UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 31, 2019

Mr. Keith J. Polson
Senior Vice President
and Chief Nuclear Officer
DTE Electric Company
Fermi 2 – 260 TAC
6400 North Dixie Highway
Newport, MI 48166

SUBJECT: FERMI, UNIT 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS RELATED TO ORDER EA-13-109 (CAC NO. MF4362; EPID NO. L-2014-JLD-0048)

Dear Mr. Polson:

On June 6, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13143A334), the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-13-109, "Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," to all Boiling Water Reactor (BWR) licensees with Mark I and Mark II primary containments. The order requirements are provided in Attachment 2 to the order and are divided into two parts to allow for a phased approach to implementation. The order required each licensee to submit an Overall Integrated Plan (OIP) for review that describes how compliance with the requirements for both phases of Order EA-13-109 would be achieved.

By letter dated June 30, 2014 (ADAMS Accession No. ML14182A203), DTE Electric Company the licensee) submitted its Phase 1 OIP for Fermi, Unit 2 (Fermi 2) in response to Order EA-13-109. At 6-month intervals following the submittal of the Phase 1 OIP, the licensee submitted status reports on its progress in complying with Order EA-13-109 at Fermi 2, including the combined Phase 1 and Phase 2 OIP in its letter dated December 23, 2015 (ADAMS Accession No. ML15357A289). These status reports were required by the order and are listed in the enclosed safety evaluation. By letters dated May 27, 2014 (ADAMS Accession No. ML14126A545), and August 10, 2017 (ADAMS Accession No. ML17220A328), the NRC notified all BWR Mark I and Mark II licensees that the staff will be conducting audits of their implementation of Order EA-13-109 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated April 1, 2015 (Phase 1) (ADAMS Accession No. ML15077A574), August 30, 2016 (Phase 2) (ADAMS Accession No. ML16231A443), and July 10, 2018 (ADAMS Accession No. ML18186A421), the NRC issued Interim Staff Evaluations and an audit report, respectively, on the licensee's progress. By letter dated December 14, 2018 (ADAMS Accession No. ML18348B112), the licensee reported that Fermi 2 is in full compliance with the requirements of Order EA-13-109, and submitted a Final Integrated Plan for Fermi 2.

The enclosed safety evaluation provides the results of the NRC staff's review of Fermi's hardened containment vent design and water management strategy for Fermi 2. The intent of the safety evaluation is to inform Fermi 2 on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Order EA-13-109. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515-193, "Inspection of the Implementation of EA-13-109: Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions" (ADAMS Accession No. ML17249A105). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Dr. Rajender Auluck, Senior Project Manager, Beyond-Design-Basis Engineering Branch, at 301-415-1025, or by e-mail at Rajender.Auluck@nrc.gov.

Sincerely,

Nathan Sanfilippo, Chief
Beyond-Design-Basis Engineering Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-341

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDER EA-13-109

DTE ELECTRIC COMPANY

FERMI, UNIT 2

DOCKET NO. 50-341

1.0 INTRODUCTION

The earthquake and tsunami at the Fukushima Dai-ichi nuclear power plant in March 2011 highlighted the possibility that extreme natural phenomena could challenge the prevention, mitigation and emergency preparedness defense-in-depth layers already in place in nuclear power plants in the United States. At Fukushima, limitations in time and unpredictable conditions associated with the accident significantly challenged attempts by the responders to preclude core damage and containment failure. During the events at Fukushima, the challenges faced by the operators were beyond any faced previously at a commercial nuclear reactor and beyond the anticipated design basis of the plants. The U.S. Nuclear Regulatory Commission (NRC) determined that additional requirements needed to be imposed at U.S. commercial power reactors to mitigate such beyond-design-basis external events (BDBEEs) during applicable severe accident conditions.

On June 6, 2013 [Reference 1], the NRC issued Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions." This order requires licensees to implement its requirements in two phases. In Phase 1, licensees of boiling-water reactors (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. 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.

By letter dated June 30, 2014 [Reference 2], DTE Electric Company (DTE, the licensee) submitted its Phase 1 Overall Integrated Plan (OIP) for Fermi, Unit 2 (Fermi 2) in response to Order EA-13-109. By letters dated December 18, 2014 [Reference 3], June 11, 2015 [Reference 4], December 23, 2015 (which included the combined Phase 1 and Phase 2 OIP) [Reference 5], June 20, 2016 [Reference 6], December 9, 2016 [Reference 7], June 27, 2017 [Reference 8], December 14, 2017 [Reference 9], and June 26, 2018 [Reference 10], the licensee submitted 6-month updates to its OIP. By letters dated May 27, 2014 [Reference 11], and August 10, 2017 [Reference 12], the NRC notified all BWR Mark I and Mark II licensees that the staff will be conducting audits of their implementation of Order EA-13-109 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 13]. By letters dated April 1, 2015 (Phase 1) [Reference 14], August 30, 2016 (Phase 2) [Reference 15], and July 10, 2018 [Reference 16], the NRC issued Interim Staff Evaluations (ISEs) and an audit report, respectively, on the licensee's progress. By letter dated December 14, 2018 [Reference 17], the licensee reported that full compliance with the requirements of Order EA-13-109 was achieved and submitted its Final Integrated Plan (FIP).

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 [Reference 18]. Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012 [Reference 19], the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami", to the Commission. This paper included a proposal to order licensees to implement the installation of a reliable hardened containment venting system (HCVS) for Mark I and Mark II containments. As directed by the Commission in staff requirements memorandum (SRM)-SECY-12-0025 [Reference 20], the NRC staff issued Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents" [Reference 21], which required licensees to install a reliable HCVS for Mark I and Mark II containments.

While developing the requirements for Order EA-12-050, the NRC acknowledged that questions remained about maintaining containment integrity and limiting the release of radioactive materials if the venting systems were used during severe accident conditions. The NRC staff presented options to address these issues for Commission consideration in SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments" [Reference 22]. In the SRM for SECY-12-0157 [Reference 23], the Commission directed the staff to issue a modification to Order EA-12-050, requiring licensees with Mark I and Mark II containments to "upgrade or replace the reliable hardened vents required by Order EA-12-050 with a containment venting system designed and installed to remain functional during severe accident conditions." The NRC staff held a series of public meetings following issuance of SRM SECY-12-0157 to engage stakeholders on revising the order. Accordingly, as directed by the Commission in SRM-SECY-12-0157, on June 6, 2013, the NRC staff issued Order EA-13-109.

Order EA-13-109 requires that BWRs with Mark I and Mark II containments have a reliable, severe-accident capable HCVS. Attachment 2 of the order provides specific requirements for implementation of the order. The order shall be implemented in two phases.

2.1 Order EA-13-109, Phase 1

For Phase 1, licensees of BWRs with Mark I and Mark II containments are required to 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.

The NRC staff held several public meetings to provide additional clarifications on the order's requirements and comments on the proposed draft guidance prepared by the Nuclear Energy Institute (NEI) working group. On November 12, 2013 [Reference 24], NEI issued NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 0, to provide guidance to assist nuclear power reactor licensees with the identification of measures needed to comply with the requirements of Phase 1 of Order EA-13-109. The NRC staff reviewed NEI 13-02, Revision 0, and on November 14, 2013 [Reference 25], issued Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2013-02, "Compliance with Order EA-13-109, 'Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Performing under Severe Accident Conditions'", endorsing, in part, NEI 13-02, Revision 0, as an acceptable means of meeting the requirements of Phase 1 of Order EA-13-109, and on November 25, 2013, published a notice of its availability in the *Federal Register* (78 FR 70356).

2.2 Order EA-13-109, Phase 2

For Phase 2, licensees of BWRs with Mark I and Mark II containments are required to design and install a venting system that provides venting capability from the drywell under severe accident conditions, or, alternatively, to develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions.

The NRC staff, following a similar process, held several meetings with the public and stakeholders to review and provide comments on the proposed drafts prepared by the NEI working group to comply with the Phase 2 requirements of the order. On April 23, 2015 [Reference 26], NEI issued NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 1, to provide guidance to assist nuclear power reactor licensees with the identification of measures needed to comply with the requirements of Phase 2 of Order EA-13-109. The NRC staff reviewed NEI 13-02, Revision 1, and on April 29, 2015 [Reference 27], the NRC staff issued JLD-ISG-2015-01, "Compliance with Phase 2 of Order EA-13-109, 'Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Performing under Severe Accident Conditions'", endorsing, in part, NEI 13-02, Revision 1, as an acceptable means of meeting the requirements of Phase 2 of Order EA-13-109, and on April 7, 2015, published a notice of its availability in the *Federal Register* (80 FR 26303).

3.0 TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 1

Fermi is a single unit General Electric BWR site with a Mark I primary containment system. To implement Phase 1 requirements of Order EA-13-109, the licensee uses a nominal 10-inch diameter pipe connected to the existing 24" standby gas treatment system (SGTS) inlet header on the reactor building fifth floor. The vent is routed through the reactor building siding and discharges at an elevated location. The HCVS is initiated, operated, and monitored from the

HCVS control panel or from the main control room (MCR) at the appropriate time based on procedural guidance in response to plant conditions from observed or derived symptoms. The HCVS control panel is installed in a readily accessible location and provides a means to manually operate the wetwell vent. The controls available at the HCVS control panel are accessible and functional under a range of plant conditions, including severe accident conditions. The HCVS control panel location is in the auxiliary building on the third floor across from the MCR.

The HCVS control panel is the primary operating station for the HCVS. During an extended loss of ac power (ELAP), electric power to operate the vent valves will be provided by batteries with a capacity to supply required loads for at least the first 24 hours. Before the batteries are depleted, the FLEX generator will supplement and recharge batteries to support operation of the vent valves.

The operators can operate all the HCVS isolation valves from the HCVS control panel except the torus valves (T4600F400 and T4600F401) and check the status for the SGTS interface air-operated valves (AOVs) (T4600F408 and T4600F409). Local instrumentation is available to measure the torus level, torus pressure, drywell pressure, torus hardened vent temperature, and hardened vent system radiation.

The MCR is designated as the alternate (secondary) control location and method. Since this method requires FLEX electrical to supply the original alternating current (ac) solenoid valves, and FLEX air to supply non-interruptible air supply (NIAS) for pneumatics to the HCVS valves, it would only be credited after the 24-hour period established in EA-13-109.

