G – METHOD TO EVALUATE SOURCE TERM FOR VENT

The purpose of this appendix is to provide a link to information on methods that are already established in response to regulatory source term considerations for fuel damage and core ex-vessel. The approach proposed to use to evaluate source terms for the HCVS under the severe accident conditions that may be present under a EA-13-109 order scenarios is the information from the various documents used for similar purposes in the industry, such as, Alternative Source Term, Part 100.11, NUREG 1465, SORCA. An example of this is the use of the Source Term from the NUREG 1465 assumption of short term core relocation inside containment because it is conservative for the piping source term application for Order EA-13-109that would occur from a core damage/vessel breach scenario at a later time several hours after SCRAM. The following information provides a general overview of some of those elements for personnel not readily familiar with the NUREG and its application.

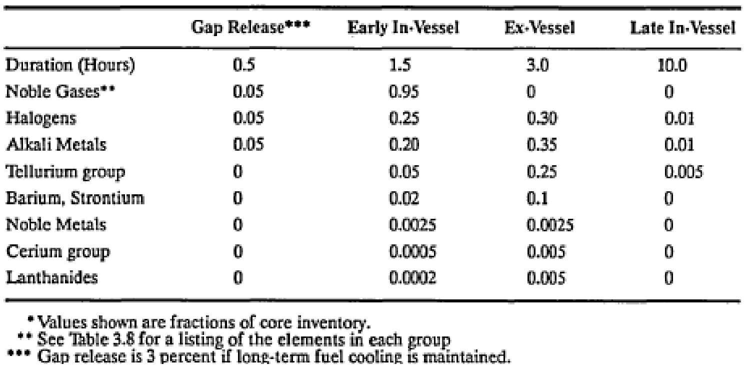
While this appendix purports using the existing regulatory basis it is understood that the severe accident conditions that may be present under a EA-13-109 order scenario are beyond design basis conditions and there is no express or implied change in the regulatory position on other guidelines because of the use of that guidance in this document

G.1 Methodology for Computation of Source Term

The U.S. NRC Response Technical Manual RTM-96 (Ref G-1) contains simple methods for estimating the radiation levels within containment during a core damage event. RTM-96 provides expected containment radiation monitor readings based on fission product inventories as defined in NUREG-1465 (Ref G-2). The source terms defined in NUREG-1465 for cladding damage and overheating damage are summarized in Table G-1:

- Cladding damage releases the gap activity, consisting of approximately 5% of the total core inventory of noble gases and volatile fission products.
- Overheating damage, corresponding to the early in-vessel release phase, releases virtually all of the remaining noble gases and larger amounts of the volatile fission products from the fuel pellets themselves—approximately 25% of the total core inventory of iodine and 20% of the cesium. Smaller amounts of less volatile products may also be released primarily tellurium, strontium, and barium. The total radionuclide content in the primary containment following overheating damage is the sum of the gap activity and early in-vessel releases.

Table G-1: Fission Product releases into Containment



	Gap Release***	Early In-Vessel	Ex-Vessel	Late In-Vessel
Duration (Hours)	0.5	1.5	3.0	10.0
Noble Gases**	0.05	0.95	0	0
Halogens	0.05	0.25	0.30	0.01
Alkali Metals	0.05	0.20	0.35	0.01
Tellurium group	0	0.05	0.25	0.005
Barium, Strontium	0	0.02	0.1	0
Noble Metals	0	0.0025	0.0025	0
Cerium group	0	0.0005	0.005	0
Lanthanides	0	0.0002	0.005	0

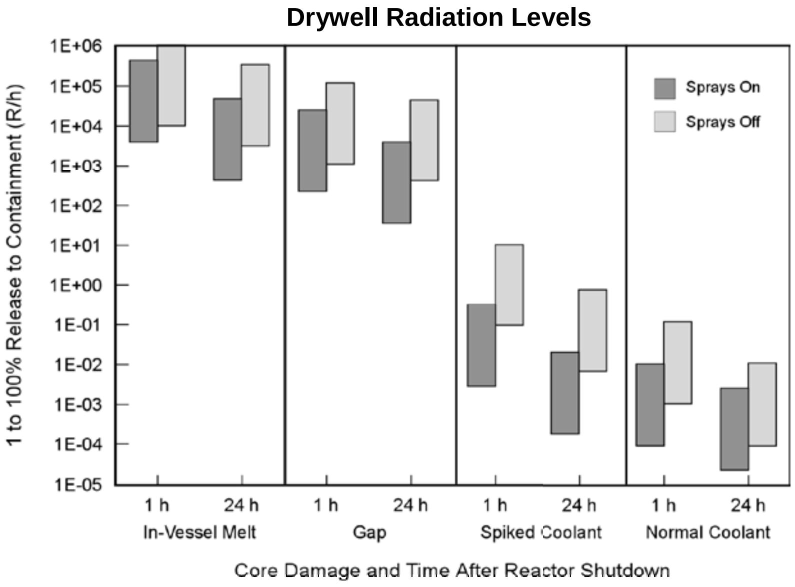
* Values shown are fractions of core inventory.

** See Table 3.8 for a listing of the elements in each group

*** Gap release is 3 percent if long-term fuel cooling is maintained.

Equivalent plant-specific radiation levels may be calculated using any accepted analytical tool. Figure G-1provides representative values for the Mark I and II containment design taken from RTM-96. In general, the radiation levels associated with the onset of cladding damage are expected to be at least two orders of magnitude greater than those attributable to coolant releases and the ranges associated with overheating damage are expected to be approximately one order of magnitude greater than those for cladding damage. The cladding damage and overheating damage ranges each span approximately two orders of magnitude.

G.2 Example Plant-specific Source Term Calculation



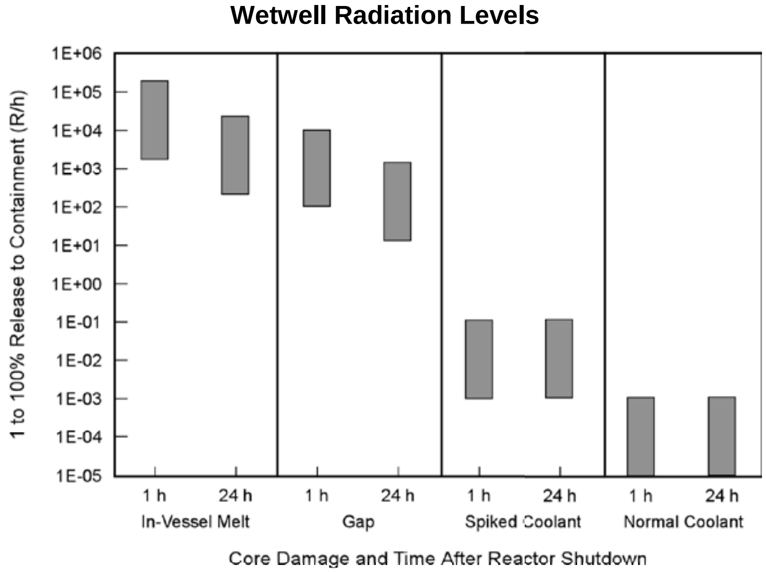


Figure G-1: Mark I/II Primary Containment Radiation Levels (Reference G-1)

The radiation monitor readings as defined in RTM-96 are assumed to provide an adequate estimate for designing the HCVS.

G.3 References

G.3.1 USNRC, “RTM-96, Response Technical Manual,” NUREG/BR-0150, Vol. 1, Rev. 4, March 1996.

G.3.2 Accident Source terms for Light-Water Nuclear Power Plants, NUREG-1465, February 1995

APPENDIX H – METHODS TO ADDRESS CONTROL OF FLAMMABLE GASES

H.1 Bases and Methodology

Order Reference: 1.2.11 – The HCVS shall be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation.

Hydrogen will be produced as a result of core damage during a severe accident. Although not cited in the requirements section of Reference 2 (in particular Requirement 1.2.11 relative to consideration of "hydrogen deflagration or detonation"), carbon monoxide is cited as a combustible gas in the introduction paragraph to Attachment 2 to that reference. Carbon monoxide (CO) can be produced in sufficient quantities to deflagrate and potentially detonate (in a vent pipe) by the process of Molten Core Concrete Interaction (MCCI). This would occur in the most severe of accidents once the reactor vessel is breached and corium has reached (and interacted sufficiently with) the pedestal or lower liner protecting concrete. It should be noted that the potential to produce sufficient quantities of CO is dependent on the aggregate used in the drywell concrete. The chemical makeup of limestone (which contains large amounts of calcium carbonate - $CaCO_3$), will produce CO with a corium interaction. Although the amount of CO produced is relatively small as compared to hydrogen produced by gross metal-water reaction, the potential for a deflagration/detonation cannot be ruled out with limestone aggregate. Basalt based aggregate (which has no appreciable carbon constituents) will produce only minor amounts of CO due to MCCI. Therefore CO production for those plants that utilize that type of aggregate should be considered inconsequential (although a final evaluation should be made by the affected plant).

Detonation of either Hydrogen or CO is not expected to occur in containment, given existing plant controls to ensure the containment remains free of Oxygen. Detonation in the HCVS may occur if venting occurs and Oxygen is allowed to enter the HCVS discharge piping. Air/Oxygen would most likely enter the HCVS piping following a vent cycle, either through steam collapse or by rising Hydrogen leaving the HCVS piping (replaced by inflow of air).

Values are provided for the resultant pressure from a detonation. Calculations for the values presented relative to detonation pressures for hydrogen and carbon monoxide were performed based on methodology presented in Reference 15. Values given are based on resultant pressure following the passage of a detonation wave, often called the Chapman-Jouguet pressure (or C-J pressure). Using that methodology, a formula is set up involving ratios and load factors which provide a pathway to a resultant pressure based on the starting pressure at the time that the combustible gas is ignited. Deflagration to detonation transition (DDT) is assumed such that the detonations are considered with less than accepted detonable combustible gas concentration (~18% for hydrogen). Initial P_0 to P_f ratio for hydrogen is based on ratios provided in Reference 1 (ratio for carbon monoxide is based on information found in

Reference 3) with dynamic load factor (DLF) based on Reference 6 (including a check that the typical resonance velocity of such a detonation in a typical vent pipe section is less than the C-J velocity of a pure stoichiometric mixture of hydrogen and oxygen). A multiplier is also utilized based on the assumption of closed ends on the pipe (although pipe elbows are not closed ends, they do present the opportunity for reflection which enhances the DDT phenomenon) as per Reference 6.

