Exelon Generation.

Order No. EA-13-109

RS-18-089

August 14, 2018

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Quad Cities Nuclear Power Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

Subject: Report of Full Compliance with Phase 1 and Phase 2 of 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)

References:

1. NRC Order Number EA-13-109, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," dated June 6, 2013
2. Exelon Generation Company, LLC's Answer 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, 2013
3. NRC Interim Staff Guidance JLD-ISG-2015-01, "Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," Revision 0, dated April 2015
4. NEI 13-02, "Industry Guidance for Compliance With Order EA-13-109, BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions", Revision 1, dated April 2015
5. Exelon Generation Company, LLC 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 (Order Number EA-13-109), dated June 30, 2014 (RS-14-063)
6. Exelon Generation Company, LLC First Six-Month Status Report 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 (Order Number EA-13-109), dated December 17, 2014 (RS-14-306)
7. Exelon Generation Company, LLC Second Six-Month Status Report 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 (Order Number EA-13-109), dated June 30, 2015 (RS-15-152)

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8. Exelon Generation Company, LLC Phase 1 (Updated) and Phase 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 December 16, 2015 (RS-15-304)
9. Exelon Generation Company, LLC Fourth 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 30, 2016 (RS-16-110)
10. Exelon Generation Company, LLC Fifth 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 January 26, 2017 (RS-17-008)
11. Exelon Generation Company, LLC Sixth 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 27, 2017 (RS-17-069)
12. Exelon Generation Company, LLC Seventh 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 December 11, 2017 (RS-17-156)
13. NRC letter to Exelon Generation Company, LLC, Quad Cities Nuclear Power Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Phase 1 of Order EA-13-109 (Severe Accident Capable Hardened Vents) (TAC Nos. MF4460 and MF4461), dated April 1, 2015
14. NRC letter to Exelon Generation Company, LLC, Quad Cities Nuclear Power Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Phase 2 of Order EA-13-109 (Severe Accident Capable Hardened Vents) (TAC Nos. MF4460 and MF4461), dated April 28, 2017
15. NRC letter to Exelon Generation Company, LLC, 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, dated June 15, 2018

On June 6, 2013, the Nuclear Regulatory Commission ("NRC" or "Commission") issued Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," (Reference 1) to Exelon Generation Company, LLC (EGC). Reference 1 was immediately effective and directs EGC to require their BWRs with Mark I and Mark II containments to take certain actions to ensure that these facilities have a hardened containment vent system (HCVS) to remove decay heat from the containment, and maintain control of containment pressure within acceptable limits following events that result in loss of active containment heat removal capability while maintaining the capability to operate under severe accident (SA) conditions resulting from an Extended Loss of AC Power

(ELAP). Specific requirements are outlined in Attachment 2 of Reference 1. Reference 2 provided EGC's initial answer to the Order.

Reference 3 provided the NRC interim staff guidance on methodologies for compliance with Phases 1 and 2 of Reference 1 and endorsed industry guidance document NEI 13-02, Revision 1 (Reference 4) with clarifications and exceptions. Reference 5 provided the Quad Cities Nuclear Power Station, Units 1 and 2 Phase 1 Overall Integrated Plan (OIP), which was replaced with the Phase 1 (Updated) and Phase 2 OIP (Reference 8). References 13 and 14 provided the NRC review of the Phase 1 and Phase 2 OIP, respectively, in an Interim Staff Evaluation (ISE).

Reference 1 required submission of a status report at six-month intervals following submittal of the OIP. References 6, 7, 8, 9, 10, 11, and 12 provided the first, second, third, fourth, fifth, sixth, and seventh six-month status reports, respectively, pursuant to Section IV, Condition D.3, of Reference 1 for Quad Cities Nuclear Power Station, Units 1 and 2.

The purpose of this letter is to provide the report of full compliance with Phase 1 and Phase 2 of the 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) (Reference 1) pursuant to Section IV, Condition D.4 of the Order for Quad Cities Nuclear Power Station, Units 1 and 2.