The operators utilize containment parameters of pressure and level from the MCR instrumentation to monitor effectiveness of the venting actions. Vent operation is monitored by HCVS valve position, HCVS vent line temperature, and effluent radiation levels. The HCVS motive force is monitored and has the capacity to operate for 24 hours with installed equipment. Replenishment of the motive force will be by use of portable equipment once the installed motive force is exhausted. Venting actions are capable of being maintained for a sustained period of at least 7 days.

3.1 HCVS Functional Requirements

3.1.1 Performance Objectives

Order EA-13-109 requires that the design and operation of the HCVS shall satisfy specific performance objectives including minimizing the reliance on operator actions and plant operators' exposure to occupational hazards such as extreme heat stress and radiological conditions, and accessibility and functionality of HCVS controls and indications under a broad range of plant conditions. Below is the staff's assessment of how the licensee's HCVS meets the performance objectives required by Order EA-13-109.

3.1.1.1 Operator Actions

Order EA-13-109, Attachment 2, Section 1.1.1 requires that the HCVS be designed to minimize the reliance on operator actions. Relevant guidance is found in NEI 13-02, Section 4.2.6 and HCVS-FAQ [Frequently Asked Questions]-01.

In its FIP, the licensee stated that the HCVS was designed to minimize the reliance on operator actions in response to hazards identified in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide (Reference 28)," which are applicable to the plant site. Operator actions to initiate the HCVS vent path can be completed by plant personnel and include the capability for remote-manual initiation from the HCVS control panel. A list of the remote manual actions performed by plant personnel to open the HCVS vent path are listed in Table 3-1, "HCVS Operator Actions," of the FIP. An HCVS ELAP Failure Evaluation Table (FIP Table 3-2), which shows alternate actions that can be performed, is also provided in the FIP.

The licensee also stated that permanently-installed electrical power and pneumatic supplies are available to support operation and monitoring of the HCVS for a minimum of 24 hours. No large portable equipment needs to be moved in the first 24 hours to operate the HCVS. After 24 hours, available personnel will be able to connect supplemental electric power and pneumatic supplies for sustained operation of the HCVS for a minimum of 7 days. The FLEX generators and replacement nitrogen bottles provide this motive force. It is likely that these actions will be completed in less than 24 hours. However, the HCVS can be operated for at least 24 hours without any supplementation.

The NRC staff reviewed the HCVS Operator Actions Table, compared it with the information contained in NEI 13-02, and determined that these actions should minimize the reliance on operator actions. These actions are consistent with the type of actions described in NEI 13-02, Revision 1, as endorsed, in part, by JLD-ISG-2013-02 and JLD-ISG-2015-01, as an acceptable means for implementing applicable requirements of Order EA-13-109. The NRC staff also reviewed the HCVS Failure Evaluation Table and determined that the actions described adequately address all the failure modes listed in NEI 13-02, Revision 1, which include: loss of normal ac power, long-term loss of batteries, loss of normal pneumatic supply, loss of alternate pneumatic supply, and solenoid operated valve failure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design should minimize the reliance on operator actions, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.2 Personnel Habitability – Environmental

Order EA-13-109, Attachment 2, Section 1.1.2 requires that the HCVS be designed to minimize plant operators' exposure to occupational hazards, such as extreme heat stress, while operating the HCVS. Relevant guidance is found in: NEI 13-02, Sections 4.2.5 and 6.1.1; NEI 13-02, Appendix I; and HCVS-FAQ-01.

In its FIP, the licensee stated that primary control of the HCVS is accomplished from the HCVS control panel, which is located in the Division 2 switchgear room. Alternate control of the HCVS is accomplished from the MCR. FLEX actions that may be taken to maintain the HCVS control panel and MCR habitable were implemented in response to NRC Order EA-12-049. These FLEX actions include:

1. Restoring reactor building heating, venting, and air conditioning (RBHVAC) via the FLEX generator(s). RBHVAC was included as a load in the FLEX generator sizing calculations and is acceptable;
2. Opening MCR doors to the turbine building (if required); and
3. Operating portable fans to move outside air through the MCR (if required).

In the FIP, Table 2 contains a thermal evaluation of all the operator actions that may be required to support HCVS operation. Design calculation DC-6639, "Loss of HVAC Room Environmental Analysis," Revision 0, in conjunction with the operations toolbox mitigating actions (as described above), demonstrates that the areas where operator actions occur meets the order requirements to minimize the plant operators' exposure to occupational hazards.

The NRC staff audited calculation DC-6639, which predicts a maximum temperature in the Division 2 switchgear room of 146 degrees Fahrenheit (°F) with doors closed (144°F with doors open). The calculation assumes an ambient temperature of 105°F with a 15°F diurnal temperature variation and an initial room temperature of 95°F. The room does not exceed 110°F until between 10 and 20 hours into the event. In response to the NRC staff's questions regarding habitability of the Division 2 switchgear room due to the high temperature, the licensee clarified that operators have the option to start RBHVAC to mitigate these higher temperatures per procedure 29.FSG. FLEX Support Guideline 29.400.03, "HCVS," refers to 29.FSG.20. 29.FSG.20, "FLEX Ventilation and Building Heat Control," recommends restoring power to the switchgear room A/C units per 29.FSG.19, "FLEX RBHVAC Restoration," when power is available (about 4-6 hours). The NRC staff concurred that based on the calculation and procedural guidance environmental conditions should not prevent operators from performing their required actions.

The NRC staff also audited the temperature response for the MCR under Order EA-12-049 compliance and documented in the NRC staff's safety evaluation [Reference 36] that the licensee has developed a plan that, if implemented appropriately, should maintain or restore equipment and personnel habitability conditions in the MCR following a BDBEE.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to personnel habitability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.3 Personnel Habitability – Radiological

Order EA-13-109, Attachment 2, Section 1.1.3 requires that the HCVS be designed to account for radiological conditions that would impede personnel actions needed for event response. Relevant guidance is found in: NEI 13-02, Sections 4.2.5 and 6.1.1; NEI 13-02, Appendices D, F, G and I; HCVS-FAQ-01, -07, -09 and -12; and HCVS-WP [White Paper]-02.

The licensee performed calculations RWA-1805-002, "Fermi 2 Power Plant HCVS Radiological Dose Analysis," and DC-6645 VOL I, "HCVS Radiological Assessment," which document the dose assessment for designated areas inside the Fermi 2 reactor building (outside of containment) and outside the Fermi 2 reactor building caused by the sustained operation of the HCVS under the beyond-design-basis severe accident condition of an ELAP. Calculations RWA-1805-002 and DC-6645 VOL I were performed using NRC-endorsed HCVS-WP-02 [Reference 29] and HCVS-FAQ-12 [Reference 30] methodologies. Consistent with the definition of sustained operations in NEI 13-02, Revision 1, the integrated whole-body gamma dose equivalent[1] due to HCVS operation over a 7-day period as determined in the licensee's

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[1] For the purposes of calculating the personnel whole-body gamma dose equivalent (rem), it is assumed that the radiation units of Roentgen (R), radiation absorbed dose (rad), and Roentgen equivalent man (rem) are equivalent. The conversion from exposure in R to absorbed dose on in rad is 0.874 in air and < 1 in soft tissue. For photons, 1 rad is equal to 1 rem. Therefore, it is conservative to report radiation exposure in units of R and to assume that 1 R = 1 rad = 1 rem.

dose calculations should not exceed 10 Roentgen equivalent man (rem).[2] The calculated 7-day dose due to HCVS operation is a conservative maximum integrated radiation dose over a 7-day period with ELAP and fuel failure starting at reactor shutdown. For the sources considered and the methodology used in the calculations, the timing of HCVS vent operation or cycling of the vent will not create higher doses at personnel habitability and equipment locations (i.e., maximum doses determined in the calculation bound operational considerations for HCVS vent operation).

The licensee determined the expected dose rates in all locations requiring access following a beyond-design-basis ELAP. The licensee's evaluation indicates that for the areas requiring access in the early stages of the ELAP, the expected dose rates would not be a limiting consideration. For those areas where expected dose rates would be elevated at later stages of the accident, the licensee has determined that the expected stay times would ensure that operations could be accomplished without exceeding the emergency response organization (ERO) emergency worker dose guidelines.

The licensee evaluated the maximum dose rates and 7-day integrated whole-body gamma dose equivalents for the HCVS control panel, which is the primary operating station, and the MCR, which is designated as the alternate control location. In its FIP, the licensee states that the HCVS control panel and the travel path to the HCVS control panel have been evaluated for habitability and accessibility during a severe accident. The licensee further states that during an accident, the distance and shielding combined with the short duration of actions required at the HCVS Control Panel show that this location is an acceptable location for primary control. In its FIP, the licensee states that the MCR has been evaluated as the alternate control location and shown to be acceptable for habitability and accessibility during a severe accident. The evaluation (as documented in RWA-1805-002 and DC-6645 VOL I) demonstrates that the integrated whole-body gamma dose equivalent to personnel occupying defined habitability locations (resulting from HCVS operation under beyond-design-basis severe accident conditions) should not exceed 10 rem.

The NRC staff notes that there are no explicit regulatory dose acceptance criteria for personnel performing emergency response actions during a beyond-design-basis severe accident. The Environmental Protection Agency (EPA) Protective Action Guides (PAG) Manual, EPA-400/R- 16/001, "Protective Action Guides and Planning Guidance for Radiological Incidents," provides emergency worker dose guidelines. Table 3.1 of EPA-400/R-16/001 specifies a guideline of 10 rem for the protection of critical infrastructure necessary for public welfare, such as a power plant, and a value of 25 rem for lifesaving or for the protection of large populations. The NRC staff further notes that during an emergency response, areas requiring access will be actively monitored by health physics personnel to ensure that personnel doses are maintained as low as reasonably achievable.