Preventing the detonation in HCVS is possible, either through design of the HCVS to ensure Oxygen is not allowed to enter the piping, or by inerting the HCVS piping after venting. If a detonation is not prevented, the piping should be designed to withstand the detonation without failing.

The size of the vent must meet the criteria cited in Section 4.1.1 of this guidance for the primary design objective of the HCVS is to prevent overpressure failure of the containment prior to core damage and subsequent to core damage. The following sections provide high level methodology and discussion on possible approaches to either prevent or withstand a detonation during or following venting through the HCVS. The approaches discussed below are not considered to be the only possible approaches to protecting the HCVS. Alternative design approaches are considered acceptable, provided that either detonation in the HCVS is prevented or the system is designed to withstand the possible detonation of Hydrogen or CO.

H.2 Design Systems to Prevent Detonation/Deflagration

Design of the HVCS may include features that prevent air/oxygen backflow into the discharge piping. Use of design features in sections of pipe susceptible to air intrusion from intermittent HCVS operation can also be used to minimize detonation/deflagration potential.

There are several possible approaches to be able to prevent air from entering the discharge piping:

> One approach is to use an isolation valve or other device (e.g., similar to a loop-seal device) at the discharge point of the vent. If an isolation system is used to prevent air back-flow, the system should account for the possible vacuum created by the cooling of steam in the susceptible piping sections once the HCVS isolation valves are closed. However, there are difficulties related to this option due to the operational burden for periodic system checks and replenishment of water required during vent operation.
>
> A water-based filter may also prevent air from entering the upstream piping entering the filter. The design should consider that the vacuum generated in the piping could result in sufficient air leakage that can result in a mixture that can detonate. However, difficulties associated with this are back pressure concerns, contamination of the medium and fouling as well as replenishment during vent operation.
>
> Another possible approach to prevent detonation is to size the vent such that continuous venting occurs, once the vent is opened. This can also be

accomplished through use of a flow-control valve restricting vent flow. This approach would be used if the containment would be expected to remain pressurized for an extended period (e.g., sustained operation) given a severe accident has occurred and no containment cooling is provided. The use of a continuous vent operation should include several high level features:

1) Procedural guidance should ensure the HCVS operation begins prior to the production of Hydrogen or CO. This will prevent any detonation when the initial venting occurs.
2) Spurious Closure of the HCVS isolation valves should be prevented through the use of designing valves using this guidance. Protection from automatic closure signals should be provided.
3) The design should include methods for purging the HCVS piping following completion of the containment venting. Use of portable bottles or similar is considered sufficient for this process. See discussion below for attributes important to the use of a purge system.
4) As with any containment atmosphere control/venting strategy, controls must be in place (administrative or otherwise) to prevent negative pressure inside containment drawing air/oxygen back into that volume.

The feasibility of a continuous vent path for all scenarios would need to be evaluated.

H.3 Vent Path Inerting

Use of a purge system in sections of pipe susceptible to air intrusion from intermittent HCVS operation can also be used to minimize detonation/ deflagration potential. Given the pressure and significant flow through the HCVS when the vent is initially opened, it is not expected that a detonation would occur in the HCVS line when the vent process begins. Detonation is a concern; however, once the vent line is closed, as air enters the piping following steam condensation or Hydrogen gas leaving the discharge. Therefore, purging of the line may be considered as a mitigation strategy immediately following the closure of the HVCS isolation valves.

Additionally, purge system operation should account for any piping elevation changes, where oxygen, Hydrogen or CO might accumulate at a high point in non-inerted piping in the HCVS.

Alternatively; the design may utilize an inert gas system which provides positive pressure in the vent pipe above atmospheric. Use of a continuously operating system should consider the elevation of the HCVS discharge to ensure positive flow through the system when containment vent is not occurring.

H.4 Design HCVS Piping for Detonation

Methods of designing the HCVS piping/components against flammable gas detonation/deflagration are discussed below. Susceptible portions of the piping should be determined based on where oxygen can be drawn into the piping/interfacing piping.

The evaluation of gas ignition is to document the capability of the HCVS piping to maintain integrity should deflagration or detonation occurs. Deformation of the pipe is acceptable given the integrity of the pipe is shown to be maintained.

The design of the HCVS is required to withstand the dynamic loading resulting from hydrogen deflagration/detonation. For design purposes, the HCVS is not required to consider assumed simultaneous loads that would not be present or occur during the venting of hydrogen (e.g. seismic loads).

The following provides a list of steps to be considered to ensure the HCVS is properly designed to tolerate a possible hydrogen deflagration/detonation:

1. Review the history/commitments of associated site equipment
    a. Research existing/similar piping system(s) for:
        1) ASME Code commitments.
        2) Seismic Classification.
        3) Current Service Level of like/similar equipment.
2. Establish classifications of new piping or piping to be modified
    a. New loading combinations for pipe in standby (with Containment Isolation Valves -CIV(s) closed
        1) Consider hydrogen detonation pressure loading (7878 kPa/1143 psia).
        2) If it is determined that a potential carbon monoxide detonation could occur, consider a detonation pressure loading of 9393 kPa (1362 psia) instead of the value for hydrogen cited in 2.a.i (See Note 3).
        3) Determine the additional loads (both dynamic and static) which should be considered the detonation load (if the option to design the vent to accommodate a detonation is chosen.) Note that, if a filter is used in the vent system, its ability to accommodate a potential hydrogen detonation should be a consideration.
    b. New loading combinations for pipe in operation
        1) Determine max pipe metal temperature.
        2) Determine max pressure based on “Order” sections 1.2.1 and 1.2.8.
        3) Determine applicability of seismic loading.
        4) Determine the probability of occurrence and the ASME classification as suggested in the next section.

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[3] Note: Although Reference 2 cites carbon monoxide as an example of a “severe accident condition” combustible gas in the introduction paragraph of Attachment 2, that compound is not cited again in Requirement 1.2.11 as having the potential to deflagrate or detonate.

3. Establish configuration for new/modified pipe
    a. Configure piping to meet applicable requirements of the "Order."
4. Determine maximum stresses on vent piping
    a. Considerations
        1) Set load combination using detonation load as dominant for each stress category. For example:
            a) General membrane (pipe pressure retaining material shell).
            b) Local membrane.
            c) Bending.
        2) Consider worst case thrust load due to detonation, for example:
            a) Maximum pressure.
            b) Maximum temperature.
            c) Acoustic wave load for each pipe segment.
            d) Dynamic responses and bending moments.
        3) Design the pipe supports
            a) Evaluate the existing pipe supports (if applicable) and allowable loads.
            b) Perform stress analysis of the pipe to determine the support system so that all the stresses meet allowable limits.
            c) Perform support design and also determine whether the existing supports meet the design requirements.
        4) There are many pipe stress analysis codes available in the market and each utility may have their own standard. Individual sites are expected to use pipe stress analysis codes that comply with that station's design process.

H.4.1 Suggested Classification and Load Combination Approach based on Contemporary Guidance

This section provides a suggested Service Level classification and Load Combination for the particular case of detonation loading from a combustible gas detonation. Individual sites must determine the applicability of this approach with respect to their unique site requirements and piping design commitments.

Code Class - Document 10CFR50.55a recommends RG 1.26 (Reference 9) as offering guidance for Quality Groups which provide an indication for ASME Code classifications. Per the cited regulatory guide (see Section 2.(d)), the piping associated with the HCVS downstream from the second containment isolation valve should be considered as Quality Group C based on the risk of ground level release due to vent integrity failure. This is considered analogous to ASME Code Class III. As such, ASME Section III, Subsection ND is used to provide guidance for the allowable stresses for this material. ND-3600 is used for piping design.

Service Level – NUREG-0661 (Reference 11) provides guidance for consideration of service “limits” in Section 4.3. Note that “limit” and “level” are considered to be interchangeable. Both Service Level C and Service Level D are cited under sub-sections 4.3.1.3 and 4.3.1.4 (respectively). Both of these service levels are considered to be associated with low-probability events. However, combining this reference with Reference 10, Service Level C is the only level which is cited as applicable to hydrogen detonations (see further information below relative to RG-1.57). As such, Service Level C is considered appropriate for this loading.

Load Combinations - In the “Background” Section of RG 1.57 (Reference 10), 10 CFR 50.44(b)(5)(v)(B) is cited as the basis for a statement saying that, “systems and components necessary to…maintain containment integrity will be capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen, including local detonations, unless such detonations can be shown to be unlikely to occur.” This statement specifically refers to Mark III containments as Mark I and Mark II containments require an inert atmosphere. However, in the venting case considered, the isolated vent systems in these models can no longer rely on the inerted containment effluent to prevent hydrogen detonations; therefore, these loads typically reserved for Mark III containments should be considered for this isolated extension of containment in this particular scenario. Such a scenario (conducive to a local detonation) can only be typified as a severe accident.

With respect to the SSE it is understood that (based on the example of Fukushima Dai-ichi) a SSE may well be the precursor to an accident which could evolve into a severe accident (including core damage and hydrogen generation). And aftershocks will likely occur after the initial earthquake. However these aftershocks (along with the earthquake itself) are typically not long duration events. They are more typically lower in magnitude, short and sporadic. As discussed in I.B.3(c) in Part C of RG 1.57, the Service Level C load combinations, all consider the SSE except for those combinations which deal with pressure from hydrogen generation or hydrogen burning. Considering the minimal opportunity for a hydrogen detonation to occur in a vent pipe, that pipe would not be expected to experience these 2 unlikely loading conditions simultaneously.

