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

June 15, 2018

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNITS 1 & 2 – REPORT FOR THE AUDIT OF LICENSEE RESPONSES TO INTERIM STAFF EVALUATIONS OPEN ITEMS RELATED TO NRC ORDER EA-13-109 TO MODIFY LICENSES WITH REGARD TO RELIABLE HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS (CAC NOS. MF4460 AND MF4461; EPID L-2014-JLD-0054)

Dear Mr. Hanson:

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 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 licensees to submit for review overall integrated plans (OIPs) that describe how compliance with the requirements for both phases of Order EA-13-109 will be achieved.

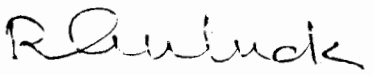
By letter dated June 30, 2014 (ADAMS Accession No. ML14184A017), Exelon Generation Company, LLC (the licensee) submitted its Phase 1 OIP for Quad Cities Nuclear Power Station, Units 1 and 2 (Quad Cities). By letters dated December 17, 2014, June 30, 2015, December 16, 2015 (which included the combined Phase 1 and Phase 2 OIP), June 30, 2016, January 26, 2017, June 27, 2017, and December 11, 2017 (ADAMS Accession Nos. ML14351A433, ML15181A330, ML15350A416, ML16182A396, ML17026A366, ML17178A079, and ML17345A778, respectively), the licensee submitted its 6-month updates to the OIP. The NRC staff reviewed the information provided by the licensee and issued interim staff evaluations (ISEs) for Phase 1 and Phase 2 of Order EA-13-109 for Quad Cities by letters dated April 1, 2015 (ADAMS Accession No. ML15089A421), and April 28, 2017 (ADAMS Accession No. ML17109A077), respectively. When developing the ISEs, the staff identified open items where additional information was still needed to complete its review.

The NRC staff is using the audit process described in letters dated May 27, 2014 (ADAMS Accession No. ML14126A545), and August 10, 2017 (ADAMS Accession No. ML17220A328), to gain a better understanding of licensee activities being performed for compliance with the order. As part of the audit process, the staff reviewed the licensee's closeout of the ISE open

items. The NRC staff conducted a teleconference with the licensee on May 17, 2018. The enclosed audit report provides a summary of that aspect of the audit.

If you have any questions, please contact me at (301) 415-1025 or by e-mail at Rajender.Auluck@nrc.gov.

Sincerely,



Rajender Auluck, Senior Project Manager
Beyond-Design-Basis Engineering Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-254 and 50-265

Enclosure:
Audit report

cc w/encl: Distribution via Listserv

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

# AUDIT REPORT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

# AUDIT OF LICENSEE RESPONSES TO INTERIM STAFF EVALUATIONS OPEN ITEMS

# RELATED TO ORDER EA-13-109 MODIFYING LICENSES

# WITH REGARD TO RELIABLE HARDENED CONTAINMENT VENTS CAPABLE OF

# OPERATION UNDER SEVERE ACCIDENT CONDITIONS

# EXELON GENERATION COMPANY, LLC

# QUAD CITIES NUCLEAR POWER STATION, UNITS 1 & 2

# DOCKET NOS. 50-254 AND 50-265

## BACKGROUND

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 Condition," to all Boiling-Water Reactor (BWR) licensees with Mark I and Mark II primary containments. The order requirements are divided into two parts to allow for a phased approach to implementation.

Phase 1 of Order EA-13-109 requires license holders of BWRs with Mark I and Mark II primary containments to design and install a Hardened Containment Vent System (HCVS), using a vent path from the containment wetwell to remove decay heat, vent the containment atmosphere (including steam, hydrogen, carbon monoxide, non-condensable gases, aerosols, and fission products), and control containment pressure within acceptable limits. The HCVS shall be designed for those accident conditions (before and after core damage) for which containment venting is relied upon to reduce the probability of containment failure, including accident sequences that result in the loss of active containment heat removal capability or extended loss of alternating current (ac) power (ELAP). The order required all applicable licensees, by June 30, 2014, to submit to the Commission for review an overall integrated plan (OIP) that describes how compliance with the Phase 1 requirements described in Order EA-13-109 Attachment 2 will be achieved.

Phase 2 of Order EA-13-109 requires license holders of BWRs with Mark I and Mark II primary containments to design and install a system that provides venting capability from the containment 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 order required all applicable licensees, by December 31, 2015, to submit to the Commission for

review an OIP that describes how compliance with the Phase 2 requirements described in Order EA-13-109, Attachment 2, will be achieved.

By letter dated June 30, 2014 (ADAMS Accession No. ML14184A017), Exelon Generation Company, LLC (Exelon, the licensee) submitted its Phase 1 OIP for Quad Cities Nuclear Power Station, Units 1 and 2 (Quad Cities). By letters dated December 17, 2014, June 30, 2015, December 16, 2015 (which included the combined Phase 1 and Phase 2 OIP), June 30, 2016, January 26, 2017, June 27, 2017, and December 11, 2017 (ADAMS Accession Nos. ML14351A433, ML15181A330, ML15350A416, ML16182A396, ML17026A366, ML17178A079, and ML17345A778, respectively), the licensee submitted its 6-month updates to the OIP, as required by the order.