The NRC staff audited the licensee's evaluation of the expected radiological conditions to ensure that operating personnel can safely access and operate controls and support equipment. Based on the expected integrated whole-body dose equivalent at the HCVS control panel and the MCR during the sustained operating period, the NRC staff agrees that the mission doses

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[2] Although radiation may cause cancer at high doses and high dose rates, public health data do not absolutely establish the occurrence of cancer following exposure to low doses and dose rates below about 10,000 mrem (100 mSv). https://www.nrc.gov/about-nrc/radiation/health-effects/rad-exposure-cancer.html

associated with actions taken to protect the public under beyond-design-basis severe accident conditions will not subject plant personnel to an undue risk from radiation exposure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to personnel habitability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.4 HCVS Controls and Indications

Order EA-13-109, Attachment 2, Section 1.1.4 requires that the HCVS controls and indications be accessible and functional under a range of plant conditions, including severe accident conditions, ELAP, and inadequate containment cooling. Relevant guidance is found in: NEI 13-02, Sections 4.1.3, 4.2.2, 4.2.3, 4.2.4, 4.2.5, and 6.1.1; NEI 13-02, Appendices F, G and I; and HCVS-FAQs-01 and -02.

Accessibility of the controls and indications for the environmental and radiological conditions are addressed in Sections 3.1.1.2 and 3.1.1.3 of this safety evaluation, respectively.

In its FIP, the licensee stated that primary control of the HCVS is accomplished from the HCVS control panel located on AB-3 (in the Division 2 switchgear room) and that alternate control of the HCVS is accomplished from the MCR. In its FIP, the licensee also stated that under the postulated scenarios of Order EA-13-109, the MCR is adequately protected from excessive radiation dose and no further evaluation of its use is required (HCVS-FAQ-06). The licensee also provided, in Table 1 of its FIP, a list of the controls and indications that are or may be required to operate the HCVS during a severe accident, including the locations, anticipated environmental conditions, and the environmental conditions (temperature and radiation) to which each component is qualified.

The NRC staff reviewed the FIP, including the evaluation in Section 1.1.4 of the FIP and examined the information provided in Table 1. The NRC staff determined that the controls and indications appear to be consistent with the NEI 13-02 guidance. The NRC staff also confirmed some of the environmental qualification information in Table 1 of the FIP through audit reviews of Fermi document DC-6639 Volume 1, "Loss of HVAC Room Environmental Analysis," Revision 4. The NRC staff also noted that the Regulatory Guide (RG) 1.97 instruments (including drywell pressure and wetwell level) did not have qualification information listed in Table 1, but are considered acceptable, in accordance with the NEI 13-02 guidance, based on the original qualification for severe accident conditions. The NRC staff also notes that the pressure indicators PI-042-170-1 and PI-042-270-1 qualification was considered separately and not part of the FAQ for RG 1.97 instruments.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to accessibility and functionality of the HCVS controls and indications during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2 Design Features

Order EA-13-109 requires that the HCVS shall include specific design features, including specifications of the vent characteristics, vent path and discharge, control panel, power and pneumatic supply sources, inadvertent actuation prevention, HCVS monitoring, equipment operability, and hydrogen control. Below is the staff's assessment of how the licensee's HCVS meets the performance objectives required by Order EA-13-109.

3.1.2.1 Vent Characteristics

Order EA-13-109, Attachment 2, Section 1.2.1 requires that the HCVS has the capacity to vent the steam/energy equivalent of one 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. Relevant guidance is found in NEI 13-02, Section 4.1.1.

The licensee performed calculation DC-6646, "Torus Hardened Vent Sizing Analysis and Dynamic Analysis," Revision 0, which provides the verification of one percent power flow capacity at the design pressure (56 pound per square inch gauge (psig)). The calculation verified that the HCVS has the required capacity to vent the steam/energy equivalent of one percent of licensed/rated thermal power and maintain containment pressure below the primary containment pressure limit to establish compliance with NRC Order EA-13-109.

The calculation assumed a licensed thermal power of 3,486 megawatts thermal (MWt) and determined that the steam energy equivalent of one percent reactor power is 130,182 pounds mass per hour (lbm/hr). The maximum calculated flow rate through the HCVS, at the minimum primary containment pressure limit (PCPL) of 48 psig was calculated to be 131,640 lbm/hr. Since the computed maximum flow rate exceeds the requirement, the acceptance criteria are satisfied. Suppression pool heat capacity is contained in calculation DC-6668, "Torus Capacity to Absorb Decay Heat Generated During First 3 Hours after Shutdown," Revision 0.

The calculation determines the minimum allowable flow coefficient, Cv, for a new check valve to be installed near the discharge of the vent piping. Since the calculation establishes the check valve Cv, there are no acceptance criteria for this value. The calculation also determines the maximum containment pressure due to presence of nitrogen in the vent flow following the first actuation of the system at a torus pressure of 15 psig. The maximum containment pressure is calculated to be 47.2 psig, which is lower than the minimum PCPL of 48 psig. Therefore, this acceptance criterion is satisfied.

The NRC staff reviewed the information provided and audited the calculations. Based on the evaluation, the HCVS vent design appears to have the capacity to vent one percent of rated thermal power during ELAP and severe accident conditions with margin.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design characteristics, if implemented appropriately, appear to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.2 Vent Path and Discharge

Order EA-13-109, Attachment 2, Section 1.2.2 requires that the HCVS discharge the effluent to a release point above main plant structures. Relevant guidance is found in: NEI 13-02, Section 4.1.5; NEI 13-02, Appendix H; and HCVS-FAQ-04.

The NRC staff evaluated the HCVS vent path and the location of the discharge. The wetwell vent utilizes the 20" pipe that penetrates the torus and continues to the reactor building 5th floor with 24" pipe. The 10" HCVS exhaust stack branches off the 24" pipe on the reactor building 5th floor and continues to an elevated release point on the auxiliary building roof. The vent pipe extends approximately 3 feet above the parapet wall of the reactor building roof. The effect of the HCVS effluent due to the nearby 36" SGTS pipe that is higher in elevation was evaluated to have negligible effects. The NRC staff's review indicates that this appears to be consistent with the guidance provided in HCVS-FAQ-04.

Guidance document NEI 13-02, Section 5.1.1.6, provides guidance that missile impacts are to be considered for portions of the HCVS. The NRC-endorsed NEI white paper, HCVS-WP-04, "Tornado Missile Evaluation for HCVS Components 30 Feet Above Grade," Revision 0 [Reference 32], provides a risk-informed approach to evaluate the threat posed to exposed portions of the HCVS by wind-borne missiles. The white paper concludes that the HCVS is unlikely to be damaged in a manner that prevents containment venting by wind-generated missiles coincident with an ELAP or loss of normal access to the ultimate heat sink (UHS) for plants that are enveloped by the assumptions in the white paper. Fermi meets all the assumptions of this white paper except for the small tubing on RB 5th Floor items, as described in 2.b, below.

The licensee evaluated the vent pipe robustness with respect to wind-borne missiles against the requirements contained in HCVS-WP-04. This evaluation demonstrated that the pipe was robust with respect to external missiles per HCVSWP-04 in that:

1. For the portions of exposed piping below 30 feet above grade, all piping is in the East side of the reactor building and thus protected from wind driven missiles by analysis of the building and Safe Shutdown structures, systems, components contained therein.

2. The exposed piping greater than 30 feet above grade has the following characteristics:
    a. The total vent pipe exposed area is 210 square feet which is less than the 300 square foot limit.
    b. The pipe is made of schedule 40 stainless steel and is not plastic and the pipe components have no small tubing susceptible to missiles. Fermi 2 does have small stainless-steel tubing to the air operators for T4600F410/F420/F421 on RB-5 that is susceptible to wind borne missile damage, and therefore Fermi 2 conducted more extensive site specific FMEA (See EDP-37115.B125) for component failure with multiple plans to inspect and allow use of T4600F410 as a vent path for damage to the tubing on RB-5.
    c. There are no obvious sources of missiles located in the proximity of the exposed HCVS components. Conduct manuals reinforce removal of potential missiles on RB-5.

3. Fermi 2 maintains a large cutoff saw as part of the FLEX equipment. This saw can cut the vent pipe should it become damaged such that it restricts flow to an unacceptable level.

4. Hurricanes are not screened for Fermi 2.

The NRC staff reviewed the information provided and audited the evaluations. The NRC staff agrees that the HCVS pipe is adequately protected against seismic or tornado events.

Based on the evaluation above, the NRC staff concludes that the licensee's location and design of the HCVS vent path and discharge, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.3 Unintended Cross Flow of Vented Fluids

Order EA-13-109, Attachment 2, Section 1.2.3 requires that the HCVS include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site. Relevant guidance is found in: NEI 13-02, Sections 4.1.2, 4.1.4, and 4.1.6; and HCVS-FAQ-05.

In its FIP, the licensee described Fermi as an independent facility with no connections to any other units on site. Unintended crossflow between units is not possible.

Regarding unintended crossflow of vented fluids within the unit, the FIP states that Fermi's potential cross-flow paths for the HCVS vent consist of the following flow paths:

- SGTS inlet to Division 1 and Division 2 Trains (and auxiliary building airspace) are blocked by valves T4600F409 and T4600F408, respectively. These two valves fail close on loss of ac power or NIAS Division 1 or NIAS Division 2 (both of which occur during the ELAP). Additionally, these valves have indication of valve position in both the MCR and the HCVS control panel. The RB-5 inspection verifies these valves are closed prior to HCVS use. The valves are also tested to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors," [Reference 32] standards by procedure 47.000.94, "Local Leakage Rate Testing for Hardened Vent."

- HCVS vent pipe to reactor building HVAC/SGTS connections occur on RB-3 at T4600F407 and on RB-5 at T4600F410. Both of these valves fail open on loss of ac power or NIAS Division 1 and Division 2 (both of which occur during the ELAP). These valves were modified to include HCVS direct current (dc) operators and connections to the HCVS AB-4 Rack for nitrogen, so the valves can be closed as part of the HCVS pipe alignment. These valves have valve indications in both the MCR and HCVS control panel. The valves are also tested to 10 CFR Part 50 Appendix J standards by procedure 47.000.94, "Local Leakage Rate Testing for Hardened Vent."

- HCVS vent pipe to high pressure coolant injection (HPCI) barometric condenser exhaust connection occurs on auxiliary building sub-basement: HPCI room at T4600F406. This valve is normally closed and fails closed on loss of ac power or NIAS Division 2 (both of which occur during the ELAP). This valve was repaired in refueling outage RF-18 to ensure it met leak rate criteria. The valve is also tested to 10 CFR Part 50, Appendix J standards by procedure 47.000.94.