With the SSE not considered in the loading combination, the remaining loading combination to be considered for combustible gas detonation load (based on Reference 10 guidance) is as follows:

$$D + Pg_2 + T_0 + R_0$$

Or - Dead load+Detonation Pressure load+Thermal load+Pipe Reaction load

Where:

D = Dead loads
Pg_2 = Pressure resulting from uncontrolled hydrogen burning (this is considered as detonation pressure).
T_0 = Most critical thermal loads (assumed to be effluent temperature).
R_0 = Pipe reaction load (assumed to be thrust loading from detonation)
P_0 = Any external pressure loading based on variations in ambient pressure (outside of vent piping)

Note that peak temperature (due to detonation) will lag behind the detonation pressure load such that T_0 would be minimal. Pipe reaction load will be determined by pipe designers.

H.4.2. Methodology

The loading being considered (hydrogen detonation) is considered as a Service Level C (Emergency) condition. As such the allowable stress allowance provided in ND-3654.1 may be utilized. Section 4.3 of NUREG-0661, Service Level C is characterized as applicable to design basis type events. As the precursor to such a detonation (release of hydrogen during a severe accident) would be characterized as a well beyond design basis accident that deteriorates into a severe accident with core damage, and the aforementioned required conditions for an actual detonation to occur are so remote, Service Level D allowable stresses may be considered appropriate for this scenario. However, it is understood that the intent of the Level D limit is to withstand a single occurrence. It is expected that the vent be capable of withstanding multiple hydrogen detonations; therefore, Service Level D alone would not provide the margin required to ensure system functionality.

The purpose of this evaluation is not to consider the vent system function, only that the occurrence of hydrogen detonations (as stated in this document) will not cause a failure of the pipe's pressure retaining capability. System function and component survivability to perform that function will be addressed in the final design detailed analysis for the system.

H.4.2.1 Bases for Loading due to Detonation

In order to address the Reference 2, Requirement 1.2.11 statement that the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation, a simplified evaluation can be performed using standard methods.

H.4.2.2 Detonation Pressure Considered for Carbon Monoxide

Once CO is a part of the vented gas, deflagration/detonation (of CO) will occur much the same as it would for hydrogen as outlined above.

H.5 Discussion

Based on the conclusions/positions stated above, the potential scenario of concern would be one in which steam collapses in an HCVS after fuel damage (and after the venting off of the majority of the original nitrogen loading) and draws outside air back into the vent system. This is the only scenario with reasonable potential to cause the formation of a deflagrable mixture. As such, it is the scenario to be considered in an evaluation of a potential hydrogen deflagration and the worst case damage which could occur.

With typical calculated pressure loadings using methods above, many standard grades and thicknesses of the commonly used SA-106 pipe could accommodate the stresses from such a loading condition. Stress calculations utilizing contemporary ASME Section III formulae show that such a loading can be accommodated by standard SA-106 Gr A 12” pipe prior to any corrosion considerations. Since this pipe will be isolated normally and not subject to typical flow conditions, corrosion can be considered negligible. However, due to the dynamic loading induced on a typical piping system (with bends and elbows) by such a pressure spike, the actual stresses experienced for any given vent system will be dependent on the piping system configuration and support structures.

H.6 References

H.6.1. J. E. Shepherd, “Structural Response of Piping to Internal Gas Detonation.” ASME Pressure Vessels and Piping Conference, 2006. VP2006-ICPVT11-93670, presented July 23-27, 2006 Vancouver BC, Canada.

H.6.2. USNRC EA-13-109, “Issuance of Order to Modify Licenses with Regard to reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, “ dated June 6, 2013. ML13143A321.

H.6.3. C-J Detonation Studies in Hydrogen-Chlorine, Carbon Disulfide-Oxygen and Carbon Monoxide-Hydrogen-Oxygen-Nitrogen Mixtures, Christiane M. Guirao, et al, McGill University, July 1972.

H.6.4. “Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants,” International Atomic Energy Agency, Vienna, 2011.

H.6.5. NUREG-1367, “Functional Capability of Piping Systems.”

H.6.6. J. E. Shepherd, A. Teodorcyzk, R. Knystautas, J. H. Lee, “Shock Waves Produced by Reflected Detonations.” Progress in Astronautics and Aeronautics 134, 244-264.

H.6.7. “Combustion of BWR-Typical Radiolytic Gas Mixtures,” Final Report for the International Radiolytic Gas Combustion Project, VGB-Contract SA “AT” 13/04, December, 2007.

H.6.8. ASME Boiler and Pressure Vessel Code, Section III.

H.6.9. Regulatory Guide 1.26, “Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants,” revision 4.

H.6.10. Regulatory Guide 1.57, “Design Limits and Loading Combinations for metal Primary Reactor Containment System Components,” Revision 2.

H.6.11. NUREG-0661, “Safety Evaluation Report, Mark I Containment, Long-Term Program,” March 1980.

H.6.12. Comparison of critical conditions for DDT in regular and irregular cellular detonation systems; M.S. Kuznetsov et al, May 2000.

H.6.13. NRC Inspection Manual, Temporary Instruction 2515/121, (as associated with) Verification of Mark I Hardened Vent Modifications (GL 89-16), 5/24/94.

H.6.14. JLD-ISG-2012-02, Compliance with Order EA-12-050, Reliable Hardened Containment Vents, Interim Staff Guidance, Revision 0, September 29, 2012.

H.6.15. NEDO-33572, Revision 3, Licensing Topical Report, ESBWR ICS and PCCS Condenser Combustible Gas Mitigation and Structural Evaluation, September 2010.

APPENDIX I – SEVERE ACCIDENT WATER ADDITION (SAWA)

The purpose of this appendix is to provide guidance for implementing SAWA, which may be used in combination with a severe accident capable drywell vent designed to 545°F as described in Section 2 or in combination with Severe Accident Water Management as described in Appendix C.

I.1 Severe Accident Water Addition (SAWA)

I.1.1 This section will define the hardware requirements necessary to support SAWA including:

- Hardened piping and valves to w**W**ater addition point
- RPV Pressure Control
- Water addition source
- Motive force
- Instrumentation
- Severe accident considerations

I.1.2 Water Addition Point

I.1.2.1 The water addition point may be either to the RPV or to the Drywell.

I.1.2.1.1 The RPV addition point is generally preferred because:

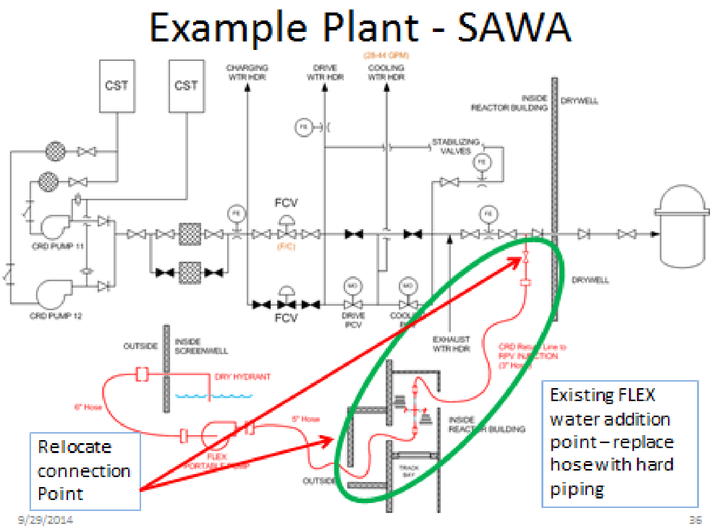
- it provides quenching and cooling for core debris and deposited fission products/aerosols remaining within the RPV
- It provides in-vessel retention (no RPV breach) of core debris for a subset of dominant accident sequences as demonstrated in the CPRR technical analysis.
- SAWA will follow the path of core debris exiting the RPV on a breach

I.1.2.1.2 There are other plant specific factors that may make the RPV injection point less preferred, such as accessibility under severe accident conditions. If the selected addition point will be based on plant specific design features, the licensee should state the selection and reason in the Phase 2 OIP.

Comment [N41]: On the other hand, water addition to the drywell can be readied and placed in operation early to be able to be able to have more water on the floor when vessel breach occurs. In addition, it can also be done without the need to depressurize the RPV.

Comment [N42]: If the water addition point follows the example plant sketch, why would accessibility be any worse?

Comment [N43]: Given the guidance and the discussion, all plants should do this (i.e. provide the selection and reason).



Example Plant - SAWA

Relocate connection Point

Existing FLEX water addition point – replace hose with hard piping

9/29/2014

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I.1.3 RPV Pressure Control

I.1.3.1 All plants will have methods available to extend the operational capability of manual pressure control using SRVs. Assessment of manual SRV pressure control capability for use of SAWA during the Order defined accident is unnecessary for the following reasons.

I.1.3.1.1 RPV depressurization is directed by the EPGs in all cases prior to entry into the SAGs.

- This is true even in the case where RPV depressurization is terminated to preserve steam driven injection in the EOPs.
    - o Upon loss of the steam driven injection, the RPV depressurization is completed before entry into the SAGs, and this is accomplished by use of the SRVs dedicated to the Automatic Depressurization System (ADS).
- Once the ADS SRVs are opened, they remain open with no further cycling. The ADS system is

comprised of DC powered solenoids, dedicated pneumatic tanks and controls and instrumentation necessary to support the system.

- The mitigating strategies developed to support Order EA-12-049 provide AC power to battery chargers to maintain critical DC loads, which includes the ADS system.

I.1.3.1.2 If a Drywell water addition point is selected, water addition will be possible independent of RPV pressure.

Comment [N44]: Does this change the number of pumps required under provisions of Order EA-12-049?

I.1.4 Water Addition Source

I.1.4.1 The water addition source, whether to RPV or drywell, should be capable of the flow rate and pressures as determined by the analysis performed for compliance with NRC Order EA 12-049.