The NRC staff reviewed the information provided by the licensee and issued interim staff evaluations (ISEs) for Phase 1 and Phase 2 of Order EA-13-109 for Quad Cities by letters dated April 1, 2015 (ADAMS Accession No. ML15089A421), and April 28, 2017 (ADAMS Accession No. ML17109A077), respectively. When developing the ISEs, the staff identified open items where additional information was still needed to complete its review.

The NRC staff is using the audit process in accordance with the letters dated May 27, 2014 (ADAMS Accession No. ML14126A545), and August 10, 2017 (ADAMS Accession No. ML17220A328), to gain a better understanding of licensee activities as they come into compliance with the order. The staff reviews submitted information, licensee documents (via ePortals), and preliminary Overall Program Documents (OPDs)/OIPs, while identifying areas where additional information is needed. As part of this process, the staff reviewed the licensee closeout of the ISE open items.

AUDIT SUMMARY

As part of the audit, the NRC staff conducted a teleconference with the licensee on May 17, 2018. The purpose of this audit teleconference was to continue the audit review and provide the NRC staff the opportunity to engage with the licensee regarding the closure of open items from the ISEs. As part of the preparation for the audit call, the staff reviewed the information and/or references noted in the OIP updates to ensure that closure of ISE open items and the HCVS design are consistent with the guidance provided in Nuclear Energy Institute (NEI) 13-02, Revision 1, other related documents (e.g., white papers (ADAMS Accession Nos. ML14126A374, ML14358A040, ML15040A038 and ML15240A072, respectively), and frequently asked questions (FAQs), (ADAMS Accession No. ML15271A148)) that were developed and reviewed as part of overall guidance development. The NRC staff audit members are listed in Table 1. Table 2 is a list of documents reviewed by the staff. Table 3 provides the status of the ISE open item closeout for Quad Cities. The open items are taken from the Phase 1 and Phase 2 ISEs issued on April 1, 2015, and April 28, 2017, respectively.

FOLLOW UP ACTIVITY

The staff continues to audit the licensee's information as it becomes available. The staff will issue further audit reports for Quad Cities, as appropriate.

Following the licensee's declarations of order compliance, the licensee will provide a final integrated plan (FIP) that describes how the order requirements are met. The NRC staff will evaluate the FIP, the resulting site-specific OPDs, as appropriate, and other licensee documents, prior to making a safety determination regarding order compliance.

CONCLUSION

This audit report documents the staff's understanding of the licensee's closeout of the ISE open items, based on the documents discussed above. The staff notes that several of these documents are still preliminary, and all documents are subject to change in accordance with the licensee's design process. In summary, the staff has no further questions on how the licensee has addressed the ISE open items, based on the preliminary information. The status of the NRC staff's review of these open items may change if the licensee changes its plans as part of final implementation. Changes in the NRC staff review will be communicated in the ongoing audit process.

Attachments:
1. Table 1 – NRC Staff Audit and Teleconference Participants
2. Table 2 – Audit Documents Reviewed
3. Table 3 – ISE Open Item Status Table

**Table 1 - NRC Staff Audit and Teleconference Participants**

| Title | Team Member | Organization |
|---|---|---|
| Team Lead/Sr. Project Manager | Rajender Auluck | NRR/DLP |
| Project Manager Support/Technical Support – Containment / Ventilation | Brian Lee | NRR/DLP |
| Technical Support – Containment / Ventilation | Bruce Heida | NRR/DLP |
| Technical Support – Electrical | Kerby Scales | NRR/DLP |
| Technical Support – Balance of Plant | Kevin Roche | NRR/DLP |
| Technical Support – I&C | Steve Wyman | NRR/DLP |
| Technical Support – Dose | John Parillo | NRR/DRA |