- HCVS vent pipe to nitrogen inerting bypass is normally closed and has a check valve to protect it from being a cross-flow path, T4600F438. This check valve is normally closed and would be expected to close due to reverse seating when the HCVS pipe is pressurized. The valve is also tested to 10 CFR Part 50, Appendix J standards by procedure 47.000.94.

The NRC staff reviewed the information provided, including FIP, Attachment 2, "One Line Diagram of HCVS Vent Path," and audited procedure 47.000.94. The NRC staff verified that the valves providing a potential cross flow between the HCVS and other connected systems are tested for leak-tight integrity on an established schedule, which appears to be acceptable for prevention of inadvertent cross flow of vented fluids and consistent with the guidance provided in HCVS-FAQ-05.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design limits the potential for unintended cross flow of vented fluids and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.4 Control Panels

Order EA-13-109, Attachment 2, Section 1.2.4 requires that the HCVS be designed to be manually operated during sustained operations from a control panel located in the MCR or a remote but readily accessible location. Relevant guidance is found in NEI 13-02, Sections 4.2.2, 4.2.4, 4.2.5, 5.1, and 6.1; NEI 13-02, Appendices A and H; and HCVS-FAQs-01 and -08.

In its FIP, the licensee stated that the HCVS control panel allows initiation, operation, and monitoring of the existing torus vent from a control panel located on AB-3 in the Division 2 switchgear room (approximately 50' across the corridor from the MCR). Accessibility to the HCVS control panel from the MCR is provided by two sets of double doors, one of which is a security door. Table 1 of the FIP contains a list of the HCVS instrumentation and controls components including their location and qualification information. The NRC staff reviewed Section III.B.1.2.4 and confirmed these statements by comparing the instrumentation and controls component locations provided in Table 1 of the FIP.

Based on the evaluation above, the NRC staff concludes that the licensee's location and design of the HCVS control panels, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.5 Manual Operation

Order EA-13-109, Attachment 2, Section 1.2.5 requires that the HCVS, in addition to meeting the requirements of Section 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. Relevant guidance is found in NEI 13-02, Section 4.2.3 and in HCVS-FAQs-01, -03, -08, and -09.

In its FIP, the licensee stated that Fermi 2 utilizes the normal operational method for the HCVS valves as the alternate means of operation. This requires several items that were not allowed for the primary method under Order EA-13-109 constraints. Normal operations method from the main control room requires the following:

- AC power to the normal ac solenoid-operated valves (SOVs) used to operate all six of the HCVS valves. This ac power comes from modular power unit (MPU) #1 and MPU #2 which must be energized from the FLEX generators (contrary to the 24 hour no FLEX rule in EA-13-109).

- Power alignment for primary and secondary containment valves (T4600F400/F401 for primary containment isolation valves; T4600F407/F410 for secondary containment isolation valves) must be changed from normal power (RPS A/B based on containment reliability constraints) to MPU #1 / MPU #2 using the power plugs in H11P622/H11P623.

- Interlock defeats for primary and secondary containment valves must occur to allow operation from the H11P817 panel in the MCR. This is done by operating the six keylock defeat switches located on the H11P617, H11P618, and H11P915 panels.

- Pneumatic force restoration by restoring NIAS Divisions 1 and 2 to allow operation of these six HCVS valves. This is done by providing compressed air from the FLEX air compressors (contrary to the 24 hour no FLEX rule in EA-13-109) and connecting this source to the Division 1 and Division 2 NIAS systems. Hoses and manual valves allow this connection from FLEX air into Division 1 and Division 2 NIAS systems. Included in this realignment is opening of the Division 1 and Division 2 NIAS isolation valves (P5000F440/P5000F441) that close on loss of power/pneumatic pressure. New connections were made to allow remote opening of the P5000F440/P5000F441 as local positioning of these NIAS isolation valves is in an area that will be inaccessible in a severe accident.

The location for the secondary HCVS operating method is the MCR, which provides all necessary controls and indications for HCVS operations.

As part of the audit, the NRC staff questioned needing to use FLEX equipment earlier than 24 hours. The NRC staff noted that Order Item 1.2.6 requires that the HCVS shall be capable of operating with dedicated and permanently installed equipment for at least 24 hours. The licensee clarified that the guidance in NEI 13-02, Revision 1 states that "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. ... A method (primary or alternate) of HCVS operation may use an alternative method to that described by the 1.2.5 requirement."

The NRC staff also questioned the use of existing electrical switches in the MCR to meet the requirement of manual operation of the HCVS. The licensee responded that NEI 13-02, Revision 1, HCVS-FAQ-03, "HCVS Alternate Control Operating Mechanisms," permits the use of separate electrical components with diverse and flexible power supplies (such as the normal valve operators with FLEX power). To meet the requirement of Order EA-13-109 Item 1.2.5, Fermi 2 will use the switches in the MCR using station batteries supplemented by a FLEX generator and a FLEX air compressor. The licensee has performed validation that the FLEX equipment can be placed into operation before operation of the HCVS is required. The NRC staff also audited those procedures.

Table 1 of the FIP contains an evaluation of the required controls and instruments that are required for severe accident response and demonstrates that all these controls and instruments will be functional during a loss of ac power and severe accident. Table 2 of the FIP contains a summary of thermal and radiological evaluation of the operator actions that may be required to support HCVS operation during a loss of ac power and severe accident. The licensee's evaluations conclude that these actions will be possible without undue hazard to the operators. These evaluations demonstrate that the design meets the requirement to be manually operated from a remote but readily accessible location during sustained operation. Attachment 6 to the FIP contains a site layout showing the location of these HCVS actions. The NRC staff audited the pertinent plant drawings and evaluation documents. The NRC staff's audit confirmed that the actions appear to be consistent with the guidance.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for manual operation, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.6 Power and Pneumatic Supply Sources

Order EA-13-109, Attachment 2, Section 1.2.6 requires that the HCVS 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 ELAP. Relevant guidance is found in: NEI 13-02, Sections 2.5, 4.2.2, 4.2.4, 4.2.6, and 6.1; NEI 13-02, Appendix A; HCVS-FAQ-02; and HCVS-WPs-01 and -02.

Pneumatic Sources Analysis

For the first 24 hours following the ELAP event, the motive force for the six HCVS AOVs will be supplied by three nitrogen air bottles. The nitrogen air bottles are stored in the auxiliary building reactor building closed cooling water (RBCCW) heat exchanger room and the AB-4 floor exhaust fan room. These bottles have been sized such that they can provide motive force for at least eight cycles of a vent path.

In calculation DC-6636, "Hardened Containment Vent System Bottle Sizing, Vol. 1," Revision 0, the licensee determined the required pneumatic supply storage volume and supply pressure set point required to operate the AOVs for 24 hours following a loss of normal pneumatic supplies during an ELAP. The required pressure for AOV actuation is calculated at around 80 psig. The licensee's calculation determined that three nitrogen bottles, each filled at the maximum capacity of 2,400 psig, will provide sufficient capacity for eight cycles of the six AOVs for 24 hours following an ELAP. This pressure includes an allowance for leakage. The NRC staff audited the calculation and confirmed that there should be sufficient pneumatic supply available to provide motive force to operate the AOVs for 24 hours following a loss of normal pneumatic supplies during an ELAP.

Power Source Analysis

In its FIP, the licensee stated that during the first 24 hours of an ELAP event, Fermi 2 would rely on existing Class 1E station Division 2 ESF battery 2B-1 and its associated battery charger to provide power to HCVS components. The 130-volt (V) dc HCVS battery and battery charger are located in the auxiliary building on the 3rd floor. The station Division 2 ESF battery 2B-1 and its associated battery charger are installed where they are protected from applicable hazards. C&D Technologies manufactured battery 2B-1.

Battery 2B-1 is model LCR-21 with a nominal capacity of 1500 ampere hours (Ah) at an 8-hour discharge rate. Battery 2B-1 has a minimum capacity capable of providing power for 24 hours without recharging. During the audit period, the licensee provided the NRC staff an evaluation for battery 2B-1 and its associated battery charger including incorporation into the FLEX diesel generator (DG) loading calculation.

The NRC staff audited licensee calculation DC-6584, "FLEX DC Calculations," Revision A, which verified the capability of the Division 2 ESF battery 2B-1 to supply power to the required loads during the first phase of the Fermi 2 venting strategy for an ELAP. The licensee's calculation identified the required loads and their associated ratings (amperage and minimum system operating voltage). The licensee conservatively showed that the maximum HCVS load is 5 amperes of continuous loading for a 24-hour duty period. The addition of 5 amperes is within the capacity of station Division 2 ESF battery 2B-1. Therefore, the Fermi 2 Division 2 ESF battery should have sufficient capacity to supply power for at least 24 hours.

The licensee's strategy includes repowering the 2B-1 battery charger within 24 hours after initiation of an ELAP. The licensee's strategy relies on one of two 550-kilowatt (kW) 480 Volt alternating current (Vac) FLEX DG for the HCVS electrical strategy. The 480 Vac FLEX DG would provide power to the HCVS load in addition of loads addressed under Order EA-12-049.

The NRC staff audited licensee calculation DC-6583, "FLEX AC Calculations," Revision 0, which incorporated the Division 2 ESF battery charger on the FLEX DGs. Based on the NRC staff's review of calculation DC-6583, it appears that the FLEX DG should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

<u>Electrical Connection Points</u>

The licensee's strategy to supply power to HCVS components requires using a combination of permanently installed and portable components. Staging and connecting the 550 kW FLEX DG was addressed under Order EA-12-049. Licensee procedures 29.FSG.01, "FLEX Plant," Revision 0, provide guidance to place the 2B-1 battery charger in service and power it from the FLEX DG.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for reliable operation with dedicated and permanently installed equipment, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.7 Prevention of Inadvertent Actuation

Order EA-13-109, Attachment 2, Section 1.2.7 requires that the HCVS include means to prevent inadvertent actuation. Relevant guidance is found in NEI 13-02, Section 4.2.1.

In its FIP, the licensee stated that the emergency operating procedures (EOPs) provide clear guidance to operators that the HCVS is not to be used to defeat containment integrity during any design basis transients and accident. In addition, the HCVS was designed to provide features that prevent inadvertent actuation due to equipment malfunction or operator error.