Comment [N45]: The flow rates are determined by Order EA-13-109 and the CPRRR.

I.1.4.2 The time to establish the water addition capability in I.1.4.1 should be less than 7 hours from the onset of the ELAP event (before NUREG/CR 7110, Vol. 1, RPV Breach at 8.2 hours).

I.1.4.2.1 Water addition, before 8.2 hours, prior to RPV breach is conservative

I.1.4.2.2 In lieu of the using 7 hours, licensees may perform a plant-specific analysis that documents successful containment function preservation with an injection commencing at a time later than 7 hours.

Comment [N46]: Why is this necessary? To put it in another way, what is it the licensees would be doing differently, if for instance, time changed from 7 to 8 or 9 hours? Does this also mean that the assumption of RPV breach at 8.2 hours will change? Replace the word "injection" with "water addition" to avoid any misunderstanding.

I.1.4.3 Plant connection points and portable pumps satisfying the requirements of EA-12-049 may be credited for meeting I.1.4.1 and I.1.4.2 provided the actions necessary to deploy and maintain equipment can be performed under the thermal and radiological conditions that exist during a severe accident as defined by EA-13-109 and this document. This meets the requirements of Sections 4.1.3, 4.2.5, and 4.2.6 of this document.

I.1.4.3.1 When performing evaluations of radiological conditions, guidance from HCVS-WP-02 may be used.

I.1.4.3.2 Guidance from HCVS-WP-04 and HCVS-FAQ-09 may be used to evaluate and define actions to improve accessibility for deployment of water addition equipment

I.1.5. Motive Force

I.1.5.1 Power and pneumatic sources supporting the wetwell vent path are defined in Sections 2.5, 4.2.2, 4.2.6 and 6.1 of this document. These requirements will not be changed by this Appendix.

I.1.5.2 Diesel or electric driven installed or portable pumps may be used as water sources. As described in I.1.4.3, pumps used to satisfy the requirements of EA-12-049 may be credited for meeting I.1.4.1 and I.1.4.2.

I.1.5.3 Electrical generators satisfying the requirements of EA-12-049 may be credited for powering components and instrumentation needed to establish a flow path from the water source to the addition point provided the actions necessary to deploy and maintain equipment can be performed under the thermal and radiological conditions that may exist during a severe accident as defined by EA-13-109 and this document.

I.1.5.3.1 When performing evaluations of radiological conditions, guidance from HCVS-WP-02 may be used.

I.1.5.3.2 Guidance from HCVS-WP-04 and HCVS-FAQ-09 may be used to evaluate and define actions to improve accessibility for deployment of water addition equipment.

I.1.6 Instrumentation

I.1.6.1 Instrumentation supporting the wetwell vent path is defined in Sections 4.2.2 and 4.2.4 of this document. These requirements will not be changed by this Appendix.

Comment [N47]: This section, for most part, is a repeat of what is in Section C.2.4 (Appendix C). Staff's recommendation is to leave the requirement in Appendix I and make a cross reference to Appendix I in Appendix C. Also, include any additional requirements for SAWM in Appendix C (e.g. accomplishment of flow modulation).

I.1.6.2 Containment Pressure and Wetwell level are indications needed to support water addition and water management in the accident stabilization phase. These indications are addressed by Section 4.2.2.1.9 of this document and are adequate to support Phase 2 implementation.

I.1.6.3 Monitoring wetwell level will also provide feedback to the operator that a flow path has been established.

I.1.6.3.1 Operators may have additional indications available at the installed or portable pump location to determine that flow is occurring.

I.1.6.4 The instrumentation described in I.1.6.2 is part of the set of post-accident monitoring instruments and, for most plants, conforms to Regulatory Guide (RG) 1.97. Pre RG 1.97 plants have similar qualification requirements for this set of instrumentation.

I.1.7 Severe Accident Considerations

I.1.7.1 Severe accident considerations for water addition are limited to the thermal and radiological impacts on operator actions that may exist under severe accident conditions assumed in Order EA-13-109 and as defined in this document.

I.1.7.1 Water addition elements are not considered susceptible to the effects of combustible gas detonation or extreme high temperature associated with severe accident conditions.

I.1.7.2 Guidance for addressing radiological and thermal impacts on operator actions is provided in applicable sections of this Appendix and Sections 4.2 and 6.1 of this document.

I.1.7.3 SAWA Flow rate is dependent on pump capacity. Section 4.1.1 does not apply as the use of SAWA at the seven hour point would be less than the 1% decay heat specified.

Comment [N48]: Provide more specific guidance on flow requirements for SAWA and SAWM, including how the pumps under EA-12-049 would meet the requirements.

APPENDIX J – FREQUENTLY ASKED QUESTIONS

A. TOPIC: HCVS Primary and Alternate Controls and Monitoring locations Inq. No.: HCVS-FAQ-01

Source document: NEI 13-02

Sections: Order EA-13-109, Element 1.2.4, 1.2.5, 1.2.6, NEI 13-02 Section 4.2.2 and 4.2.3

B. DESCRIPTION:

What radiological and thermal conditions have to be considered in the design and location of the Primary (1.2.4) and Alternate (1.2.5) Controls locations?

Order Element 1.2.4 states, “The HCVS shall be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location.”

Order Element 1.2.5 states, “The HCVS shall, in addition to meeting the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations.

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 3)

Use of Main Control Room (MCR) as the preferred location for primary and/or alternate control stations is acceptable because the MCR is designed to conform to GDC 19/Alternate Source Term (AST) for radiation shielding considerations. Not having power for MCR is not a factor. During an ELAP event, there is no motive force to move source term contaminants into the control room envelope with the exception of natural circulation. Adequate protective clothing and respirators are available near the MCR to address contamination issues. Thus no evaluation is required for use of the MCR as the preferred location.

Primary and/or Alternate Control locations located outside the main control room must be determined to be readily accessible locations by performing an evaluation that includes:

- Accessibility
- Habitability
- Staffing sufficiency
- Communication capability with vent use decision makers

When evaluating accessibility and habitability of control locations outside the Control Room, consider the following:

Environmental Conditions:

Thermal Considerations: (Response support Order Elements 1.1.2 and 1.1.4):

- Temperature and heat load that exist from operation of the HCVS system
- Temperature and heat load that exist due to proximity to the undercooled containment including under severe accident conditions.

- Temperature and heat load that exists due to the ELAP condition (loss of ventilation). Action taken to provide ventilation may be considered when evaluating habitability.
- Thermal impact to the Spent Fuel Pool Area caused by the ELAP condition, but for at least one unit per site full core off load need not be considered since HCVS operation is not required when a reactors core is off loaded into the SFP.

Radiological Considerations: (Response support Order Elements 1.1.3)

- Radiological conditions that exist from operation of the HCVS system

The specific event progression that leads to the Severe Accident is NOT specified and does not have to include source terms from loss of Spent Fuel Pool Cooling as this would presume that the event progression that leads to the Severe Accident also prevents or causes the mitigating measures for loss of Spent Fuel Pool Cooling to fail. Order element 1.1.3 does discuss the requirement to consider the dose and radiological conditions caused by operation of the HCVS system but not failure of Mitigating systems related to Spent Fuel Pool Cooling.

Operator conditions: This would be governed by the above environmental conditions. Temperature conditions should be such that occupancy stay times consistent with the time to conduct HCVS operation and monitoring (instrumentation controls and displays) functions from the primary and/or alternate locations.

Communication capability does not necessarily have to be direct between the operator performing the HCVS operations and the decision maker but must be reliable and accessible while HCVS operation is required.

Time frame:

Time frames are typically associated with pre and post 24 hour actions as illustrated in Order element 1.2.6, which states: “The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power.”

This means that with minimal operator action the equipment should be capable of operating in the thermal and radiological environment for at least 24 hours. Other provisions of NEI-13-02 such as the definition of “Sustained Operations” extend this time but do NOT preclude mitigating measures from FLEX or offsite support for reduction of thermal impacts (e.g. portable fans, AC power for ventilation, possible cooling water supplies to the area coolers if part of the FLEX mitigating measures). The restriction on permanently installed equipment only exists for the 24 hour period to ensure HCVS functionality for at least a 24 hour mission time without significant operator action to maintain functionality. However, all portable equipment usage needed for HCVS operation will be evaluated to be capable of operating in the thermal and radiological environment during severe accident conditions. See FAQ HCVS-02 on Order Element 1.2.6 use of “dedicated equipment”. This time frame concept may be applied to operator accessibility and habitability for primary control locations outside of the control room. The HCVS OIP should include the actions relied upon for HCVS initiation and if the actions are coming from some other guidance such as FLEX, provide a cross reference to where the information can be found.

Radiological conditions will also vary with the source term over time and could either drop or rise depending on deposition of source term in the HCVS system and vent system use. This will have to be accounted for over the time frame during which the HCVS system is being used. The definition of "sustained operation" prescribes this time frame based on when other containment cooling measures are put in place and when HCVS system operation ceases.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 3)

The proposed resolution is correct. Discussed with NRC in Public meetings in January, February and March 2014. Discussed MCR rewrite on May 22 conference call

Revision: 3 Date: May 22, 2014

E. NRC Review:

Not Necessary______ Interpretation X Agency Position______

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. Incorporated additional comments from NEI workshop on April 10, 2014. Addressed MCR comments received 4/14/2014

F. Industry Approval:

Documentation Method: FAQ Date: 05/22/2014

A. TOPIC: HCVS Dedicated Equipment

Inq. No.: HCVS-FAQ-02

Source document: EA-13-109 / NEI 13-02

Sections: EA-13-109, Element 1.2.6, NEI 13-02 Sec 4.1.2, 4.2.1.1, 4.2.6.1.2,

B. DESCRIPTION:

What is the meaning of "Dedicated" in order element 1.2.6, "**Order Reference: 1.2.6** – The HCVS shall be capable of operating **with dedicated and permanently installed equipment for at least 24 hours** following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power."?