Quad Cities Nuclear Power Station, Units 1 and 2 have designed and installed a venting system that provides venting capability from the wetwell during severe accident conditions in response to Phase 1 of NRC Order EA-13-109. Quad Cities Nuclear Power Station, Units 1 and 2 have implemented a reliable containment venting strategy that makes it unlikely that the plant would need to vent from the containment drywell before alternative reliable containment heat removal and pressure control is reestablished in response to Phase 2 of NRC Order EA-13-109. The information provided herein documents full compliance for Quad Cities Nuclear Power Station, Units 1 and 2 with NRC Order EA-13-109.

Quad Cities Nuclear Power Station, Units 1 and 2 Phases 1 and 2 OIP Open Items have been addressed and closed as documented in Reference 12 and as provided below, and are considered complete per Reference 15.

EGC's response to the NRC Interim Staff Evaluation (ISE) Phase 1 Open Items identified in Reference 13 have been addressed and closed as documented in Reference 12 and as provided below, and are considered complete per Reference 15. The following table provides completion references for each OIP and ISE Phase 1 Open Item.

Reference 15 provided the results of the audit of ISE Open Item closure information provided in Reference 12. All Phases 1 and 2 ISE Open Items are statused as closed in Reference 15.

OIP Phase 1 Open Item No. 1 Determine how Motive Power and/or HCVS Battery Power will be disabled during normal operation.	Closed per Reference 12.
OIP Phase 1 Open Item No. 2 Confirm that the Remote Operating Station (ROS) will be in an accessible area following a Severe Accident (SA).	Deleted (Closed to ISE Open Item No. 4 below)
OIP Phase 1 Open Item No. 3 Confirm diameter on new common HCVS Piping.	Deleted (Closed to ISE Open Item No. 5 below)
OIP Phase 1 Open Item No. 4 Confirm suppression pool heat capacity.	Closed per Reference 12.
OIP Phase 1 Open Item No. 5 Determine the approach for combustible gases.	Deleted (Closed to ISE Open Item Nos. 10 and 11 below)
OIP Phase 1 Open Item No. 6 Develop a procedure for HCVS out-of-service requirements and compensatory measures.	Complete – Incorporated into QCAP 1500-07, Administrative Tracking Requirements for Unavailable FLEX Equipment. References have been provided in eportal.
OIP Phase 1 Open Item No. 7 Provide procedures for HCVS Operation.	Deleted (Closed to ISE Open Item No. 14 below)
OIP Phase 1 Open Item No. 8 Confirm 125 Volt DC Station Battery Life.	Closed per Reference 12.
ISE Phase 1 Open Item No. 1 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.	Closed per Reference 12.
ISE Phase 1 Open Item No. 2 Make available for NRC staff audit the final sizing evaluation for HCVS batteries/battery charger including incorporation into FLEX DG loading calculation.	Closed per Reference 12.

ISE Phase 1 Open Item No. 3 Make available for NRC staff audit documentation of the HCVS nitrogen pneumatic system design including sizing and location.	Complete – Both Units nitrogen systems installed. Calculation QDC-1600-M-2212 for sizing approved and applicable to both Units. References have been provided in eportal.
ISE Phase 1 Open Item No. 4 Make available for NRC staff audit an evaluation of temperature and radiological conditions to ensure that operating personnel can safely access and operate controls and support equipment.	Closed per Reference 12.
ISE Phase 1 Open Item No. 5 Make available for NRC staff review documentation that confirms the final design diameter of the HCVS piping.	Closed per Reference 12.
ISE Phase 1 Open Item No. 6 Make available for NRC staff audit analyses demonstrating that HCVS has the capacity to vent the steam/energy equivalent of one percent of licensed/rated thermal power (unless a lower value is justified), and that the 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 pressure limit.	Closed per Reference 12.
ISE Phase 1 Open Item No. 7 Make available for NRC staff audit the seismic and tornado missile final design criteria for the HCVS stack.	Closed per Reference 12.
ISE Phase 1 Open Item No. 8 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, etc.) required for HCVS venting including confirmation that the components are capable of performing their functions during ELAP and severe accident conditions.	Closed per Reference 12.