At Fermi 2, inadvertent actuation prevention of the HCVS is accomplished by the following physical design features. Key-lock handles are installed on panel doors to prevent inadvertent operator action. The nitrogen system bottle racks are secured with locked valves. A double block and bleed system is installed on the auxiliary building west wall to prevent inadvertent operation of two HCVS process valves. A pressure switch, which is associated with the primary containment isolation valves (PCIVs) T4600F400 and T4600F401, is installed to provide annunciation in the MCR during normal operation. For emergency conditions, the pressure switch indicates the manual override of the automatic isolation operation of the two PCIVs. Control circuits are modified to install key-lock switches to override the containment isolation signal for AOVs T4600F400, T4600F401, T4600F407, and T4600F410. The NRC staff's audit of the HCVS confirmed that the licensee's design appears to be consistent with the guidance and should preclude inadvertent actuation.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to prevention of inadvertent actuation, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.8 Monitoring of HCVS

Order EA-13-109, Attachment 2, Section 1.2.8 requires that the HCVS include means to monitor the status of the vent system (e.g. valve position indication) from the control panel required by Section 1.2.4. In addition, Order EA-13-109 requires that the monitoring system be designed for sustained operation during an ELAP. Relevant guidance is found in NEI 13-02, Section 4.2.2; and HCVS-FAQs-01, -08, and -09.

The NRC staff reviewed the following channels documented in Table 1 of the FIP that support HCVS operation: SGTS hard vent temperature; HCVS radiation; drywell pressure; wetwell level; valve position indication; nitrogen supply pressure; and dc battery volts. The NRC staff notes that drywell pressure and wetwell level are declared Fermi 2 post-accident monitoring (PAM) variables as described in RG 1.97 and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1. The NRC staff also reviewed FIP Section III.B.1.2.8 and determined that the HCVS instrumentation appears to be adequate to support HCVS venting operations and can perform its intended function during ELAP and severe accident conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for the monitoring of key HCVS instrumentation, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.9 Monitoring of Effluent Discharge

Order EA-13-109, Attachment 2, Section 1.2.9 requires that the HCVS include means to monitor the effluent discharge for radioactivity that may be released from operation of the HCVS. In addition, Order EA-13-109 requires that the monitoring system provide indication from the control panel required by Section 1.2.4 and be designed for sustained operation during an ELAP. Relevant guidance is found in: NEI 13-02, Section 4.2.4; and HCVS-FAQs-08 and -09. The NRC staff reviewed the following channels documented in Sections I.A.1, III.A.2, III.B.1.2.8, III.B.1.2.9 and Table 1 of the FIP that support monitoring of HCVS effluent: HCVS valve position; HCVS temperature; and HCVS radiation. The NRC staff found that effluent radiation monitor provides sufficient range to adequately indicate effluent discharge radiation levels.

In Section III.B.1.2.9 and Table 1 of its FIP, the licensee stated that the radiation monitor detector is fully qualified for the expected environment at the vent pipe during accident conditions, and the process and control module is qualified for the mild environment in the MCR. The NRC staff reviewed the qualification summary information provided in Table 1 of the FIP and found that it appears to meet the guidance. The NRC staff also confirmed the summary information through audit reviews of Fermi 2 documents EDP 37115 "Reliable, Severe Accident Capable Containment Wetwell venting Sys Mod for NRC Order EA-13-109," Revision A and DC-6639 Volume 1, "Loss of HVAC Room Environmental Analysis," Revision 0.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for the monitoring of effluent discharge, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.10 Equipment Operability (Environmental/Radiological)

Order EA-13-109, Attachment 2, Section 1.2.10 requires that the HCVS 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. Relevant guidance is found in: NEI 13-02, Sections 2.3, 2.4, 4.1.1, 5.1 and 5.2; NEI 13-02 Appendix I; and HCVS-WP-02.

Environmental

The FLEX diesel-driven severe accident water addition (SAWA) pump and FLEX DG will be staged outside so they will not be adversely impacted by a loss of ventilation.

As discussed above in Section 3.1.1.2, the licensee performed design calculation DC-6639, which documented the expected temperature at the primary operating station (Division 2 switchgear room) following an ELAP. Licensee procedures provide guidance to plant operators to energize the switchgear room A/C unit to cool the switchgear rooms after the Phase 2 FLEX DG is deployed and to restore water-based cooling to the rooms in 24-30 hours by restoring cooling to the RBCCW system as part of Phase 3. It is reasonable to assume that the licensee's actions would reduce and maintain the Division 2 switchgear room temperature below 120°F.

The Division 2 batteries and battery chargers are permanently installed in the auxiliary building on the 3rd floor. Licensee calculation DC-6639 determined the expected temperature in the Division 2 battery rooms and battery charger rooms following an ELAP. The calculation also shows that the maximum temperature in the Division 2 battery rooms would be maintained less than the manufacturer's maximum design limit of 122°F. Therefore, the Class 1E Division 2 ESF batteries appear to be adequate to perform their design function under event conditions.

Based on the above, the NRC staff concurs with the licensee's evaluations that show the Division 2 ESF battery will remain within the maximum temperature limit of 122°F for the Class 1E ESF batteries. Furthermore, based on licensee actions of restoring cooling to the RBCCW system to reduce and maintain temperatures below 120°F (the temperature limit for electronic equipment to be able to survive indefinitely, identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, as endorsed by NRC RG 1.155), the NRC staff believes that electrical equipment located at the HCVS control panel should not be adversely impacted by the loss of ventilation as a result of an ELAP event with the HCVS in operation. Therefore, the NRC staff concurs that the HCVS equipment located in the Division 2 switchgear room should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Radiological

The licensee's calculations RWA-1805-002, "Fermi 2 Power Plant HCVS Radiological Dose Analysis," and DC-6645 VOL I, "HCVS Radiological Assessment," document the dose assessment for both personnel habitability and equipment locations associated with event response to a postulated ELAP condition. The NRC staff audited calculations RWA-1805-002 and DC-6645 VOL I and note that the licensee used conservative assumptions to bound the peak dose rates for the analyzed areas. For the sources considered and the methodology used in the dose calculations, the timing of HCVS vent operation or cycling of the vent will not create higher doses at personnel habitability and equipment locations (i.e., maximum doses determined in the calculation bound operational considerations for HCVS vent operation). The NRC staff's audit confirmed that the anticipated severe accident radiological conditions will not preclude the operation of necessary equipment or result in an undue risk to personnel from radiation exposure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to equipment operability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.11 Hydrogen Combustible Control

Order EA-13-109, Attachment 2, Section 1.2.11 requires that the HCVS 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. Relevant guidance is found in: NEI 13-02, Sections 4.1.7, 4.1.7.1, and 4.1.7.2; NEI 13-02, Appendix H; and HCVS-WP-03.

In NEI 13-02, Section 4.1.7 provides guidance for the protection from flammable gas ignition for the HCVS system. The NEI issued a white paper, HCVS-WP-03, "Hydrogen /Carbon Monoxide Control Measures," Revision 1, endorsed by the NRC [Reference 33], which provides methods to address control of flammable gases. One of the acceptable methods described in the white paper is to install a check valve near or at the exhaust end of the vent stack to restrict the ingress of air to the vent pipe when venting stops and steam condenses (Option 5).

In its FIP, the licensee stated that to prevent a detonable mixture from developing in the HCVS pipe, a check valve is installed near the top of the pipe in accordance with HCVS-WP-03. This valve will open on venting but will close to prevent air from migrating back into the pipe after a period of venting. The check valve is installed and tested to ensure that it limits back-leakage to preclude a detonable mixture from occurring in the case venting is stopped prior to the establishment of alternate reliable containment heat removal. The use of a check valve meets the requirement to ensure the flammability limits of gases passing through the vent pipe will not be reached.

Fermi 2 HCVS pipe is a part of the RBHVAC system and therefore has a unique issue. Air would be present in the HCVS pipe prior to initial operation. Based on this, an operator purge of the air in the pipe is planned prior to generation of significant hydrogen from the zirconium-water reaction at about 75 minutes into the severe accident sequence. The actions to conduct this initial purge (using the drywell/torus nitrogen) following an ELAP event were validated using the validation program at 51 minutes .

The NRC staff audited design package EDP-37115, Index Item B104. This evaluation included investigation of the formation of a combustible mixture due to check valve leakage. The NRC staff audited the information provided and the referenced calculation. The NRC staff confirmed that the licensee's design appears to be consistent with Option 5 of white paper HCVS-WP-03 and that the use of a check valve in conjunction with the HCVS venting strategy should meet the requirement to prevent a detonable mixture from developing in the pipe.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design ensures that the flammability limits of gases passing through the system are not reached, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.12 Hydrogen Migration and Ingress

Order EA-13-109, Attachment 2, Section 1.2.12 requires that the HCVS be designed to minimize the potential for hydrogen gas migration and ingress into the reactor building or other buildings. Relevant guidance is found in NEI 13-02, Section 4.1.6; NEI 13-02, Appendix H; HCVS-FAQ-05; and HCVS-WP-03.

As discussed in Section 3.1.2.3, "Unintended Cross Flow of Vented Fluids," Fermi 2 is an independent facility with no connections to any other units on site. Unintended cross flow between units is not possible.

Unintended cross flow of vented fluids within the unit are identified, discussed, and evaluated in Section 3.1.2.3. In summary, the potential cross flow paths are blocked by double-isolation valves tested to Appendix J standards, a single normally-closed, fail-closed, isolation valve leak tested to Appendix J standards, and a normally closed valve – check-valve combination. The NRC staff's audit confirmed that the design appears to be consistent with the guidance and meets the design requirements to minimize the potential of hydrogen gas migration into other buildings.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design minimizes the potential for hydrogen gas migration and ingress, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.13 HCVS Operation/Testing/Inspection/Maintenance

Order EA-13-109, Attachment 2, Section 1.2.13 requires that the HCVS include features and provisions for the operation, testing, inspection and maintenance adequate to ensure that reliable function and capability are maintained. Relevant guidance is found in NEI 13-02, Sections 5.4 and 6.2; and HCVS-FAQs-05 and -06.