**Table 2 – Audit Documents Reviewed**

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| Calculation QDC-8300-E-2100, "Unit 1(2) 125 VDC Battery Coping Calculation For Beyond Design Basis FLEX Event," Revision 0 |
| Calculation QDC-1600-E-2200, "125 VDC Battery Sizing Calculation for Hardened Containment Vent System for 24 Hour Duty Cycle," Revision 1 |
| Calculation QDC-7300-E-2099, "Unit 1(2) 480 VAC FLEX Diesel Generator and Cable Sizing for Beyond Design Basis FLEX Event," Revision 1 |
| Engineering Change (EC) 392256, "Hardened Containment Vent System (Non-Outage Portion) As Required by NRC Order EA-13-109 Units 1 & 2 - Fukushima," Revision 2 |
| EC 400666, "Hardened Containment Vent System As Required by NRC Order EA-13-109 Units 2 – Fukushima, Part 2 of 3," Revision 0 |
| Calculation QDC-1600-M-2212, "HCVS Nitrogen Bottle Sizing and Pressure Regulator Set Point Determination," Revision 0 |
| Calculation 2014-02948, "Reactor Building Temperature Analysis Resulting from Extended Loss of AC Power," Revision 0 |
| Calculation QDC-1600-M-2247, "Unit 2 HCVS Vent Line Sizing Calculation," Revision 0 |
| Calculation QDC-1600-M-2188, "HCVS Vent Line Sizing Calculation" Revision 1 (Unit 1) |
| EC 402709, "Temperature in Proposed Location of HCVS Remote Operating Station Battery Racks and Gas Bottles," Revision 0 |
| Calculation QDC-0000-M-2199, "HCVS 7 Day Dose Analysis," Revision 0 |
| Calculation QDC-0020-S-2192, "HCVS Steel Tower Structural Calculation," Revision 0 |
| Procedure QCOP 0050-09 "FLEX Response Instrumentation and Communication Equipment," Revision 4 |
| Calculation QDC-1600-2190, "Hardened Containment System Design Calculation," Revision 0 |
| Calculation QDC-0000-M-2097, "PIPE FLO Analysis of FLEX Strategy," Revision 0 |
| Calculation QDC-0000-M-2223, "HCVS Phase II 7 Day Dose Analysis," Revision 0 |
| BWROG-TP-008, "Severe Accident Water Addition Timing" |
| BWROG-TP-011, "Severe Accident Water Management Supporting Evaluations" |

**Quad Cities Nuclear Power Station, Units 1 and 2**
**Vent Order Interim Staff Evaluation Open Items:**

**Table 3 - ISE Open Item Status Table**

| ISE Open Item Number<br><br>Requested Action | Licensee Response – Information provided in 6 month updates and on the ePortal | NRC Staff Close-out notes | Safety Evaluation (SE) status<br>Closed; Pending; Open (need additional information from licensee) |
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| Phase 1 ISE OI 1<br><br>Make available for NRC staff audit the calculation (QDC-8300-E-2100) that confirms that Order EA-12-49 actions to restore power are sufficient to ensure continuous operation of non-dedicated containment instrumentation. | Complete - Supplied to NRC Audit team during onsite FLEX evaluation (Jan 2015). (Ref. 13). Calculation QDC-8300-E-2100 confirms that Order EA-12-49 actions to restore power are sufficient to ensure; continuous operation of non-dedicated containment instrumentation.<br><br>Reference 13 has been provided in e-portal. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Calculation QDC-8300-E-2100, "Unit 1(2) 125 VDC [volts direct current]Battery Coping Calculation For Beyond Design Basis FLEX Event," Revision 0, shows that 125 VDC Battery is capable of providing power for the continuous operation of non-dedicated containment instrumentation.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.6] |
| Phase 1 ISE OI 2<br><br>Make available for NRC staff audit the final sizing evaluation for HCVS batteries/battery charger including incorporation into FLEX DG loading calculation. | Started - HCVS Battery design has been completed. (Refs. 14 and 17)<br><br>Calculation QDC-1600-E-2200 evaluates the sizing of the HCVS battery. (Ref. 28)<br><br>References have been provided in e-portal.<br><br>Incorporation into FLEX DG loading calculations is in progress. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The licensee stated that all electrical power required for operation of HCVS components is provided by the 125 Vdc battery/battery charger.<br><br>The battery sizing calculation (QDC-1600-E-2200) confirmed | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.6] |

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| | | that the HCVS batteries have a minimum capacity capable of providing power for 24 hours without recharging, and therefore is adequate.<br><br>The licensee provided EC 392256 and EC 400666, which discusses re-powering of the HCVS battery charger using a FLEX DG.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 3<br><br>Make available for NRC staff audit documentation of the HCVS nitrogen pneumatic system design including sizing and location. | Started- Unit 1 nitrogen system installed. Calculation QDC-1600-M-2212 for sizing approved and applicable to both Units. Unit 2 system installation in progress. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The Staff reviewed the Calculation QDC-1600-M-2212, "HCVS Nitrogen Bottle Sizing and Pressure Regulator Set Point Determination," Revision 0 and noted that 2 nitrogen bottles can operate an air-operated valave (AOV) 1-1601-60 one time and AOV 1699-98 16 times (12 required). The calculation credited the bottle pressures starting at 2000per square inch gauge (psig) down to 200 psig.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.6] |
| Phase 1 ISE OI 4<br><br>Make available for NRC staff audit an evaluation of temperature and radiological conditions to ensure that operating personnel can safely | Complete- Temperature evaluation (Calculation 2014-02948) was made available to NRC Audit team during onsite FLEX evaluation (Jan 2015)(Ref. 21).<br><br>Phase 1 Radiological evaluation has been completed. (Ref. 16). | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Main control room (MCR) temperatures have been addressed as part of the FLEX | Closed<br><br>[Staff evaluation to be included in SE Sections 3.1.1.2 and 3.1.1.3] |