ISE Phase 1 Open Item No. 9 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.	Closed per Reference 12.
ISE Phase 1 Open Item No. 10 Provide a description of the final design of the HCVS to address hydrogen detonation and deflagration.	Closed per Reference 12.
ISE Phase 1 Open Item No. 11 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.	Closed per Reference 12.
ISE Phase 1 Open Item No. 12 Make available for NRC staff audit documentation of a determination of seismic qualification evaluation of HCVS components.	Complete – The Quad Cities seismic evaluation is based on the Quad Cities SSE, which is sufficient by Exelon Position Paper EXC-WP-15. References have been provided in eportal.
ISE Phase 1 Open Item No. 13 Make available for NRC staff audit descriptions of all instrumentation and controls (existing and planned) necessary to implement this order including qualification methods.	Closed per Reference 12.
ISE Phase 1 Open Item No. 14 Make available for NRC staff audit the procedures for HCVS operation.	Complete – The procedure for HCVS operation is QCOP 1600-13, "Post-Accident Venting of the Primary Containment." References have been provided in eportal.

EGC's response to the NRC ISE Phase 2 Open Items identified in Reference 14 have been addressed and closed as documented in Reference 12, and are considered complete per Reference 15. The following table provides completion references for each ISE Phase 2 Open Item.

OIP Phase 2 Open Item No. 9 Supply Part 3 Drywell Boundary Condition.	Closed per Reference 12.
OIP Phase 2 Open Item No. 10 Determine deployment path for Discharge Bay boster pump with respect to HCVS dose.	Closed per Reference 12.
ISE Phase 2 Open Item No. 1 Licensee to demonstrate that the hydraulic analysis for the FLEX pump is capable to support the required 400 gpm SAWA flow rate.	Closed per Reference 12 utilizing BWROG generic response template.
ISE Phase 2 Open Item No. 2 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.	Closed per Reference 12 utilizing BWROG generic response template.
ISE Phase 2 Open Item No. 3 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.	Closed per Reference 12 utilizing BWROG generic response template.
ISE Phase 2 Open Item No. 4 Licensee to demonstrate that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions.	Closed per Reference 12 utilizing BWROG generic response template.
ISE Phase 2 Open Item No. 5 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.	Closed per Reference 12 utilizing BWROG generic response template.

ISE Phase 2 Open Item No. 6 Licensee to demonstrate that there is adequate communication between the MCR and the SAWA/SAWM control location during severe accident conditions.	Closed per Reference 12 utilizing BWROG generic response template.
ISE Phase 2 Open Item No. 7 Licensee to demonstrate the SAWM flow instrumentation qualification for the expected environmental conditions.	Closed per Reference 12 utilizing BWROG generic response template.

MILESTONE SCHEDULE – ITEMS COMPLETE

Quad Cities Nuclear Power Station, Units 1 and 2 - Phases 1 and 2 Specific Milestone Schedule

Milestone	Completion Date
Submit Phase 1 Overall Integrated Plan	**Jun. 2014**
Submit Phase 2 Overall Integrated Plan	**Dec. 2015**
Submit 6 Month Updates:	
Update 1	**Dec. 2014**
Update 2	**Jun. 2015**
Update 3	**Dec. 2015**
Update 4	**Jun. 2016**
Update 5	**Jan. 2017**
Update 6	**Jun. 2017**
Update 7	**Dec. 2017**
Phase 1 Modifications:	
Complete Conceptual Design	**Jun. 2014**
Unit 2 Complete Detailed Design and Issue Modification Package	**Jul. 2017**
Unit 2 Complete Online Installation	**Mar. 2018**
Unit 2 Complete Complete Outage Installation	**Apr. 2018**
Unit 2 Installation Operational Acceptance	**Jun. 2018**