In the Fermi 2 FIP, Table 3-3 includes testing and inspection requirements for HCVS components. The NRC staff reviewed Table 3-3 and confirmed that it is consistent with Section 6.2.4 of NEI 13-02, Revision 1. Implementation of these testing and inspection requirements for the HCVS will ensure reliable operation of the systems.

In its FIP, the licensee stated that the maintenance program was developed using the guidance provided in NEI 13-02, Sections 5.4 and 6.2, and it utilizes the standard Electric Power Research Institute (EPRI) industry preventive maintenance process for the maintenance calibration and testing for the HCVS components. The NRC staff reviewed the information provided and confirmed that the licensee has implemented adequate programs for operation, testing, inspection and maintenance of the HCVS.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for operation, testing, inspection, and maintenance, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.2 HCVS QUALITY STANDARDS

3.2.1 Component Qualifications

Order EA-13-109, Attachment 2, Section 2.1 requires that the HCVS vent path up to and including the second containment isolation barrier 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. Relevant guidance is found in NEI 13-02, Section 5.3.

In its FIP, the licensee states that the HCVS piping upstream of and including the second containment isolation valve T4600F401 and penetrations are not being modified for order compliance so that they continue to be designed consistent with the design basis of primary containment including pressure, temperature, radiation, and seismic loads. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators, and containment isolation valve position indication components. The hardened vent piping between the wetwell and the reactor building roof is designed to 62 psig and 340°F.

NEI 13-02 suggests a 350°F value for HCVS design temperature based on the highest PCPL among the Mark I and II plants. The Fermi 2 PCPL is 58.8 psig with a corresponding saturation temperature of 306.2°F. Fermi 2 used a design value of 340°F for the vent piping, corresponding to primary containment design temperature. This provides a 30.9°F margin to the 309.1°F saturation temperature at the primary containment maximum code allowable pressure of 62 psig. Thus, the temperature of 340°F will be retained as the pipe design temperature. This lower HCVS design temperature is adequate for component qualifications, since it is acceptable (per the guidance in NEI 13-02 Rev. 1, Section 2.4.3.1) to assume saturation conditions in containment.

The HCVS downstream of the outboard containment isolation valve, including piping and supports, electrical power supply, valve actuator pneumatic supply, and instrumentation (local and remote) components, has been designed and analyzed to conform to the requirements consistent with the applicable design codes for the plant and to ensure functionality following a design-basis earthquake. This includes environmental qualification consistent with expected conditions at the equipment location.

Table 1 of the FIP contains a list of components, controls, and instruments required to operate the HCVS, their qualification limits, and a summary of the expected environmental conditions. All instruments are fully qualified for the expected seismic conditions so that they will remain functional following a seismic event. The NRC staff reviewed Table 1 and confirmed that the components required for HCVS venting are designed to remain functional following a design basis earthquake. The NRC staff also confirmed the I&C component qualifications through audit reviews of Fermi 2 documents EDP 37115, Rev A, "Reliable, Severe Accident Capable Containment Wetwell venting Sys Mod for NRC Order EA-13-109," Revision A and DC-6639 Volume 1, Rev 0, "Loss of HVAC Room Environmental Analysis," Revision 0.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to component qualifications, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.2.2 Component Reliability and Rugged Performance

Order EA-13-109, Attachment 2, Section 2.2 requires that all other HCVS components be designed for reliable and rugged performance, 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. Relevant guidance is found in NEI 13-02, Sections 5.2 and 5.3.

In its FIP, the licensee stated that HCVS components downstream of the outboard containment isolation valve and components that interface with the HCVS are routed in seismically-qualified structures or supported from seismically-qualified structure(s) and that all instruments are fully qualified for the expected seismic conditions so that they will remain functional following a seismic event.

As part of the NRC staff's audit, the NRC staff requested verification that PCIVs will both close and open under the anticipated severe accident conditions. The licensee responded that the expected differential pressure is within the scope of containment design for compliance with Generic Letter (GL) 89-16, "Installation of a Hardened Wetwell Vent."

The licensee provided calculations addressing opening capabilities using higher actuator supply air pressure. The calculations show that the valves will spring close under design-basis differential pressure conditions. The calculations also show that the inboard PCIV, T4600F-400 and outboard PCIV, T4600F-401 will open, with margin, when the air pressure to the valve actuator is at least 92 psig. Per ECR-37115-9, Index Item #B092, the nitrogen regulator, supplying backup air to the actuators, is set at 98 ±5 psig. The relief valve is set at 125 psig.

Calculation DC-6636, "Hardened Containment Vent System Bottle Sizing," Revision 0 indicates that valve T4600F-400 will operate with an air pressure as low as 80 psig. Based on the torque calculations, 80 psig may be low. The NRC staff requested verification of the minimum operational air pressure for valve T4600F-400. In response, the licensee clarified that for BDBEE conditions, Scenario 3 of Kalsi Calculation 3612C is applicable and the minimum air pressure for T4600F-400 is 92 psig. The pressure used for sizing the volumetric capacity of the nitrogen bottles was based on a downstream pressure of 125 psig. The NRC staff audited the calculations and confirmed that the PCIVs should open under the maximum expected differential pressure during beyond-design-basis and severe accident wetwell venting.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to component reliability and rugged performance, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.3 Conclusions for Order EA-13-109, Phase 1

Based on its review, the NRC staff concludes that the licensee has developed guidance and a HCVS design that, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.0 TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 2

As stated above in Section 2.2, Order EA-13-109 provides two options to comply with the Phase 2 order requirements. Fermi has elected the option to develop and implement a reliable containment venting strategy that makes it unlikely the licensee would need to vent from the containment drywell before alternate reliable containment heat removal and pressure control is reestablished.

For this method of compliance, the order requires licensees to meet the following:

- 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;

- 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; and,

- 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.

Relevant guidance is found in NEI 13-02, Sections 4, 5 and 6; and Appendices C, D, and I.

4.1 Severe Accident Water Addition (SAWA)

The licensee plans to use the FLEX (SAWA) pump to provide SAWA flow into the reactor pressure vessel (RPV). Flow control for SAWA will be performed at the SAWA manifold trailer along with instrumentation and procedures to ensure that the torus vent is not submerged. Once SAWA flow is initiated, operators will have to monitor and maintain SAWA flow and ensure refueling of the diesel-driven equipment as necessary. In its FIP, the licensee states that the operator locations for deployment and operation of the SAWA equipment that are external to the reactor building are either shielded from direct exposure to the vent line or are a significant distance from the vent line so that dose will be maintained below ERO exposure guidelines.

4.1.1 Staff Evaluation

4.1.1.1 Flow Path

The SAWA injection flow path starts with the Neptune FLEX pump taking suction from the circulating water pond and being fed through a second centrifugal pump to raise the discharge pressure to at least 70 psig. The water discharged from this portion is supplied to a duplex strainer and through 10" hoses to the Dominator FLEX pump. The SAWA flow path continues from the Dominator FLEX pump through a hose to the manifold trailer, which contains two manifolds and four branch lines to inject the water into the residual heat removal (RHR) system. The four branch lines are used to allow up to 3,500 gallons per minute (gpm) (all four lines used) of flow into the torus for FLEX containment cooling. The remaining branch lines can be used to reduce flow for other injection paths such as RPV injection, drywell spray, or torus cooling/spray. Specifically, for the SAWA flow path, Division 2 of the RHR system is used while Division 1 of the RHR system is used to inject water into the spent fuel pool. Drywell pressure and wetwell level will be monitored and flow rate will be adjusted by use of the throttle valves on the SAWA manifold trailer branch lines. The hoses and pumps used for SAWA flow are stored in the two FLEX storage buildings, which is protected from all external hazards. This SAWA injection path is also protected from all external hazards in addition to severe accident conditions.

4.1.1.2 SAWA Pump

In its FIP, the licensee states that the strategy is to use three portable diesel-driven FLEX pumps in series to provide FLEX and SAWA flow. The three FLEX pumps in series are capable of 3,000 gpm of total flow, which includes 500 gpm for RPV injection. The FLEX pumps are stored in the FLEX storage buildings, where they are protected from all applicable external hazards. The initial SAWA flow will be injected into the RPV within 8 hours of the loss of injection. In its FIP, the licensee described the hydraulic analysis performed to demonstrate the capability of the three portable FLEX pumps to provide the required SAWA flow. The NRC staff audited calculations DC-0367, "Hydraulic Calculation for RHR System, Vol. I," Revision Q and calculation DC-0367, "FLEX RHR Injection Configuration-Pressure Drop Calculation, Vol. VIII," Revision B, which determined that the required SAWA flow rate of 500 gpm was within the capacity of the three portable FLEX pumps connected in series.

The NRC staff audited the flow rates and pressures evaluated in the hydraulic analyses and confirmed that the equipment can provide the needed flow. Based on the NRC staff's audit of the FLEX pumping capabilities, as described in the above hydraulic analysis and the FIP, it appears that the licensee has demonstrated that the portable FLEX pumps should perform as intended to support SAWA flow.

4.1.1.3 SAWA Analysis of Flow Rates and Timing

The licensee developed the overall accident management plan for Fermi from the BWR Owners Group (BWROG) emergency procedure guidelines and severe accident guidelines (EPG/SAG) and NEI 13-02, Appendix I. The SAWA/SAWM implementing procedures are integrated into the Fermi 2 severe accident guidelines (SAGs) (29.200.01). The EPG/SAG, Revision 3, when implemented with Emergency Procedures Committee Generic Issue 1314, allows throttling of SAWA valves to protect containment while maintaining the wetwell vent in service. The Severe Accident Management Guideline (SAMG) flow charts direct the use of the hardened vent as well as SAWA/SAWM when the appropriate plant conditions have been reached.

The licensee used NEI 12-06, Appendix E to validate the FLEX water system pumps used for SAWA can be deployed and commence injection in 1.88 hours which complies with the industry position of SAWA injection in less than 8 hours. The studies referenced in NEI 13-02 demonstrated that establishing flow within 8 hours will protect containment. Guidance document NEI 13-02, Appendix I, establishes an initial water addition rate of 500 gpm based on EPRI Technical Report 3002003301, "Technical Basis for Severe-Accident Mitigating Strategies." The initial SAWA flow rate will be at least 500 gpm. After roughly 4 hours, during which the maximum flow rate is maintained, the SAWA flow will be reduced. The reduction in flow rate and the timing of the reduction will be based on stabilization of the containment parameters of drywell pressure and torus level.