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| access and operate controls and support equipment | Phase 2 Radiological evaluation has been completed (Ref. 6).<br><br>Evaluations of temperature and radiological conditions ensure that operating personnel can safely access and operate controls and support equipment. References have been provided in e-portal. | order and were found to be acceptable by the NRC staff.<br><br>EC 398588 and EC 402709 discusses the environmental conditions for the remote operating station (ROS) as it relates to personnel habitability and equipment operability.<br><br>EC 398588 was specifically meant as a bounding input for a calculation (2014-05860) for qualification of the Station batteries, which are located on the 639' elevation of the Turbine Building. The highest temperature was 135 degrees Fareneit (°F), from EC 398588, which was the temperature recorded at the highest point in the Turbine Building exhaust. Quad Cities used this same maximum temperature as an input for the travel paths from the MCR to the ROS. The MCR and the ROS are elevation 611', with the travel path dropping to 595' elevation between them. The expected temperature is much below the maximum temperature used for design of the system (135°F).<br><br>EC 402709 was a specific input to the design of the ROS. For both Units, the ROS area is generally surrounded by concrete walls except for the access path. As a result, temperatures exceeding | |

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| | | 125°F was not a concern for the design of the ROS. Also of note, the High Pressure (HP) Heater Bay is separated from the ROS area by concrete walls.<br><br>As a result of the evaluation of the above paragraphs, 135°F was chosen as the maximum temperature used for qualification of equipment and personnel habitability.<br><br>If the Turbine Building were to reach the maximum temperatures of 135°F, Operations has chosen to use toolbox approach, including the use of ice vests. Also of note, a complete manual operation of the HCVS system using bypass valves around solenoids to operate the primary containment isolation valves (PCIVs) and argon purge system would not need more than 15 minutes in an hour between cycles. The Quad Cities design does not require Operators continuously occupy the ROS.<br><br>Calculation QDC-0000-M-2199, "HCVS 7 Day Dose Analysis," Revision 0 was performed to determine the integrated radiation dose due to HCVS operation. The NRC staff reviewed this calculation and determined that the licensee used conservative assumptions and followed the guidance outlined in NEI 13-02 | |

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| | | Rev.1 and HCVS-WP-02 Rev. 0. Based on the expected integrated whole body dose equivalent in the MCR and ROS and the expected integrated whole body dose equivalent for expected actions during the sustained operating period, the NRC staff believes that the order requirements are met.<br><br>Based on the these evaluations, the temperature and radiological conditions should not inhibit operator actions needed to initiate and operate the HCVS during an ELAP with severe accident conditions.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 5<br><br>Make available for NRC staff review documentation that confirms the final design diameter of the HCVS piping. | Complete. Refer to the response to ISE open item 6. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The final design diameter of the HCVS piping was determined to be 12 inches.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.1] |
| Phase 1 ISE OI 6<br><br>Make available for NRC staff audit analyses demonstrating that HCVS has the capacity to vent the steam/energy equivalent of one (1) percent of licensed/rated thermal power (unless a lower value is justified), and that the | Complete. Calculation QDC-1600-M-2188 for Unit 1 line sizing approved (Ref. 19). Calculation QDC-1600-M-2247 for Unit 2 line sizing approved. (Ref. 30)<br><br>In addition, MAAP [Modular Accident Analysis Program] analyses (Ref. 12) are credited to verify that (1) venting can be delayed for at least three hours and (2) anticipatory venting sufficiently limits the | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Calculation QDC-1600-M-2247, "Unit 2 HCVS Vent Line Sizing Calculation," Revision 0 used a rated thermal power of 2,957 MWt [megawatt thermal]. The flow rate | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.1] |

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| suppression pool and the HCVS together are able to absorb and reject decay heat, such that following a reactor shutdown from full power containment pressure is restored and then maintained below the primary containment design pressure and the primary containment. | suppression pool heat up to maintain RCIC [reactor core isolation cooling] functional.<br><br>MAAP also confirms the HCVS is of sufficient size to prevent the Suppression Pool from reaching PCPL.<br><br>References have been provided in e-portal. | equivalent of 1% reactor power thermal energy is 110,453 lbm/hr at 47.7 psig. 47.7 psig is the primary containment pressure limit (PCPL) limit with the torus water level at the vent line opening. The 12" vent has the capacity of ~109,800 lbm/hr at 25 psig, ~124,400 lbm/hr at 30 psig, and ~173,000 lbm/hr at 47.7 psig.<br><br>Calculation QDC-1600-M-2188, "HCVS Vent Line Sizing Calculation," Revision 0 for Unit 1, shows the venting capacity at 47.9 psig PCPL (with torus filled with water up to the vent elevation) is 167,000 lbm/hr. The flow rate equivalent of 1% reactor power thermal energy is 110,465 lbm/hr. Vent capacity at 5 psig is 39,700 lbm/hr and 59,100 lbm/hr at 10 psig.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 7<br><br>Make available for NRC staff audit the seismic and tornado missile final design criteria for the HCVS stack. | Complete —The HCVS stack seismic design meets the Station's design basis earthquake design criteria. (Ref. 20)<br><br>Reference has been provided in e-portal.<br><br>The information provided in December 2015 OIP (Ref. 7) demonstrates that the external piping meets the tornado missile protection criteria of HCVS-WP-04. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Calculation QDC-0020-S-2192, "HCVS Steel Tower Structural Calculation," Revision 0, shows that the HCVS stack seismic design meets the Quad Cities design basis earthquake design criteria. | Closed<br><br>[Staff evaluation to be included in SE Section 3.2.2] |