Milestone	Completion Date
Unit 1 Complete Detailed Design and Issue Modification Package	**Jul. 2017**
Unit 1 Complete Online Installation	**Dec. 2017**
Unit 1 Complete Complete Outage Installation	**Apr. 2017**
Unit 1 Installation Operational Acceptance	**Jun. 2018**
Phase 1 Procedure Changes	
Operations Procedure Changes Developed	**Dec. 2017**
Site Specific Maintenance Procedure Developed	**Dec. 2017**
Procedure Final Validation and Implementation	**Jun. 2018**
Phase 1 Training:	
Training Complete	**Apr. 2018**
Phase 1 Completion	
Unit 2 HCVS Implementation	**Jun. 2018**
Unit 1 HCVS Implementation	**Jun. 2018**
Phase 2 Modifications:	
Complete Conceptual Design	**Feb. 2017**
Unit 2 Complete Detailed Design and Issue Modification Package	**Jul. 2017**
Unit 2 Complete Online Installation	**Mar. 2018**
Unit 2 Installation Operational Acceptance	**Jun. 2018**
Unit 1 Complete Detailed Design and Issue Modification Package	**Jul. 2017**
Unit 1 Complete Online Installation	**Mar. 2018**
Unit 1 Installation Operational Acceptance	**Jun. 2018**
Phase 2 Procedure Changes	
Operations Procedure Changes Developed	**Apr. 2018**
Site Specific Maintenance Procedure Developed	**Apr. 2018**
Procedure Changes Active	**Apr. 2018**
Procedure Final Validation and Implementation	**Jun. 2018**
Phase 2 Units 1 and 2 Training:	
Training Complete	**Apr. 2018**

Milestone	Completion Date
Phase 2 Completion	
Unit 2 HCVS Implementation	**June 15, 2018**
Unit 1 HCVS Implementation	**June 15, 2018**
Submit Units 1 and 2 Phases 1 and 2 Completion Report	**Aug. 2018 – Complete with this submittal**

ORDER EA-13-109 COMPLIANCE ELEMENTS SUMMARY

The elements identified below for Quad Cities Nuclear Power Station, Units 1 and 2, as well as the Phase 1 (Updated) and Phase 2 OIP response submittal (Reference 8), and the 6-Month Status Reports (References 6, 7, 8, 9, 10, 11, and 12), demonstrate compliance with NRC Order EA-13-109. The Quad Cities Nuclear Power Station, Units 1 and 2 Final Integrated Plan for reliable hardened containment vent Phase 1 and Phase 2 strategies is provided in the enclosure to this letter.

HCVS PHASE 1 AND PHASE 2 FUNCTIONAL REQUIREMENTS AND DESIGN FEATURES – COMPLETE

The Quad Cities Nuclear Power Station, Units 1 and 2, Phase 1 HCVS provides a vent path from the wetwell to remove decay heat, vent the containment atmosphere, and control containment pressure within acceptable limits. The Phase 1 HCVS will function for those accident conditions for which containment venting is relied upon to reduce the probability of containment failure, including accident sequences that result in the loss of active containment heat removal capability during an extended loss of alternating current power.

The Quad Cities Nuclear Power Station, Units 1 and 2, Phase 2 HCVS provides a reliable containment venting strategy that makes it unlikely that the plant would need to vent from the containment drywell before alternative reliable containment heat removal and pressure control is reestablished. The Quad Cities Nuclear Power Station, Units 1 and 2, Phase 2 HCVS strategies implement Severe Accident Water Addition (SAWA) with Severe Accident Water Management (SAWM) as an alternative venting strategy. This strategy consists of the use of the Phase 1 wetwell vent and SAWA hardware to implement a water management strategy that will preserve the wetwell vent path until alternate reliable containment heat removal can be established.