This FAQ does not address "dedicated" motive force which is addressed in white paper HCVS-WP-01.

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 2)

The classical definition of "dedicated" is "*used only for one particular purpose [function]".*

- Dictionary.com – *set apart or reserved for a specific use or purpose*
- Merriam-webster.com – *used only for one particular purpose, given over to a particular purpose*

Using this literal interpretation, the words of Order element 1.26 means that all equipment associated with the HCVS should be permanently installed and only serve the HCVS function. This is inconsistent with other Order elements that permit shared component functions as discussed below:

- HCVS components may serve multiple functions described in the plant Current License Basis (CLB). Examples include:
  - ✓ Piping, valves and penetrations for both Drywell and Wetwell may be used for Drywell/Wetwell vent and purge prior to or following refueling outages or for pressure control during normal plant operation.
  - ✓ Containment Isolation valves in the HCVS system may provide a containment isolation function independent of the HCVS function.
  - ✓ Containment Isolation valve position indication for valves in the HCVS may be used for post-accident indications.
  - ✓ Instrumentation supporting HCVS and non HCVS functions.
- Some components in the HCVS system are powered electrically or pneumatically by non-dedicated sources to support non-HCVS functions as described in the plant CLB documents. Examples include:
  - ✓ Power to solenoids for Primary Containment Isolation valves.
  - ✓ Plant safety related air or nitrogen systems to operate isolation valves.
  - ✓ DC power from station batteries to instrumentation and indications for valves.

In summary, the correct interpretation of the word "dedicated" in the context of the HCVS order is essential for the proper implementation of the order.

The following components are examples of what does not have to be dedicated to the HCVS function and may be shared with other systems and support functions:

- Containment penetrations
- Containment isolation valves
- System boundary valves
- Piping
- Instrumentation
- Wiring, conduit and connection points used to service non-dedicated components

While the above components need not be dedicated, they need to be available to support HCVS function when containment venting using the HCVS system is required. Compliance with NEI 13-02 guidance will ensure that this condition is met.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 2)

The proposed resolution is correct and discussed with NRC in Public meetings in January and February 2014.

Revision: 0 Date: March 11, 2014

E. NRC Review:

Not Necessary__________ Interpretation X Agency Position_________

Explanation:____

F. Industry Approval:

Documentation Method: FAQ Date: March 11, 2014

A. TOPIC: HCVS Alternate Control Operating Mechanisms

Inq. No.: HCVS-FAQ-03

Source document: NEI 13-02

Sections: Order EA-13-109, Element 1.2.5, 1.2.6, NEI 13-02 Section 4.2.3

B. DESCRIPTION:

What means of alternate manual operation is allowable for use in the HCVS system?

Order Element 1.2.5 states, "The HCVS shall, in addition to meeting the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations."

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 2)

The examples of alternate operating mechanisms provided in Order element 1.2.5 (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location) are only intended to be examples. Other means of alternate manual operation (mechanical or single electrical source and single solenoid pneumatic supply valve independent) are acceptable including but not limited to:

- Separate electrical components with diverse and flexible power supplies (such as the normal valve operators with FLEX power)*
- Solenoid valves with manual overrides that may be used to manually operate vent valves without electrical power
- Manual valves in pneumatic supply and vent lines that may be used to manually operate vent valves independent of solenoid valves or electrical power
- Hydraulic operators

The inclusion of direct operation capability for valves is acceptable.

* NEI 13-02 Section 6.1 – "…At least one method of operation of the HCVS should be capable of operating with permanently installed equipment for at least 24 hours during the extended loss of AC power. The system should be designed to function in this mode with permanently installed equipment providing electrical power (e.g., DC power batteries or electrical or pneumatic operation) valve motive force (e.g., N_2/air cylinders)" A method (primary or alternate) of HCVS operation may use an alternative method to that described by the 1.2.5 requirement.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 2)

The proposed resolution is correct. Discussed with NRC in Public meetings in January, February and March 2014. NRC conference call on May 22, 2014.

Revision: 2

Date: May 22, 2014

E. NRC Review:

Not Necessary__________ Interpretation X Agency Position__________

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. NRC comment on electrical power supply discussed on May 22, 2014 call.

F. Industry Approval:

Documentation Method: FAQ

Date: 05/22/2014

A. TOPIC: HCVS Release Point

Inq. No.: HCVS-FAQ-04

Source document: NEI 13-02

Sections: Order EA-13-109, Element 1.2.2, and NEI 13-02 Section 4.1.5

B. DESCRIPTION:

What is the meaning of “release point above main plant structures” in order element 1.2., “**Order Reference: 1.2.2** – The HCVS shall discharge the effluent to a release point above main plant structures.”?

To be more specific, how high should the vent release point be above the building that it is based upon/emanates from and what considerations apply with respect to adjacent buildings/structures?

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 4)

As is stated in Attachment 2 to the Order, “the HCVS shall be designed for those accident conditions (before and after core damage) for which containment venting is relied upon to reduce the probability of containment failure…”. To paraphrase, the vent is designed to protect the containment against overpressurization in a beyond design basis accident such that the release of radioactive effluent will be maintained as a controlled process. This control would be lost if primary containment fails.

It is understood that the existing Plant Stack provides an acceptable release point. This is considered valid so long as it is the highest elevated release point existing at the site. It is also understood that, if the Plant Stack is used for this purpose, measures to prevent combustible gas cross-flow between plant units and into other systems must be adequately evaluated and corrective measures must be in place (if shared with another unit’s HCVS).

This response is written to address plants that have a single independent release pipe/vent per unit. This would be typically mounted onto (or emanating from) the Reactor Building, the Turbine Building, or other adjacent building convenient for the HCVS routing. This release point should only be used when venting during events which are outside of the design basis of the plant (i.e., venting for conditions from normal operation up to and including design basis accidents should be performed using ‘normal’ containment venting systems rather than the severe accident capable hardened containment venting system).

Guidance for HCVS elevated release points is separated out into a series of topics which are presented below. A synopsis of the bases for each recommendation is presented with each topic. The individual sites are encouraged to utilize this guidance as seen fit but also understand that they may take exception to any such guidance they choose with reasonable basis. This is also applicable to site specific conditions which are outside the bounds of this guidance. Note that in the case of multi-unit sites with single vents for each unit, adjacent unit emergency intake and exhaust pathways should also be considered relative to each of these 3 topics separately.

1. Release Point Height –

   The elevated release point should be at least 3’ above the roof and related structures of the building that it emanates from. Related structures, in this case, is intended to be any appurtenances associated with the building proper (e.g., parapet walls, etc.). This value agrees with accepted industry practice for roof vents. This is also considered as reasonable based on the minimal frequency at which this system is considered to be used along with the relative buoyancy, relative temperature and potentially high flowrate of the released effluent (would tend to be minimally affected by building and structure effects). Exhaust stack design considerations are dependent on the purpose for containment venting.

a) Anticipatory venting to maintain core cooling

- When venting is performed at low containment pressure to maintain core cooling using FLEX strategies, there is no minimum required exhaust stack exit velocity, since without core damage there will be negligible levels of radionuclides and/or combustible gas in the effluent. Therefore, there is no concern with entrainment of the stack effluent into the roof or downstream recirculation zones associated with airflow around the building.

b) Severe accident venting to maintain containment integrity

- The potential presence of significant quantities of radionuclides and/or combustible gas in the vent stack effluent requires additional restrictions to be applied to the design and operation of the vent under severe accident conditions.
- ASHRAE HVAC Applications and Fundamental Handbooks discuss design requirements of exhaust vent stacks, but over the years the focus of the design of the vent stack was changed from the perspective of an ‘Industrial Exhaust System’ to that of a ‘Building Exhaust System’. The 2003 ASHRAE HVAC Applications was the last edition that emphasized the design of the vent stack from an industrial ventilation perspective. Hence, the 2003 ASHRAE HVAC Applications Handbook Chapter 26 is used as the guidance document, and it says that an effluent release velocity of 8000 fpm will assure that the effluent plume will not be entrained into the roof recirculation zone of a given building. Vent pipe design (e.g., pipe diameter at the exit) and conditions under which the vent is operated (e.g., minimum containment pressure at which the vent is operated; use of flow control devices) should be considered to ensure this is the predominant minimum release velocity under severe accident conditions.
    - It should be noted at this point however that strict adherence to all available guidance is not considered practical or reasonable for all aspects of the beyond design basis venting operation. It is realized that, at some point during the venting process, the containment pressure may continue to drop such that effluent flow will be reduced and effluent release velocity may drop below the stated 8000 fpm value.
    - However it must also be realized that venting of the containment volume at the accident pressures is considered to be predominately a high velocity evolution such that for the vast majority of time the effluent will be jetted up beyond the affected building recirculation zone. Effluent will not simply waft across a building roof as if released by a predominantly buoyancy driven exhaust stack but will be jetted upward from the vent due to momentum. Hence, it should be understood that by nature of any venting strategy there may be times when the effluent release velocity may drop below the stated 8000 fpm.
    - Under severe accident conditions the main purpose of the vent is to protect the containment function and use of the vent should not be limited by an effluent release velocity of 8000 fpm (e.g., venting at low pressure may be required to optimize the timing of a release or to optimize a venting strategy). In such cases, the margin in containment pressure gained by venting is more important than dispersion of the effluent.

- This value is supported by an evaluation based on several references (e.g., “Turbulent Jets and Plumes: A Lagrangian Approach,” Lee & Chu, 2003, “Evaluation of the Effects and Consequences of Major Accidents in Industrial Plants,” Casal, 2008) and this provides further basis that the momentum driven flow from a vent will neither be appreciably affected by the roof recirculation zone nor will the effluent be effectively entrained into air in the recirculation zone.

2. Release Point Structural Requirements -

   Missile protection evaluation is required for piping segments outside of Seismic Class I structures. This evaluation, referenced by NEI 13-02, section 5.1.1.6.2, can utilize; NRC Reg Guide 1.76 R1, Design-Basis Tornado And Tornado Missiles For Nuclear Power Plants, which limits automobile missile impact to “all altitudes less than 30 feet”; the plants current licensing bases; or other pertinent information.