The licensee used the reference plant analysis included in NEI 13-02, Revision 1, and engineering report, 1DLL1T007-RPT-001, "Fermi 2 ELAP Mitigating Strategies-MAAP5.04 Assessments," to demonstrate that SAWA flow could be reduced to 100 gpm after 4 hours of initial SAWA flow rate and that suppression pool level remains below the suppression pool vent pipe for greater than 7 days of sustained operation allowing significant time for restoration of alternate containment pressure control and heat removal. At some point, if the torus level begins to rise, indicating that the SAWA flow is greater than the steaming rate due to containment heat load, SAWA flow can be further reduced as directed by the SAMGs.

In its FIP, the licensee stated that the torus vent was designed and installed to meet NEI 13-02, Revision 1, guidance and is sized to prevent containment overpressure under severe accident conditions. Fermi 2 will follow the guidance (flow rate and timing) for SAWA described in BWROG-TP-15-008, "Severe Accident Water Addition Timing," [Reference 34] and BWROG-TP-15-011 "Severe Accident Water Management" [Reference 35]. The wetwell vent will be opened prior to exceeding the PCPL value of 58.8 psig. The licensee also referenced analysis included in BWROG-TP-15-008, which demonstrates adding water to the reactor vessel within 8 hours of the onset of the event will limit the peak containment drywell temperature, significantly reducing the possibility of containment failure due to temperature. Drywell pressure can be controlled by venting the containment from the suppression chamber.

4.1.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed SAWA guidance that should ensure protection of the containment during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.2 Severe Accident Water Management

The licensee's strategy to preclude the necessity for installing a hardened drywell vent at Fermi 2 is to implement the containment venting strategy utilizing SAWA and SAWM. This strategy consists of the use of the Phase 1 torus vent and SAWA hardware to implement a water management strategy that will preserve the torus vent path until alternate reliable containment heat removal can be established. The SAWA system consist of a FLEX (SAWA) pump injecting into the RPV. The overall strategy consists of flow control by throttling valves at the FLEX (SAWA) manifold trailer along with instrumentation and procedures to ensure that the Torus vent is not submerged (SAWM). Water from the SAWA (FLEX) pump will be routed through the RHR system. The RHR connection allows the water to flow in the RPV. Throttling valves and flow meters will be used to control water flow to maintain wetwell availability. Procedures have been issued to implement this strategy including Revision 3 to the Severe Accident Management Guidelines (SAMGs). The suppression pool air space will continue to be vented using the HCVS. This strategy has been shown via Modular Accident Analysis Program (MAAP) analysis to protect containment without requiring a drywell vent for at least 7 days, which is the guidance from NEI 13-02 for the period of sustained operation.

4.2.1 Staff Evaluation

4.2.1.1 Available Freeboard Use

In its FIP, the licensee states that the freeboard between -3.16' and 4.66' elevation in the torus provides approximately 592,770 gallons of water volume before the level instrument would reach the top of the narrow range torus level instrument (4.66') or water level reaches the bottom of the vent pipe (-3.16'). Attachment 1 to the FIP shows an additional 10.33' (limited by procedure to 7.34') of freeboard is available prior to impacting the torus vent. This provides an additional 202,178 gallons of water volume before impacting the torus vent capability.

Generic assessment BWROG-TP-15-011 [Reference 35] provides the principles of SAWM to preserve the torus vent for a minimum of 7 days. After containment parameters are stabilized, SAWA flow will be reduced to a point where containment pressure will remain low while torus level is stable or very slowly rising. For Fermi, the SAWA/SAWM design flow rates (500 gpm at 8 hours followed by 100 gpm from 12 hours to 168 hours) and available freeboard volume (described above) are bounded by the values utilized in the BWROG-TP-15-011 reference plant analysis that demonstrates the success of the SAWA/SAWM strategy.

As shown in engineering report, 1DLL1T007-RPT-001, the torus level peaked at 3' at the 7-day point, thus providing a 1.66' margin to the normal freeboard limit of 4.66' and a 10.34' margin to available freeboard prior to impacting torus venting capability. Guidance for torus level control is found in the EOPs/SAGs.

The NRC staff audited engineering report, 1DLL1T007-RPT-001, "Fermi 2 ELAP Mitigating Strategies – MAAP5.04 Assessments." Section 4.2.9 of this engineering report demonstrates that starting SAWA at 500 gpm at 8 hours followed by SAWM at 100 gpm after 4 hours (12 hours into the event) that the HCVS will not become blocked by the water level. The NRC staff concurs that the flow of water added to the suppression pool can be controlled such that the suppression pool remains operational.

4.2.1.2 Strategy Time Line

As noted in Section 4.1.1.3, "SAWA Analysis of Flow Rates and Timing," the SAWA flow is based on engineering report, 1DLL1T007-RPT-001 and BWROG-TP-15-011 to demonstrate that throttling SAWA flow after containment parameters have stabilized, in conjunction with venting containment through the torus vent will result in a stable or slowly rising torus level. As noted above, for the scenario analyzed, the torus level peaked at 3' at the 7- day point thus providing a 1.66' margin to the normal freeboard limit of 4.66' and a 10.34' margin to available freeboard prior to impacting torus venting capability. This confirms a greater than 7-day period of sustained operation exists thus allowing significant time for restoration of alternate containment pressure control and heat removal. The NRC staff concurs that the SAWM approach should provide operators sufficient time to reduce the water flow rate and to maintain wetwell venting capability. The strategy is based on BWROG generic assessments in BWROG-TP-15-008 and BWROG-TP-15-011.

As noted above, BWROG-TP-15-008 demonstrates adding water to the reactor vessel within 8 hours of the onset of the event will limit the peak containment drywell temperature significantly, reducing the possibility of containment failure due to temperature. Drywell pressure can be controlled by venting the containment from the suppression chamber. Technical Paper BWROG-TP-011 demonstrates that, for a reference plant, starting water addition at a higher rate of flow and throttling after approximately 4-hours will not increase the suppression pool level to a point that could block the suppression chamber HCVS.

4.2.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed SAWM guidance that should make it unlikely that the licensee would need to vent from the containment drywell during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.3 SAWA/SAWM Motive Force

4.3.1 Staff Evaluation

4.3.1.1 SAWA Pump Power Source

As described in Section 4.1, the licensee plans to use three portable diesel-driven FLEX pumps to provide SAWA flow. Operators will refuel the FLEX pump and DGs in accordance with Order EA-12-049 procedures using fuel oil from the installed emergency diesel generator (EDG) fuel oil storage tanks. FLEX procedure 29.FSG.17, " FLEX Fuel Management," Revision 0, directs operators to refuel the portable FLEX pumps from the onsite EDG fuel oil storage tanks. In its FIP, the licensee states that refueling will be accomplished in areas that are shielded and protected from the radiological conditions during a severe accident scenario.

4.3.1.2 DG Loading Calculation for SAWA/SAWM Equipment

In its FIP, the licensee list drywell pressure, torus level, torus pressure, and the SAWA flow meter as instruments required for SAWA and SAWM implementation. The drywell pressure, torus level, and torus pressure instruments are used for HCVS venting operation.

These instruments are powered by the Class 1E station Division 2 ESF batteries until the FLEX DG is deployed and available. The SAWA flow meters do not require any electrical power. They use a venturi that measures differential pressure and drives flow indication via a diaphragm.

The NRC staff audited licensee calculation DC-6584, which verified the capability of the Class 1E station Division 2 ESF batteries to supply power to the required loads (e.g. drywell pressure, torus level, and torus pressure) during the first phase of the Fermi FLEX mitigation strategy plan for an ELAP event. The NRC staff also audited licensee calculation DC-6583, which verified that the 550kW FLEX DG is adequate to support the HCVS electrical loads. The NRC staff confirmed that the Class 1E station Division 2 ESF batteries and 550 kW FLEX DG should have sufficient capacity and capability to supply the necessary SAWA/SAWM loads during an ELAP event.

4.3.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has established the necessary motive force capable to implement the water management strategy during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.4 <u>SAWA/SAWM Instrumentation</u>

4.4.1 <u>Staff Evaluation</u>

4.4.1.1 SAWA/SAWM Instruments

In Section IV.C.10 of its FIP, the licensee stated that the instruments credited for SAWA/SAWM are:

- Torus Level: T50N406B (Instrument) / T50-R804B (CR Recorder) on H11P602 in MCR (also available at T50-R811 on HCVS control panel (H21P101))
- Drywell Pressure: T50N415B (Instrument) / T50-R802B (CR Recorder) Point 4 on H11P602 in MCR (also available at T50-R813 on HCVS control panel (H21P101))
- Torus Pressure: T50N414B (Instrument) / T50-R802B Point 2 on H11P602 in MCR (also available at T50-R812 on HCVS control panel (H21P101))
- SAWA Flowmeters: MT-001, MT-002, MT-003, MT-004 for 2.5", 2.5", 4", 6" branch lines located on Manifold Trailer (Stored in FSF-1)

The NRC staff reviewed Section IV.C.10.1, Section IV.C.10.2, and Table 1 of the FIP and found that the instruments appear to be consistent with the NEI 13-02 guidance.

4.4.1.2 SAWA Instruments and Guidance

In Section IV.C.10.2 of its FIP, the licensee stated that the drywell pressure and torus level instruments used to monitor the condition of containment are differential pressure detectors that are safety related and qualified for post-accident use. The licensee also stated that these instruments are referenced in SAGs for control of SAWA flow to maintain the torus vent in service while maintaining containment protection and are powered initially by plant ESF batteries for the first 24 hours and continue to be powered, for the sustained operating period, by the plant ESF batteries with restored plant ESF battery chargers supported by the FLEX generator.

In Section IV.C.10.2 of its FIP, the licensee stated that the SAWA flow meters use a venturi to sense differential pressure and drive a diaphragm that indicates flow independent of any electrical power source. The flow meters are mounted in the branch piping (one flowmeter per branch line) mounted on the manifold trailer.

In Section IV.C.10.2 of its FIP, the licensee stated that FLEX electrical strategies repower other containment instruments that include drywell temperature, which may provide information for the operations staff to evaluate plant conditions under a severe accident and to provide confirmation for adjusting SAWA flow rates.