The Quad Cities Nuclear Power Station, Units 1 and 2, Phase 1 and Phase 2 HCVS strategies are in compliance with Order EA-13-109. The modifications required to support the HCVS strategies for Quad Cities Nuclear Power Station, Units 1 and 2 have been fully implemented in accordance with the station processes.

HCVS PHASE 1 AND PHASE 2 QUALITY STANDARDS – COMPLETE

The design and operational considerations of the Phase 1 and Phase 2 HCVS installed at Quad Cities Nuclear Power Station, Units 1 and 2 complies with the requirements specified in the Order and described in NEI 13-02, Revision 1, "Industry Guidance for Compliance with Order EA-13-109". The Phase 1 and Phase 2 HCVS has been installed in accordance with the station design control process.

The Phase 1 and Phase 2 HCVS components including piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication have been designed consistent with the design basis of the plant. All other Phase 1 and Phase 2 HCVS components including electrical power supply, valve actuator pneumatic supply and instrumentation have been designed for reliable and rugged performance that is capable of ensuring Phase 1 and Phase 2 HCVS functionality following a seismic event.

HCVS PHASE 1 AND PHASE 2 PROGRAMMATIC FEATURES - COMPLETE

Storage of portable equipment for Quad Cities Nuclear Power Station, Units 1 and 2 Phase 1 and Phase 2 HCVS use provides adequate protection from applicable site hazards, and identified paths and deployment areas will be accessible during all modes of operation and during severe accidents, as recommended in NEI 13-02, Revision 1, Section 6.1.2.

Training in the use of the Phase 1 and Phase 2 HCVS for Quad Cities Nuclear Power Station, Units 1 and 2 has been completed in accordance with an accepted training process as recommended in NEI 13-02, Revision 1, Section 6.1.3.

Operating and maintenance procedures for Quad Cities Nuclear Power Station, Units 1 and 2 have been developed and integrated with existing procedures to ensure safe operation of the Phase 1 and Phase 2 HCVS. Procedures have been verified and are available for use in accordance with the site procedure control program.

Site processes have been established to ensure the Phase 1 and Phase 2 HCVS is tested and maintained as recommended in NEI 13-02, Revision 1, Sections 5.4 and 6.2.

Quad Cities Nuclear Power Station, Units 1 and 2 have completed validation in accordance with industry developed guidance to assure required tasks, manual actions and decisions for HCVS strategies are feasible and may be executed within the constraints identified in the HCVS Phases 1 and 2 OIP for Order EA-13-109 (Reference 8).

Quad Cities Nuclear Power Station, Units 1 and 2 have completed evaluations to confirm accessibility, habitability, staffing sufficiency, and communication capability in accordance with NEI 13-02, Revision 1, Sections 4.2.2 and 4.2.3.

This letter contains no new regulatory commitments. If you have any questions regarding this report, please contact David J. Distel at 610-765-5517.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 14th day of August 2018.

Respectfully submitted,

Patrick R. Simpson
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosure: Quad Cities Nuclear Power Station, Units 1 and 2 Final Integrated Plan Document – Hardened Containment Vent System NRC Order EA-13-109

cc: Director, Office of Nuclear Reactor Regulation
NRC Regional Administrator - Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station
NRC Project Manager, NRR – Quad Cities Nuclear Power Station
Mr. John P. Boska, NRR/JLD/JOMB, NRC
Mr. Brian E. Lee, NRR/JLD/JCBB, NRC
Mr. Rajender Auluck, NRR/JLD/JCBB, NRC
Illinois Emergency Management Agency – Division of Nuclear Safety

Enclosure

Quad Cities Nuclear Power Station, Units 1 and 2

Final Integrated Plan Document – Hardened Containment Vent System
NRC Order EA-13-109

(63 pages)

Final Integrated Plan

HCVS Order EA-13-109

for

QUAD CITIES Nuclear Power Station Units 1 and 2

August 14, 2018

Table of Contents

Section I: Introduction

In 1989, the NRC issued Generic Letter-89-16, Installation of a Hardened Wetwell Vent, (Reference 1) to all licensees of BWRs with Mark I containments to encourage licensees to voluntarily install a hardened Wetwell vent. In response, licensees installed a hardened vent pipe from the Wetwell to some point outside the secondary containment envelope (usually outside the reactor building). Some licensees also installed a hardened vent branch line from the drywell.