   In accordance with the guidance of NEI 13-02, section 4.1.5.2.3, the vent piping and appurtenances such as valve actuators, required instruments and associated instrument lines exposed to the outside (i.e., located outside of substantial seismic class I structures) should be designed or protected to withstand missiles that could be generated by the external events that screen in for the plant site using the guidance of NEI 12-06 as endorsed by JLD-ISG-12-01. As stated in NEI 13-02, section 5.1.1.6, the current design of (substantial) seismic class I structures provides adequate wind and missile protection for piping routed through it, as does current plant elevated release points (e.g., meteorological stack). An evaluation demonstrating reasonable protection for the vent system is an acceptable method of demonstrating compliance with this requirement.

3. Distance from Release Point to Nearest Structure -

   Typical points of vent exit from the power block are the reactor building or turbine building. As such, this topic is intended to address distances from adjacent buildings and/or structures associated with the building the vent is emanating from (e.g., equipment housings such as for elevator equipment, tanks, etc.). The distance from the vent release point to such a structure should be at least 25’ (horizontal distance). This value is based on the ability of the effluent stream to overcome wind effects above the roof (and cited appurtenances) elevation and agrees with accepted industry practice for roof vents. The same additional basis as stated above (for Topic 1), relative to effluent release, are considered to apply in this case.

4. Potential for Damage due to Deflagration/Detonation in Effluent Plume –

   Although momentum and buoyancy will work to drive the vented effluent upward once it has exited the release point, there is the possibility that any vented hydrogen may deflagrate or possibly detonate if an ignition source is available. Based on the guidance and philosophy presented in Topics 1 and 2, there is reasonable assurance that such an event would occur well away from building equipment. However, flammable or heat sensitive equipment should not be located in the general vicinity of the release point.

5. Distance and Elevation Relative to Emergency Filtration Intake and exhaust pathways -

   This topic is written relative to intake and exhaust pathways for systems which may be powered up from emergency power associated with facilities used in accident mitigation (e.g., EOF/TSC filter trains, CBEAF). It should not be considered applicable to normal building (such as reactor building HVAC) intake and exhaust pathways. A general "rule of thumb" of 1:5 zone of influence (5' of horizontal travel versus 1' of vertical drop) of the effluent from the release point to the potential downwind vortices/ recirculation zones is a reasonable method of release point configuration determination (2011 ASHRAE HVAC Applications Handbook, Cpt. 45). Although this approach is more conservative than the vent/jet philosophy established in topic 1, it does provide a reasonable set of guidelines that the industry can use in siting their release points. This "rule of thumb" should be applied to such intake and exhaust pathways associated with the power block. For example, if a subject intake or exhaust is 100' away from the release point, it should be situated such that it is at least 20' below the tip of the release point. As is stated, this is considered as conservative guidance which may be used with no further engineering justification. Based on Topic 1, there is reasonable leeway such that plants may deviate from this guidance with adequate engineering justification.

Good engineering judgment should be applied (relative to this ratio) for such intake and exhaust pathways located away from the power block. There is reasonable assurance (considering good engineering judgment) that no appreciable intake of HCVS effluent will occur for intake or exhaust pathways outside 100' of the vent release point that are 20' below the tip of the release point. It must be noted that this information should also be applied to changes made (such as open doors) to facilitate Control Room ventilation. The considerations listed above relative to the buoyancy, temperature, and flowrate of the effluent should be included in associated basis. It should be considered in any evaluation performed, that such ventilation systems are qualified to remove the vast majority of radionuclides associated with on-site releases.

Notes relative to this guidance –

- Buildings outside of the site's main power block should not be considered relative to the above. Administrative buildings, warehouses, and other support buildings would typically not be staffed during a BDBE unless they house an accident mitigation type emergency facility (in which case the aforementioned information should be used as stated).
- Cooling towers, by nature of their location requirements, are situated well away from the power block such that they are not able to detrimentally affect HCVS effluent flow.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 4)

The proposed resolution is correct. Discussed with NRC in Public meetings in February and March 2014. Addressed NRC comments and discussed on NRC-NEI conference call May 22, 2014. Resolved reference to RG 1.76 R1.

Revision: 3

Date: June 4, 2014

E. NRC Review:

Not Necessary_____ Interpretation X Agency Position_____

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. Incorporated additional comments from NEI workshop on April 10, 2014. Addressed NRC comments on 30 foot elevation and metal sided category 1 buildings.

F. Industry Approval:

Documentation Method: FAQ

Date: 06/04/2014

A. TOPIC: HCVS Control and 'Boundary Valves'	Inq. No.: HCVS-FAQ-05
Source document: NEI 13-02	Sections: Order EA-13-109, Element 1.2.3, 1.2.12 & 1.2.13, NEI 13-02 Section 4.1.4, 4.1.6 & 6.2

B. DESCRIPTION:

The cited NEI-13-02 sections address the prevention of cross flow between units, the prevention of effluent migration between systems (HCVS to connected systems) in a common unit, and testing of the HCVS to assure continued functionality. This FAQ addresses valving integrity relative to leakage as applicable to these Order elements.

More specifically, this FAQ addresses the operational philosophy, HCVS specific requirements and testing of those valves which include; Primary Containment Isolation Valves (PCIVs) associated with the HCVS, PCIVs not associated with HCVS (e.g., purge lines not associated with the HCVS, piping routed to an independent set of SGTS trains), control valves (if other than PCIVs), and boundary valves (which isolate other systems from the HCVS).

Questions to be answered are:

- Which valves are considered as control valves and which are boundary valves, and why?
- What are the testing criteria for the various valves cited?

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 4)

Valve Definitions as related to HCVS function (see sketch below) –

1. Control Valve – Any valve used to open the containment to the HCVS vent path such that venting may commence. This valve will also have the function of closing thereby effectively halting the venting process. This may be either of the two (PCIVs) associated with the vent system penetration or it may be a single valve installed downstream of the PCIVs used for the purpose of commencing and ceasing the venting process. Note that these downstream valves may also be pressure control valves.
2. Boundary Valve – Any valve which serves to isolate the HCVS from another system. Depending on the application these valves may be safety related or (potentially in limited cases) non-safety related. The most typical instance of a boundary valve such as this would be to isolate the Standby Gas Treatment System (SGTS) from the HCVS vent path (in which case such valves would be safety related). This category also applies to valves which isolate the vent system of one plant from that of another.

Testing Criteria to be Used for Valve Types –

Valve Types by Design Function (see sketch below) -

Several types of valves have been discussed in the definitions but there are two fundamental valve types (not yet differentiated) which must be considered when addressing leakage testing. These 2 types are (1) PCIVs and (2) all others cited. Note that these types are not directly related to the Control or Boundary function (as related to the HCVS) but to the safety function (or potentially non-safety function) of the valve as related to the licensing of the plant.

1. All PCIVs – These valves have a safety related function and are tested for that function as required

by 10 CFR 50, Appendix J. Their safety related function is to maintain the containment pressure boundary (within a site-specific prescribed leakage range) during a design bases accident.

2. Non-PCIV HCVS Control and Boundary valves– This category includes all valves that are not PCIVs and provide a boundary function or a control function for the HCVS to be effectively operated. Basically they may be expected, at some point in the use of the HCVS, to prevent the leakage of effluent from containment to an undesirable location in the affected unit (or other unit on the plant site), or prevent leakage of effluent to the atmosphere surrounding the affected unit. These valves will typically be safety related (although there may be exceptions). The safety function of these valves is typically to open and allow flow for the reactor building ESF (engineered safety feature) system. This is typically known as the Standby Gas Treatment System (SGTS). These valves may fail open during a loss of power based on their current license base function (for example, in order to align for SGTS operation once power has been restored). As such, they must be closed and secured closed in order to be credited as an HCVS boundary valve.