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| | | EC 392256 and EC 400266 addresses the tornado missile design. For the tornado missile design the licensee relies on NRC-endorsed HCVS-WP-04. The HCVS external piping is all above 30-feet from ground level, except for two berms that will not have potential tornado missiles. The piping consists solely of large bore (12-inches nominal diameter) piping and its piping supports, and the pipe has less than 300 square feet of vertical cross section. The HCVS external piping meets the reasonable protection requirements of HCVS-WP-04. The external support structure used to support the HCVS piping is analyzed to the Quad Cities design basis tornado missiles to preclude a failure of the tower due to tornado winds and missiles.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 8<br><br>Make available for NRC staff audit the descriptions of local conditions (temperature, radiation and humidity) anticipated during ELAP and severe accident for the components (valves, instrumentation, sensors, transmitters, indicators, electronics, control devices, and etc.) required for HCVS venting including confirmation | Complete — Component location design has been determined. The ROS, gas bottles, dedicated battery, and most equipment are in the Turbine Building. The HCVS primary control panel is in the MCR (Refs. 14, 15, and 17).<br><br>Reactor Building temperatures are as noted in calculation 2014-02948 (Ref. 21).<br><br>Turbine Building temperatures at the ROS are as noted in evaluation EC 402709 (Ref. 22). | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>EC 402709 and EC 392257, and QDC-0000-M-2199, "HCVS 7 Day Dose Analysis," Revision 0 discusses the environmental conditions during an accident at the locations containing instrumentation and controls (I&C) components. The staff's review indicated that the | Closed<br><br>[Staff evaluation to be included in SE Sections 3.1.1.4 and 3.1.2.6] |

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| that the components are capable of performing their functions during ELAP and severe accident conditions. | Limiting radiation conditions for equipment as per calculation QDC-0000-M-2199, HCVS 7-Day Dose Analysis (Ref. 16).<br><br>References have been provided in e-portal. | environmental qualification met the order requirements.<br><br>The HCVS Battery and Charger are in the center of the Mezzanine Level (611' elevation) of the Turbine Building. The HCVS battery and charger are designed for 120°F, which based on operating data is the applicable upper bound for this area. The temperature of this area is bounded by the north and south ends, which are the locations of the areas occupied by Bus 13/14 and Bus 23/24. The heat loads in those areas are much higher than the center area, and so the center area is always cooler, even though not directly measured.<br><br>Temperature data from the Bus 13/14 area records a highest-ever temperature of 121.6°F on 7/7/12 at 16:48. Local weather history for the Quad Cities had a max atmospheric temperature of 104°F on that day. The temperature data for the Bus 23/24 area is generally less than the area for Bus 13/14, and all records below 120°F. It should be noted that 121.6°F was the single instance of temperature over 120°F in 10 years of temperature records. Based on the fact that this data was taken with operating heats loads and in a region hotter than the area where the HCVS battery and | |

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| | | charger are installed, this supports 120°F as the upper bound for this location.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 9<br><br>Make available for NRC staff audit documentation that demonstrates adequate communication between the remote HCVS operation locations and HCVS decision makers during ELAP and severe accident conditions. | Complete — QCOP 0050-09 FLEX Response Instrumentation and Communication Equipment provides a detailed description of Communications equipment dedicated to FLEX response utilized for Severe Accident Response. This equipment includes radios programed for talk around mode with additional batteries and Sound powered phones which can be used for communications between the Main Control Room and local control stations. QCOS 0050-04 FLEX Sound Powered Phone Surveillance is being revised to test two additional connection points that can be utilized for Severe Accident response and control of SAWA/SAWM [severe accident water addition/ severe accident water management] flow and local operation of the HCVS valves.<br><br>References have been provided in e-portal. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The communication methods are the same as accepted in Order EA-12-049.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.1.1] |
| Phase 1 ISE OI 10<br><br>Provide a description of the final design of the HCVS to address hydrogen detonation and deflagration. | Complete —As stated in the December 2015 01P, Quad Cities will utilize Argon purge system to address combustible gases in the HCVS piping. A summary of I the design features is included in the December 2015 01P (Ref. 7). | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The HCVS design will include an Argon purge system that will be connected just downstream of the second PCIV. It will be designed to prevent hydrogen detonation downstream of the second PCIV. The Argon purge system will have | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.11] |