On March 19, 2013, the Nuclear Regulatory Commission (NRC) Commissioners directed the staff per Staff Requirements Memorandum (SRM) for SECY-12-0157, Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments (References 2 and 3) to require licensees with Mark I and Mark II containments to "upgrade or replace the reliable hardened vents required by Order EA-12-050, Order to Modify Licenses with Regard to Reliable Hardened Containment Vents (Reference 4) with a containment venting system designed and installed to remain functional during severe accident conditions." In response, the NRC issued Order EA-13-109, Issuance of Order to Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accidents, June 6, 2013 (Reference 5). The Order (EA-13-109) requires that licensees of BWR facilities with Mark I and Mark II containment designs ensure that these facilities have a reliable hardened vent to remove decay heat from the containment, and to maintain control of containment pressure within acceptable limits following events that result in the loss of active containment heat removal capability while maintaining the capability to operate under severe accident (SA) conditions resulting from an Extended Loss of AC Power (ELAP).

Quad Cities Station is required by NRC Order EA-13-109 to have a reliable, severe accident capable hardened containment venting system (HCVS). Order EA-13-109 allows implementation of the HCVS Order in two phases.

- Phase 1 upgraded the venting capabilities from the containment Wetwell to provide reliable, severe accident capable hardened vent to assist in preventing core damage and, if necessary, to provide venting capability during severe accident conditions. Quad Cities Station achieved Phase 1 compliance in June 2018.
- Phase 2 provided additional protections for severe accident conditions through the development of a reliable containment venting strategy that makes it unlikely that Quad Cities Station would need to vent from the containment drywell during severe accident conditions. Quad Cities Station achieved Phase 2 compliance on June 2018 for both Units.

NEI developed guidance for complying with NRC Order EA-13-109 in NEI 13-02, Industry Guidance for Compliance with Order EA-13-109, BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, Revision 0 (Reference 6) with significant interaction with the NRC and Licensees. NEI issued Revision 1 to NEI 13-02 in April 2015 (Reference 7) which contained guidance for compliance with both Phase 1 and Phase 2 of the order. NEI 13-02, Revision 1 also includes HCVS- Frequently Asked Questions (FAQs) 01 through 09 and reference to white papers (HCVS-WP-01 through 03 (References 8 through 10)). The NRC endorsed NEI 13-02 Revision 0 as an acceptable approach for complying with Order EA-13-109 through Interim Staff Guidance JLD-ISG-2013-02, Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions, issued in November 2013 (Reference 12) and JLD-ISG-2015-01, Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions issued in April 2015 (Reference 13) for NEI 13-02 Revision 1 with some clarifications and exceptions. NEI 13-02 Revision 1 provides an acceptable method of compliance for both Phases of Order EA-13-109.

In addition to the endorsed guidance in NEI 13-02, the NRC staff endorsed several other documents that provide guidance for specific areas. HCVS-FAQs 10 through 13 (References 14 through 17) were endorsed by the NRC after NEI 13-02 Revision 1 on October 8, 2015. NRC staff also endorsed four White Papers, HCVS-WP-01 through 04 (References 8 through 11), which cover broader or more complex topics than the FAQs.

As required by the order, Quad Cities Station submitted a Phase 1 Overall Integrated Plan (OIP) in June of 2014 (Reference 18) and subsequently submitted a combined Phase 1 and 2 OIP in December 2015 (Reference 19). These OIPs followed the guidance NEI 13-02 Revision 0 and 1 respectively, Compliance with Order EA-13-109, Severe Accident Reliable Hardened Containment Vents. The NRC staff used the methods described in the ISGs to evaluate licensee compliance as presented in the Order EA-13-109 OIPs. While the Phase 1 and combined Phase 1 and 2 OIPs were written to different revisions of NEI 13-02, Quad Cities Station conforms to NEI 13-02 Revision 1 for both Phases of Order EA-13-109.