Testing Criteria and Valve Requirements by Valve Type –

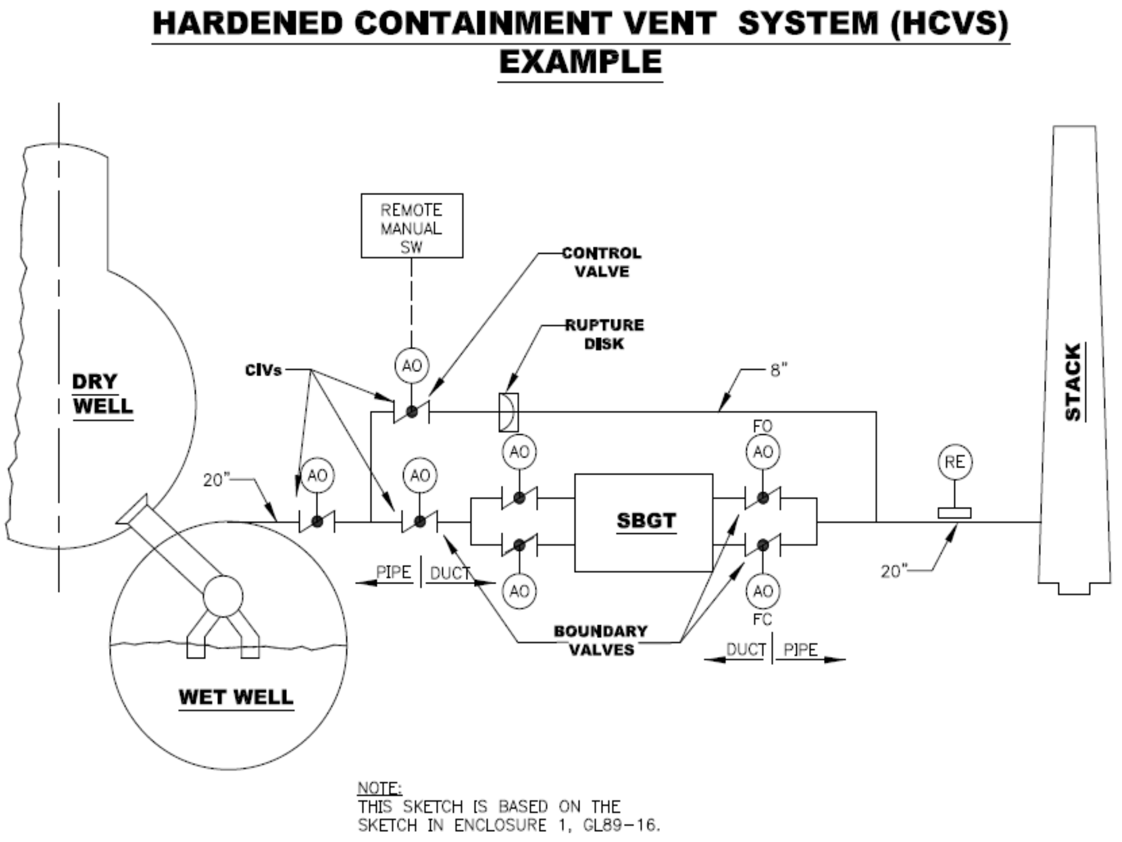
1. PCIVs – Testing criteria for PCIVs will not change. They will continue to be tested per Appendix J criteria.
2. Non-PCIVs HCVS valves (boundary or control) – Testing criteria for these valves will be based on the individual site's Appendix J test criteria for PCIVs associated with the HCVS. The allowable leakage may be set equal to the allowable leakage for the PCIV of the valve pair associated with the HCVS containment penetration which exhibits the highest accepted leakage rate during current Appendix J testing cycle or to the leakage of the single PCIV which is to serve as a control valve for the HCVS (if a PCIV is used as such). In this way, expectations set for boundary valves will not be set higher than those for the existing safety related Primary Containment Isolation Valves. Another option which a site may consider is to test such valves in accordance with the criteria listed in the ISG, Section 6.2.3.3. Note that although minimal leakage may be expected, such leakage would be into a stagnant environment (an unused pipe or a SGTS train). Leakage into a stagnant environment such as an unused pipe or SGTS train (filter, fan housing, ducting) may be more potentially problematic than into the general reactor building environment. A small leakage of steam and combustible gas into the reactor building would likely see some condensation of the steam and a mixing of the hydrogen such that there is no large volume combustible atmosphere mixture while a small leak rate of steam and combustible gas into a "dead end" pipe or ducting run may have the steam condense and the combustible gas concentration rise to combustible levels over time along with having the air originally in the "dead end" or stagnant volume. When determining an acceptable leakage rate for these boundary valves, this possibility should be considered.

   These valves should be purchased or modified such that they are or can be qualified to operate and/or remain closed (depending on their function, either control or purely isolation) at HCVS design temperature and pressure. They should be tested at a frequency as specified in ISG, Section 6.2.4. They need not be tested at HCVS design temperature and pressure but at ambient temperature and per Appendix J as formerly stated. Note that leakage requirements are to be applied separately to each valve such that cumulative consideration of the leak testing of the individual valves will suffice as leak testing of the system. As an example, consider that an HCVS is connected both upstream and downstream of the SGTS (2 isolation valves, one on either side of SGTS), is opened to containment during HCVS operation by the 2 associated PCIVs, and has a downstream control valve which controls venting and acts as an extension to containment upon halting of venting (with the upstream PCIVs remaining open during HCVS operation and isolation). The worst case leakage from that system with the vent system isolated by the control valve would be the combined leakage values of both boundary valves plus that of the control valve. Again the allowable leakage of each of these valves would be that of the associated HCVS PCIV with the highest measured leakage (of the last Appendix J applicable test cycle). Note that this total leakage would not typically be going to the same location or attached system.

It is understood that this may require evaluation and possible modification of existing site systems besides the HCVS itself (including Boundary Valves associated with those systems). System modifications such as flanged connections (for temporary blind flange installation) or maintenance valves may be required to facilitate leak testing. Test taps may also be required in the existing piping system to support boundary valve testing.

SUMMARY OF THE VALVES NEEDED FOR HCVS OPERATION

VALVE TYPE/LIST	FUNCTION	NORMAL POSITION	POSITION FOR HCVS OPERATION	TESTING CRITERIA
PCIV	Isolates primary Containment on Isolation signal	Normal Close, Fail Close	Open	Per Appendix J (No change)
Control Valve	Operates to activate HCVS Operation	Normal Close, Fail Close	Open and Close as needed	Per Appendix J (New Criteria)
Boundary Valve	Isolates SGTS or the other system	Plant Specific	Close	Per Appendix J (New Criteria)



HARDENED CONTAINMENT VENT SYSTEM (HCVS) EXAMPLE

NOTE:
THIS SKETCH IS BASED ON THE SKETCH IN ENCLOSURE 1, GL89-16.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 4)

The proposed resolution is correct. Discussed with NRC in Public meetings in January, February and March 2014.

Revision: 2 Date: April 14, 2014

E. NRC Review:

Not Necessary__________ Interpretation X Agency Position____________________

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated

F. Industry Approval:

Documentation Method: FAQ Date: 04/14/2014

A: TOPIC: HCVS FLEX and Generic Assumptions

Inq. No.: HCVS-FAQ-06

Source document: EA-13-109/NEI 12-06

Sections: Various in 13-02 and 3.2.1.2, 3.2.1.3 and 3.2.1.4 in 12-06

B. DESCRIPTION:

Provide key assumptions and characteristics associated with implementation of HCVS Phase 1 actions in a durable reference source.

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 3)

While certain core cooling features of the site response to EA-12-049 are assumed to not function such that core damage occurs, many of the diverse and flexible actions planned for the mitigation actions (FLEX) have a high confidence of being performed and should be assumed to be available unless directly stated as not available in order EA-13-109.

Applicable EA-12-049 assumptions:

049-1. Assumed initial plant conditions are as identified in NEI 12-06 section 3.2.1.2 items 1 and 2

049-2. Assumed initial conditions are as identified in NEI 12-06 section 3.2.1.3 items 1, 2, 4, 5, 6 and 8

049-3. Assumed reactor transient boundary conditions are as identified in NEI 12-06 section 3.2.1.4 items 1, 2, 3 and 4

049-4. No additional events or failures are assumed to occur immediately prior to or during the event, including security events except for failure of RCIC or HPCI. (Reference NEI 12-06 3.2.1.3 item 9)

049-5. At Time=0 the event is initiated and all rods insert and no other event beyond a common site ELAP is occurring at any or all of the units. (NEI 12-06, section 3.2.1.3 item 9 and 3.2.1.4 item 1-4

049-6. At {Site Specific Time} (time critical at a time greater than {Site Specific time}) an ELAP is declared and actions begin as defined in EA-12-049 compliance

049-7. DC power and distribution can be credited for the duration determined per the EA-12-049 (FLEX) methodology for battery usage, ({Site Specific Time}) (NEI 12-06, section 3.2.1.3 item 8)

049-8. Deployment resources are assumed to begin arriving at hour 6 and fully staffed by 24 hours

049-9. All activities associated with plant specific EA-12-049 FLEX strategies that are not specific to implementation of the HCVS, including such items as debris removal, communication, notification, SFP level and makeup, security response, opening doors for cooling, and initiating conditions for the event, can be credited as previously evaluated for FLEX.

Applicable EA-13-109 generic assumptions:

049-10. Site response activities associated with EA-13-109 actions are considered to have no access limitations associated with radiological impacts while RPV level is above 2/3 core height (core damage is not expected).

049-11. Portable equipment can supplement the installed equipment after 24 hours provided the portable equipment credited meets the criteria applicable to the HCVS. An example is use of FLEX portable air supply equipment that is credited to recharge air lines for HCVS components after 24 hours. The FLEX portable air supply used must be demonstrated to meet the “SA Capable” criteria that are defined in NEI 13-02 Section 4.2.4.2 and Appendix D Section D.1.3.

049-12. SFP Level is maintained with either on-site or off-site resources such that the SFP does not contribute to the analyzed source term (Reference HCVS-FAQ-07)

049-13. Existing containment components design and testing values are governed by existing plant primary containment criteria (e.g., Appendix J) and are not subject to the testing criteria from NEI 13-02 (reference HCVS-FAQ-05 and NEI 13-02 section 6.2.2).

049-14. Classical design basis evaluations and assumptions are not required when assessing the operation of the HCVS. The reason this is not required is that the order postulates an unsuccessful mitigation of an event such that an ELAP progresses to a severe accident with ex-vessel core debris which classical design basis evaluations are intended to prevent. (Reference NEI 13-02 section 2.3.1).

049-15. HCVS manual actions that require minimal operator steps and can be performed in the postulated thermal and radiological environment at the location of the step(s) (e.g., load stripping, control switch manipulation, valving-in nitrogen bottles) are acceptable to obtain HCVS venting dedicated functionality. (reference HCVS-FAQ-01)

049-16. HCVS dedicated equipment is defined as vent process elements that are required for the HCVS to function in an ELAP event that progresses to core melt ex-vessel. (reference HCVS-FAQ-02 and White Paper HCVS-WP-01)

049-17. Use of MAAP Version 4 or higher provides adequate assurance of the plant conditions (e.g., RPV water level, temperatures, etc.) assumed for Order EA-13-109 BDBEE and SA HCVS operation. (reference FLEX MAAP Endorsement ML13190A201) Additional analysis using RELAP5/MOD 3, GOTHIC, PCFLUD, LOCADOSE and SHIELD are acceptable methods for evaluating environmental conditions in areas of the plant provided the specific version utilized is documented in the analysis. Upper drywell temperatures will be determined as part of Phase 2 evaluation and guidance development.

049-18. Utilization of NRC Published Accident evaluations (e.g. SOARCA, SECY-12-0157, NUREG 1465) as related to Order EA-13-109 conditions are acceptable as references. (reference NEI 13-02 section 8).