The NRC staff reviewed the FIP, including Table 1 and Section IV.C.10.2 and found the licensees response appears to be consistent with the guidance. The NRC staff notes that NEI 13-02 Revision 1 Section C.8.3 clarifies that drywell temperature is not required, but may provide further information for the operations staff to evaluate plant conditions under severe accident and provide confirmation to adjust SAWA flow rates.

4.4.1.3 Qualification of SAWA/SAWM Instruments

In Section IV.C.10.3 of its FIP, the licensee stated drywell pressure, torus level instruments, and torus pressure are declared Fermi PAM variables as described in RG 1.97 and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1. The NRC staff verified the RG 1.97 variables in Chapter 7 of the Fermi Final Safety Analysis Report.

In its FIP, the licensee stated that the SAWA flow meter is rated for continuous use under the expected ambient conditions and will be available for the entire period of sustained operation. The licensee provided radiation qualification and anticipated dose in Table 1. The licensee also provided in Table 1 of the FIP the anticipated temperature at this location (105°F) and the qualification temperature (180°F). The NRC staff confirmed the proposed location of the SAWA flow meter relative to the vent in FIP Attachment 4 drawing. The NRC staff determined the SAWA flow meter appears to be qualified for the anticipated environment.

4.4.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has in place, the appropriate instrumentation capable to implement the water management strategy during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.5 <u>SAWA/SAWM Severe Accident Considerations</u>

4.5.1 <u>Staff Evaluation</u>

4.5.1.1 Severe Accident Effect on SAWA Pump and Flowpath

To address SAWA/SAWM severe accident dose considerations, the licensee performed a detailed radiological analysis documented as RWA-1805-002 Attachment A, "Fermi 2 Power Plant HCVS Radiological Dose Analysis Attachment A: Letter Report RWA-L-1805-003, Fermi 2 Equipment Design Review for Severe Accident Water Addition and Management (SAWA/SAWM)." This calculation analyzed the dose at different locations and times where operator actions will take place during FLEX/SAWA/SAWM activities. The analyzed locations include the HCVS control panel, MCR, travel paths for hose routing, and FLEX/SAWA pump locations.

In its FIP, the licensee stated that the FLEX/SAWA pumps are stored in FLEX storage facility 1 (FSF-1), inside the protected area, and FSF-2, outside the protected area adjacent to the circulating water pond and will be operated from outside the reactor building. Therefore, there will be no issues with radiation dose rates at the FLEX pump control location and there will be no significant dose to the FLEX pump. The NRC staff agrees that there should be no significant issues with radiation dose rates at the SAWA pump control locations, and there should be no significant dose to the SAWA pumps.

The SAWA flow path inside the reactor building consists of steel piping that will be unaffected by the radiation dose. The licensee analyzed the radiological conditions along the SAWA flow path to ensure that hoses will only be run in locations that are shielded from significant radiation dose or that have been evaluated for the integrated dose effects over the period of sustained operation. The NRC staff audited the information and agrees that the SAWA flow path will not be adversely affected by radiation effects due to the severe accident conditions.

4.5.1.2 Severe Accident Effect on SAWA/SAWM Instruments

The Fermi 2 SAWA strategy relies on three instruments: drywell pressure, torus level, and SAWA flow. Drywell pressure and torus level are declared Fermi 2 PAM variables as described in RG 1.97 and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1.

In its FIP, the licensee states that the SAWA pumps are stored in FSF-1 and FSF-2 and will be operated from outside the reactor building. Therefore, there will be no issues with radiation dose rates at the FLEX pump control locations. Based on this information, the NRC staff agrees that the SAWA/SAWM instruments should not be adversely affected by radiation effects due to severe accident conditions.

4.5.1.3 Severe Accident Effect on Personnel Actions

In Section IV.C.2 of its FIP, the licensee describes the reactor building actions within the first 7 hours. The actions required to implement SAWA/SAWM are expected to be completed prior to first venting of the torus. Access routes outside the reactor building during severe accident conditions (such as refueling FLEX generators and FLEX pumps) are located such that they are either shielded from direct exposure to the vent line or are a significant distance from the vent line, so that expected dose is maintained below the ERO exposure guidelines. Existing plant procedures for outdoor work will provide guidance such that operators will be able to perform required actions regardless of the temperature.

The temperature response for the main control room and the ROS was previously evaluated in Section 3.1.1.2, "Personnel Habitability – Environmental." The implementation of SAWA/SAWM will not impact the area temperatures in the primary operating station or MCR.

The licensee performed calculation RWA-1805-002 Attachment A, "Fermi 2 Power Plant HCVS Radiological Dose Analysis Attachment A: Letter Report RWA-L-1805-003, Fermi 2 Equipment Design Review for Severe Accident Water Addition and Management (SAWA/SAWM)," which documents the dose assessment for designated areas inside the Fermi 2 reactor building (outside of containment) and outside the Fermi 2 reactor building caused by FLEX activities and the sustained operation of the HCVS under the beyond-design-basis severe accident condition of an ELAP. This assessment used conservative assumptions to determine the expected dose rates in all areas that may require access during a beyond-design-basis ELAP. As stated in Section 3.1.1.3, "Personnel Habitability - Radiological," the NRC staff agrees, based on the audit of the licensee's detailed evaluations, that mission doses associated with actions taken to protect the public under beyond-design-basis severe accident conditions will not subject plant personnel to an undue risk from radiation exposure.

4.5.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has considered the severe accident effects on the water management strategy and that the operation of components and instrumentation should not be adversely affected, and the performance of personnel actions should not be impeded, during severe accident conditions following an ELAP event. The NRC staff further concludes that the water management strategy, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.6 Conclusions for Order EA-13-109, Phase 2

Based on its review, the NRC staff concludes that the licensee has developed guidance and a water management strategy that, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

5.0 HCVS/SAWA/SAWM PROGRAMMATIC CONTROLS

5.1 Procedures

Order EA-13-109, Attachment 2, Section 3.1 requires that the licensee develop, implement, and maintain procedures necessary for the safe operation of the HCVS. Furthermore, Order EA-13-109 requires that procedures be established for system operations when normal and backup power is available, and during an ELAP. Relevant guidance is found in NEI 13-02, Sections 6.1.2 and 6.1.2.1.

In its FIP, the licensee states that a site-specific program and procedures were developed following the guidance provided in NEI 13-02, Sections 6.1.2, 6.1.3, and 6.2. They address the use and storage of portable equipment including routes for transportation from the storage locations to deployment areas. In addition, the procedures have been established for system operations when normal and backup power is available, and during ELAP conditions. The FIP also states that provisions have been established for out-of-service requirements of the HCVS and the compensatory measures. In the FIP, Section V.B provides specific time frames for out-of-service requirements for HCVS functionality.

The FIP also provides a list of key areas where either new procedures were developed, or existing procedures were revised. The NRC staff audited the overall procedures and programs developed, including the list of key components included, and noted that they appear to be consistent with the guidance found in NEI 13-02, Revision 1. The NRC staff determined that procedures developed appear to be in accordance with existing industry protocols. The provisions for out-of-service requirements appear to reflect consideration of the probability of an ELAP requiring severe accident venting and the consequences of a failure to vent under such conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's procedures for HCVS/SAWA/SAWM operation, if implemented appropriately, appear to be consistent with NEI

13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the Order.

5.2 Training

Order EA-13-109, Attachment 2, Section 3.2 requires that the licensee train appropriate personnel in the use of the HCVS. Furthermore, Order EA-13-109 requires that the training include system operations when normal and backup power is available, and during an ELAP. Relevant guidance is found in NEI 13-02, Section 6.1.3.

In its FIP, the licensee stated that all personnel expected to perform direct execution of the HCVS/SAWA/SAWM actions will receive necessary training. The training plan has been developed per the guidance provided in NEI 13-02, Section 6.1.3, and will be refreshed on a periodic basis as changes occur to the HCVS actions, systems, or strategies. In addition, training content and frequency follows the systems approach to training process. The NRC staff reviewed the information provided in the FIP and confirmed that the training plan is consistent with the established systems approach to training process.

Based on the evaluation above, the NRC staff concludes that the licensee's plan to train personnel in the operation, maintenance, testing, and inspection of the HCVS design and water management strategy, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

6.0 CONCLUSION

In June 2014, the NRC staff started audits of the licensee's progress in complying with Order EA-13-109. The staff issued an ISE for implementation of Phase 1 requirements on April 1, 2015 [Reference 14], an ISE for implementation of Phase 2 requirements on August 30, 2016 [Reference 15], and an audit report on the licensee's responses to the ISE open items on July 10, 2018 [Reference 16].

The licensee reached its final compliance date on October 17, 2018, and in letter dated December 14, 2018 [Reference 17], has declared that Fermi, Unit 2 is in compliance with the order.

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance that includes the safe operation of the HCVS design and a water management strategy that, if implemented appropriately, should adequately address the requirements of Order EA-13-109.

7.0 REFERENCES

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2. Letter from Fermi to NRC, "Fermi, Unit 2 – Phase 1 Overall Integrated Plan in Response to June 6, 2013, Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions Phase 1 (Order Number EA-13-109)," dated June 30, 2014 (ADAMS Accession No. Ml14182A203)

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10. Letter from Fermi to NRC, "Eighth Six-Month Status Report For Phases 1 and 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated June 26, 2018 (ADAMS Accession No. ML18177A259)

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12. Nuclear Regulatory Commission Audits of Licensee Responses to Phase 2 of Order EA-13-109 to Modify Licenses With Regard To Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, dated August 10, 2017 (ADAMS Accession No. ML17220A328)

13. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195)

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Principal Contributors: Rajender Auluck
Bruce Heida
Brian Lee
Kerby Scales
Garry Armstrong
Steve Wyman
John Parillo

Date: July 31, 2019

SUBJECT: FERMI, UNIT 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS RELATED TO ORDER EA-13-109 (CAC NO. MF4362; EPID NO. L-2014-JLD-0048) DATED: July 31, 2019

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OFFICE	NRR/DLP/PBEB/PM	NRR/DLP/PBMB/LA	NRR/DLP/PBEB/BC
NAME	RAuluck	SLent	NSanfilppo
DATE	7/29/19	7/3/19	7/31/19

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