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| | | a switch for the control valve in the MCR to allow opening the purge for the designated time, but it will also allow for local operation in the ROS in case of a dc power or control circuit failure. The installed capacity for the Argon purge system will be sized for at least 8 purges within the first 24 hours of the ELAP.<br><br>Calculation QDC-1600-2190, "Hardened Containment System Design Calculation," Revision 0 determined that 16 Argon bottles for each unit (32 total) maintained at a minimum pressure of 2350 at 70°F, can provide necessary Argon to purge the HCVS following 8 venting evolutions during a severe accident scenario.<br><br>The licensee's design is consistent with Option 3 of the NRC-endorsed white paper HCVS-WP-03.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 11<br><br>Provide a description of the strategies for hydrogen control that minimizes the potential for hydrogen gas migration and ingress into the reactor building or other buildings. | Complete - As described in the December 2015 OIP (Ref. 7), the HCVS torus vent path in each Quad Cities unit, starting at and including the downstream PCIV, will be a dedicated HCVS flow path. There are no interconnected systems downstream of the downstream, dedicated HCVS PCIV. Interconnected systems are upstream of the downstream HCVS PCIV and are isolated by normally shut, fail shut PCIVs which, if open, would | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The HCVS wetwell pipe in each each unit provides a dedicated HCVS flowpath from the wetwell penetration PCIVs to the outside with no interconnected downstream piping. The staff's | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.12] |

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| | shut on an FLAP. There is no shared HCVS piping between the two units.<br><br>The vent path will rely on Argon purge system to prevent the formation of a combustible gas mixture from forming within the line (Refs. 14, 15 and 17).<br><br>References have been provided in e-portal | review of the proposed system indicates that the licensee's design appears to maintain hydrogen below flammability limits.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 12<br><br>Make available for NRC staff audit documentation of a seismic qualification evaluation of HCVS components. | Started — The Quad Cities seismic evaluation is based on the Quad Cities safe shutdown earthquake (SSE), which is sufficient by Exelon HCVS Position Paper EXC-WP-15. A list of component evaluations is uploaded to ePortal. Due to the size of the evaluation, they are available upon request. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The licensee provided several qualification reports which demonstrate the seismic adequacy of the HCVS components. These seismic qualification reports indicates the HCVS piping, components, supports, and wall penetrations are based on the Quad Cities SSE. The NRC staff reviewed these reports and confirmed that the components required for HCVS venting remain functional following a design basis earthquake.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 3.2.2] |
| Phase 1 ISE OI 13<br><br>Make available for NRC staff audit descriptions of all instrumentation and controls (existing and planned) necessary to implement this | Complete. Instrument design is complete with approval of modifications for construction. (Refs. 14, 15 and 17).<br><br>References have been provided in e-portal. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The existing plant instuments required for HCVS (i.e. wetwell level instruments and drywell | Closed<br><br>[Staff evaluation to be included in SE Section 3.1.2.8] |

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| order including qualification methods. | | pressure instruments) meet the requirements of RG 1.97.<br><br>EC 392256, EC 392257 and EC 400666 discusses the qualifications for new HCVS I&C components. The NRC staff's review indicated that the qualification met the order requirements.<br><br>No follow-up questions. | |
| Phase 1 ISE OI 14<br><br>Make available for NRC staff audit the procedures for HCVS operation. | Started. Procedures are under development by Operations. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The guidelines and procedures for HCVS operation will be developed and will be consistent with the guidance in NEI 13-02.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 5.1] |
| Phase 2 ISE OI 1<br><br>Licensee to demonstrate that the hydraulic analysis for the FLEX pump is capable to support the required 400 gpm SAWA flow rate. | Complete. FLEX calculation QDC-0000-M-2097 (Ref. 11) is revised with hydraulic parameters for addition of SAWA scenarios.<br><br>References have been provided in e-portal. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Calculation QDC-0000-M-2097, "Pipe Flo Analysis of FLEX Strategy," Revision 1, determined the FLEX pumps should be able to provide the required SAWA flow of 400 gallons per minute (gpm) for 1 unit while the providing FLEX flow of 196 gpm and 92 gpm to the SFP with a 10% margin.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Section 4.1.1.2] |