049-19. Permanent modifications installed or planned per EA-12-049 are assumed implemented and may be credited for use in EA-13-109 Order response.

049-20. This Overall Integrated Plan is based on Emergency Operating Procedure changes consistent with EPG/SAGs Revision 3 as incorporated per the sites EOP/SAMG procedure change process.

049-21. Under the postulated scenarios of order EA-13-109 the Control Room is adequately protected from excessive radiation dose due to its distance and shielding from the reactor (per General Design Criterion (GDC) 19 in 10CFR50 Appendix A) and no further evaluation of its use as the preferred HCVS control location is required. In addition, adequate protective clothing and respiratory protection is available if required to address contamination issues. (reference HCVS-FAQ-01)

D. RESOLUTION: (Include additional pages if necessary. Total pages: 3)

The proposed resolution is correct. Discussed with NRC in Public meetings in January, February and March 2014. Addressed NRC comments from 05-14-14 as discussed on May 22, 2014. This is a conforming change to the NRC OIP template

Revision: 3 Date: May 22, 2014

E. NRC Review:

Not Necessary____ Interpretation X Agency Position____

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. Incorporated additional comments from NEI workshop on April 10, 2014

F. Industry Approval:

Documentation Method: FAQ Date: 05/22/2014

A. TOPIC: HCVS Source Term from SFP | Inq. No.: HCVS-FAQ-07

Source document: EA-13-109/NEI 13-02/NEI 12-02/NEI 12-06 | Sections: Various

B. DESCRIPTION:

What impact of the SFP source term is required to be considered for environmentally sensitive actions supporting HCVS operation?

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 1)

SFP Level is maintained above EA-12-051 Level 2 with either on-site or off-site resources such that no contribution to analyzed source term need be considered.

The following statements support this position:

- Actions under Order EA-12-049 provides multiple mitigation actions to protect SFP cooling and Order EA-12-051 provides redundant instrumentation to plant decision makers to allow correct prioritization of any action needed for the SFP. Every site has to be in compliance with these Orders.
- There is no assumption or criteria in the EA-13-109 Order that relates to a “SFP accident”. The Order only mentions core damage and protection of Mk I & II containments, i.e., “reactor severe accident”.

If action is required for HCVS in the SFP area then the environment (i.e., temperature and humidity) in the vicinity and ingress/egress must be evaluated as identified in FAQ HCVS-01.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 1)

The proposed resolution is correct and discussed with NRC in Public meetings in January and February 2014.

Revision: 0 Date: March 11, 2014

E. NRC Review:

Not Necessary_____ Interpretation X Agency Position_____

Explanation:_____

F. Industry Approval:

Documentation Method: FAQ Date: March 11, 2014

A. TOPIC: HCVS Instrument Qualification	Inq. No.: HCVS-FAQ-08
Source document: Order EA-13-109 and NEI 13-02	Sections: Order EA-13-109, Element 1.1.1, 1.1.2, 1.1.3, 1.2.4, 1.2.5, 1.2.6, NEI 13-02 Section 4.2.2, 4.2.3 4.2.4

B. DESCRIPTION:

Note: This FAQ addresses the environmental and radiological impacts on the ability of HCVS instrumentation to remain functional during the sustained operational period. Environmental and radiological impacts on accessibility and habitability for system operation are addressed in HCVS-FAQ-01, HCVS Primary Controls and Alternate Controls and Monitoring Locations.

What conditions have to be considered in the design and siting of HCVS Controls and monitoring equipment?

Order Element 1.2.4 states, “The HCVS shall be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location.”

Order Element 1.2.5 states, “The HCVS shall, in addition to meeting the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations.”

Order Element 1.2.6 states, “The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power.”

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 3)

Environmental Conditions:

The Primary/Alternate controls and monitoring equipment design must consider the following:

Thermal Considerations: (See Order Elements 1.1.2 and 1.1.4):

- Main Control Room (MCR) temperature and heat load that exist for operation of the HCVS.
  - Temperature and heat load that exist due to proximity to the undercooled containment.
    - MCR Temperatures considered for Order EA-12-049 (FLEX) are reasonable to use since any changes as the result of a severe accident are not expected to have an adverse impact on the MCR due to Control Room location in a separate air space and FLEX ventilation methods applied to the MCR
  - Temperature and heat load that exists due to the ELAP condition (loss of ventilation).
    - Utilize toolbox actions (e.q., portable fans, opening of doors, etc.) and EA-12-049 (FLEX) mitigation strategies. (Ref HCVS-FAQ-09)
    - HCVS controls and instrumentation will be similar to other instrumentation and controls found in most MCRs. Unless the licensee uses controls and instrumentation in the HCVS system that are known to be susceptible to failure from elevated temperatures but within habitability limits, no evaluation of temperature effects needs to be performed for

HCVS components located in the MCR.

  - No portable equipment should be required to operate the HCVS within the first 24 hours per the criteria in order EA-13-109.

- Primary or Alternate Control location (if other than MCR) temperature and heat load that exist for operation of the HCVS.
  - Temperature and heat load that exist due to proximity to the undercooled containment and spent fuel pool.
  - Temperature and heat load that exists due to the ELAP condition (loss of ventilation).
    - If this location is NOT in the Reactor Building or other buildings where HCVS piping is located then the heat load impact is similar to the MCR when the location is in a separate air space.
    - HCVS controls and instrumentation located outside the MCR will be similar to other instrumentation and controls found in plant locations outside the MCR. Unless the licensee uses controls and instrumentation in the HCVS system that are known to be susceptible to failure from elevated temperatures but within habitability limits, no evaluation of temperature effects needs to be performed for HCVS components located outside of the Reactor Building or other buildings where HCVS piping is located.

Radiological Considerations: (See Order Elements 1.1.3)

- Main Control room radiological conditions that exist from operation of the HCVS system.
  - MCR complies with the intent of General Design Criteria (GDC) 19 or the Alternate Source Term (AST) which provides reasonable assurance of protection from radiological consequences.
- Primary or Alternate Control location (if other than Control Room) radiological conditions that exist for operation of the HCVS system.
  - This analysis may be bounded by the required dose considerations for Control Room design in General Design Criteria (GDC) 19 or the Alternate Source Term (AST) analysis if this location is outside the Reactor Building due to Reactor Building to Auxiliary Building Shielding design.
  - If the location is inside the Reactor Building, then it will need to be evaluated for radiological impact due to HCVS system operation under severe accident conditions.
- The specific event progression that leads to the Severe Accident is NOT specified and does not have to include multiple path source terms from loss of Spent Fuel Pool Cooling as this would presume that the event progression that leads to the Severe Accident also prevents or causes the mitigating measures for loss of Spent Fuel Pool Cooling to fail. Order element 1.1.3 does discuss the requirement to consider the dose and radiological conditions caused by operation of the HCVS system but not failure of Mitigating Strategies related to Spent Fuel Pool Cooling.

Time frame:

The instrumentation should be capable of operating in the thermal and radiological environment for at least 24 hours without significant operator action (see HCVS-FAQ-02, HCVS Dedicated Equipment, for a discussion of significant operator action considerations for the first 24 hours of the sustained operational period). Other provisions of NEI-13-02 such as the definition of "Sustained Operations" extend this time but do NOT preclude mitigating measures from FLEX or offsite support for reduction in thermal or radiological impacts (e.g. portable fans, AC power for ventilation, possible cooling water supplies to the area coolers if part of the FLEX mitigating measures. The restriction on permanently installed equipment and simple and easily performed operator actions only exists for the 24 hour period to ensure HCVS viability for at least a 24 hour mission time. See HCVS-FAQ-02 on Order Element 1.2.6 use of "dedicated equipment" and HCVS-WP-01, HCVS Dedicated Power and Motive Force.

D. RESOLUTION: (Include additional pages if necessary. Total pages: 3)

The proposed resolution is correct. Discussed with NRC in Public meetings in February and March 2014. Discussed NRC 05-14-14 comments in May 22, 2014 conference call

Revision: 2 Date: 05/22/2014

E. NRC Review:

Not Necessary_____ Interpretation X Agency Position_____

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. Added limitation on actions to time frame discussion

F. Industry Approval:

Documentation Method: FAQ Date: 05/22/2014

A. TOPIC: HCVS Toolbox Approach for Collateral Actions

Inq. No.: HCVS-FAQ-09

Source document: NEI 13-02

Sections: Order EA-13-109, Element 1.2.4, 1.2.5, 1.2.6, NEI 13-02 Section 4.2.2, 4.2.3 4.2.4

B. DESCRIPTION:

Document the use of Toolbox approach for collateral actions that will be symptom based but are within the skill of the craft or general personnel knowledge.

Order Element 1.2.4 states, "The HCVS shall be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location."

Order Element 1.2.5 states, "The HCVS shall, in addition to meeting the requirements of 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations."

Order Element 1.2.6 states, "The HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an extended loss of AC power."

C. PROPOSED ANSWER (Include additional pages if necessary. Total pages: 1)

Examples of acceptable toolbox approach for collateral actions are:

- Opening doors when room temperatures become elevated
- Using flashlights to supplement pathway use
- Exchange of personnel, use of ice vests, etc. when action is in degrading levels of heat and humidity environment, not life threatening
- Utilizing small fans for air movement
- Utilization of protective clothing and respirators to address localized contamination concerns

D. RESOLUTION: (Include additional pages if necessary. Total pages: 1)

The proposed resolution is correct. Discussed with NRC in Public meetings in February and March 2014. Discussed NRC 05-14-14 comments on May 22, 2014 conference call

Revision: 2

Date: 05/22/2014

E. NRC Review:

Not Necessary______ Interpretation X Agency Position______

Explanation: Discussed at NEI-NRC Public Meeting 3/26/2014 with specific NRC comments incorporated. Incorporated additional comments from NEI workshop on April 10, 2014.

F. Industry Approval:

Documentation Method: FAQ

Date: 05/22/2014

APPENDIX K – PHASE 1 OVERALL INTEGRATED PLAN TEMPLATE

(LATER)