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| Phase 2 ISE OI 2<br><br>Licensee to evaluate the SAWA equipment and controls, as well as the ingress and egress paths for the expected severe accident conditions (temperature, humidity, radiation) for the sustained operating period. | Complete.<br><br><u>Equipment and Controls</u><br><br>Plant instrumentation for SAWM that is qualified to RG 1.97 or equivalent is considered qualified for the sustained operating period without further evaluation. The following plant instruments are qualified to RG 1.97:<br><br>DW Pressure Pi 1(2)-1640-11A/B<br>Suppression Pool Level LI 1(2)-1640-10A/B<br><br>Passive components that do not need to change state after initially establishing SAWA flow do not require evaluation beyond the first 8 hours, at which time they are expected to be installed and ready for use to support SAWA/SAWM.<br><br>The following additional equipment performing an active SAWA/SAWM function is considered:<br><br>SAWA/SAWM flow instrument.<br>SAWA/SAWM pump<br>SAWA/SAWM generator (the FLEX generator for the associated Unit)<br><br><u>Ingress and Egress</u><br><br>For locations outside the Reactor Building between 7 hours and 7 days when SAWA is being utilized, a quantitative evaluation of expected dose rates has been performed per HCVS-WP-02 and found the dose rates at deployment locations | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>For temperature review of the MCR and ROS, see Phase 1 ISE Open Item-4 above. As noted in Phase 1 ISE Open Item-4, above, if required, operating personnel working in high temperature areas will be protected using a toolbox approach, including the use of ice vests. With the use of the toolbox approach, it is reasonable to assume the operator actions required to implement the HCVS and SAWA/SAWM strategies can be accomplished.<br><br>The NRC staff reviewed calculation QDC-0000-M-2223, "HCVS Phase II 7 Day Dose Analysis," Revision 0 and determined that the licensee used conservative assumptions and followed the guidance outlined in NEI 13-02 Rev.1 and HCVS-WP-02 Rev.0. Based on the expected integrated whole body dose equivalent in the MCR and ROS and the expected integrated whole body dose equivalent for expected actions during the sustained operating period, the NRC staff believes that the order requirements are met. | Closed<br><br>[Staff evaluation to be included in SE Sections 4.1.1.4 and 4.2.1.4] |

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| | including ingress/egress paths are acceptable. (QDC-0000-M-2223, Ref. 6)<br><br>References have been provided in e-portal. | Temperature and radiological conditions should not inhibit operator actions or SAWA equipment and controls needed to initiate and operate the HCVS during an ELAP with severe accident conditions.<br><br>No follow-up questions. | |
| Phase 2 ISE OI 3<br><br>Licensee to demonstrate how instrumentation and equipment being used for SAWA and supporting equipment is capable to perform for the sustained operating period under the expected temperature and radiological conditions. | Complete.<br><br>Equipment and Controls<br><br>Plant instrumentation for SAWA that is qualified to RG 1.97 or equivalent is considered qualified for the sustained operating period without further evaluation. The following plant instruments are qualified to RG 1.97:<br><br>DW Pressure PI 1(2)-1640-11A/B<br>Suppression Pool Level LI 1(2)-1640-10A/B<br><br>Passive components that do not need to change state after initially establishing SAWA flow do not require evaluation beyond the first 8 hours, at which time they are expected to be installed and ready for use to support SAWA/SAWM.<br><br>The following additional equipment performing an active SAWA/SAWM function is considered for temperature and radiation effects:<br><br>SAWA/SAWM flow instrument.<br>SAWA/SAWM pump (maybe the FLEX pump) | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The drywell pressure and torus level indications are RG 1.97 compliant and are acceptable as qualified.<br><br>Calculation QDC-0000-M-2223, "HCVS Phase II 7 Day Dose Analysis," Revision 0 was performed to determine the integrated radiation dose due to HCVS operation.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Sections 4.4.1.3 and 4.5.1.2] |

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| | SAWA/SAWM generator (may be the FLEX generator)<br><br><u>Temperature</u><br><br>The location of the distribution manifold is one floor below the ROS, and has similar or better temperature conditions as at the ROS. The location of the SAWA pump is similar to the FLEX pump, i.e. outside, but on the West side of the Site vs. east side.<br><br>The location of SAWA equipment and controls are the same or similar as FLEX, and are bounded by the FLEX evaluations for temperature.<br><br><u>Radiation</u><br><br>For equipment locations outside the Reactor Building between 7 hours and 7 days when SA WA is being utilized, a quantitative evaluation of expected dose rates has been performed per HCVS-WP-02 and found the dose rates at deployment locations are acceptable. (QDC-0000-M-2223, Ref. 6)<br><br>References have been provided in e-portal. | | |
| Phase 2 ISE OI 4<br><br>Licensee to demonstrate that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions. | Complete.<br><br>The Wetwell vent has been designed and installed to meet NEI 13 -02 Rev 1 guidance, which will ensure that it is adequately sized to prevent containment overpressure under severe accident conditions. | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>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 | Closed<br><br>[Staff evaluation to be included in SE Sections 4.1 and 4.2] |

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| | The SAWM strategy will ensure that the Wetwell vent remains functional for the period of sustained operation. Quad Cities will follow the guidance (flow rate and timing) for SHWA/SAWM described in [Boiling Water Reactor Owners Group] BWROG-TP-15-008 and BWROG-TP-15-011. These documents have been posted to the ePortal for NRC staff review. The Wetwell vent will be opened prior to exceeding the PCPL value of 52 PSIG. Therefore, containment over pressurization is prevented without the need for a drywell vent. | temperature significantly reducing the possibility of containment failure due to temperature. Drywell pressure can be controlled by venting the suppression chamber through the suppression pool.<br><br>BWROG-TP-011 demonstrates that starting water addition at a high rate of flow and throttling after approximately 4-hours will not increase the suppression pool level to that which could block the suppression chamber HCVS.<br><br>As noted under Phase 1, the vent is sized to pass a minimum steam flow equivalent to 1% rated core power. This is sufficient permit venting to maintain containment below the lower of PCPL or of design pressure.<br><br>No follow-up questions. | |
| Phase 2 ISE OI 5<br><br>Licensee shall demonstrate how the plant is bounded by the reference plant analysis that shows the SAWM strategy is successful in making it unlikely that a drywell vent is needed. | Complete.<br><br><u>Reference Plant</u>:<br><br>Torus free board volume is 525,000 gallons<br><br>SAWA flow is 500 GPM [gallons per minute] at 8 hours followed by 100 GPM from 12 hours to 168 hours<br><br><u>Qud Cities</u>:<br><br>Torus freeboard volume is 619,190 gallons | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>Quad Cities based its SAWA flow rates on the RCIC flow rates per the guidance in NEI 13.02, Revision 1, Section 4.1.1.2.2. The reference plant has a Torus freeboard of 525,000 gallons and Quad Cities has a Torus freeboard of 619,190 gallons. The reference plant assumes SAWA flow of 500 gpm starting at | Closed<br><br>[Staff evaluation to be included in SE Section 4.2.1.1] |

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| | SAWA flow is 400 GPM at 8 hours followed by 80 GPM from 12 hours to 168 hours.<br><br>The above parameters for Quad Cities compared to the reference plant that determine success of the SAWM strategy demonstrate that the reference plant values are bounding. SAWA flow rates are based on RCIC design flow as allowed by NEI 13-02, Rev. 1, Section 4.1.1.2.2. Therefore, the SAWM strategy implemented at Quad Cities makes it unlikely that a DW vent is needed to prevent containment overpressure related failure. | 8 hours and Quad Cities assumes a 400 gpm flow starting at 8 hours. The reference plant reduces SAWA flow to 100 gpm at 12 hours and Quad Cities reduces SAWA flow to 80 gpm at 12 hours. BWROG TP-15-011, evaluation demonstrates that the Mark I (and Mark II) fleet is bounded by the reference plant analyses. This study addressed how suppression pool level control could be achieved in a manner that maintains long term function of the wetwell vent, and determined if there would be adverse effects by controlling (limiting) flow rate. The study concludes that plants with Mark I containments, with injection into the RPV, can maintain containment cooling and preserve the wetwell vent without a plant specific analysis. The evaluation bounds the parameters at Quad Cities. Quad Cities plans to flow this strategy and is bounded by the conclusions of the BWROG evaluation.<br><br>No follow-up questions. | |
| Phase 2 ISE OI 6<br><br>Licensee to demonstrate that there is adequate communication between the MCR and the operator at the FLEX pump during severe accident conditions. | Complete. Quad Cities utilizes handheld radios to communicate between the MCR, the operator at the FLEX pump, and the operator at the SAWA flow control location. This communication method is the same as accepted in Order EA-12-049. These items will be powered and remain powered using the same methods as evaluated under EA-12-049 | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The communication methods are the same as accepted in Order EA-12-049. | Closed<br><br>[Staff evaluation to be included in SE Section 4.1] |

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| | for the period of sustained operation, which may be longer than identified for EA-12-049. | No follow-up questions. | |
| Phase 2 ISE OI 7<br><br>Licensee to demonstrate the SAWM flow instrumentation qualification for the expected environmental conditions. | Complete. For locations outside the Reactor Building between 7 hours and 7 days, when SAWA is being utilized, a quantitative evaluation of expected dose rates has been performed per HCVS-WP-02, and found the dose rates at deployment locations including ingress/egress paths are acceptable. The selected instrument is designed for the expected flow rate, temperature, and pressure for SAWA over the period of sustained operation.<br><br>**SAWA Flow Instrument Qualification**<br><br>2.21 to 736 GPM, -4 to 140 °F fluid temperature, 0-to 285 PSI<br><br>**Expected SAWA Parameter Range**<br><br>0 to 400 GPM, 32 to 120 °F fluid temperature, 0 to 120 PSI | The NRC staff reviewed the information provided in the 6-month updates and on the ePortal.<br><br>The licensee provided environmental conditions for radiation and temperature as well as the qualified temperature range for the flow instrument.<br><br>The NRC staff found the instrument appears to be qualified for the anticipated conditions during an ELAP for the proposed location.<br><br>No follow-up questions. | Closed<br><br>[Staff evaluation to be included in SE Sections 4.1.1.3 and 4.2.1.3] |

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNITS 1 AND 2 – REPORT FOR THE AUDIT OF LICENSEE RESPONSES TO INTERIM STAFF EVALUATIONS OPEN ITEMS RELATED TO NRC ORDER EA-13-109 TO MODIFY LICENSES WITH REGARD TO RELIABLE HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS (CAC NOS. MF4460 AND MF4461; EPID L-2014-JLD-0054) DATED June 15, 2018

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