The NRC performed a review of each OIP submittal and provided Quad Cities Station with Interim Staff Evaluations (ISEs) (References 20 and 21) assessing the site's compliance methods. In the ISEs, the NRC identified open items which the site needed to address before that phase of compliance was reached. Six-month progress reports (References 22 through 28) were provided consistent with the requirements of Order EA-13-109. These status reports were used to close many of the ISE open items. In addition, the site participated in NRC ISE Open Item audit calls where the information provided in the six-month updates and on the E-Portal were used by the NRC staff to determine whether the ISE Open Item appeared to be addressed.

By submittal of this Final Integrated Plan, Quad Cities Station has addressed all the elements of NRC Order EA-13-109 utilizing the endorsed guidance in NEI 13-02, Rev 1 and the related HCVS-FAQs and HCVS-WPs documents. In addition, the site has addressed the NRC Phase 1 and Phase 2 ISE Open Items as documented in previous six-month updates or within the Phase 1 and 2 Compliance Letter for the first compliance Unit.

Section III contains the Quad Cities Station Final Integrated Plan details for Phase 1 of the Order. Section IV contains the Final Integrated Plan details for Phase 2 of the Order. Section V details the programmatic elements of compliance.

Section I.A: Summary of Compliance

Section I.A.1: Summary of Phase 1 Compliance

The plant venting actions for the EA-13-109, Phase 1, severe accident capable venting scenario can be summarized by the following:

The HCVS is initiated via manual action from either the Main Control Room (MCR) or Remote Operating Station (ROS) at the appropriate time based on procedural guidance in response to plant conditions from observed or derived symptoms.

- The vent utilizes containment parameters of pressure and level from the MCR instrumentation to monitor effectiveness of the venting actions.
- The vent operation is monitored by HCVS valve position, 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.

The operation of the HCVS is designed to minimize the reliance on operator actions in response to external hazards. The screened-in external hazards are seismic, external flooding, high winds, extreme high temperature, and extreme cold – ice only. Initial operator actions are completed by plant personnel and include the capability for remote-manual initiation from the HCVS control station. Attachment 2 contains a one-line diagram of the HCVS vent flow path.

Section I.A.2: Summary of Phase 2 Compliance

The Phase 2 actions can be summarized as follows:

- Utilization of Severe Accident Water Addition (SAWA) to initially inject water into the Reactor Pressure Vessel (RPV).
- Utilization of Severe Accident Water Management (SAWM) to control injection and Suppression Pool level to ensure the HCVS Phase 1 Wetwell vent will remain functional for the removal of heat from the containment.
- Heat can be removed from the containment for at least seven (7) days using the HCVS or until alternate means of heat removal are established that make it unlikely the drywell vent will be required for containment pressure control.
- The SAWA and SAWM actions can be manually activated and controlled from areas that are accessible during severe accident conditions.

- Parameters measured are Drywell pressure, Suppression Pool level, SAWA flowrate and the HCVS Phase 1 vent path parameters.

The locations of the SAWA equipment and controls, as well as ingress and egress paths, have been evaluated for the expected severe accident conditions (temperature, humidity, radiation) for the Sustained Operating period. Equipment has been evaluated to remain operational throughout the Sustained Operating period. Personnel radiological exposure, temperature and humidity conditions for operation of SAWA equipment will not exceed the limits for ERO dose or plant safety guidelines for temperature and humidity.

The SAWA flow path is similar to the FLEX alternate injection flow path with the modification to the hose runs. The flow source is from the Discharge Bay via deployed suction hose with floating strainer through the FLEX/SAWA pump to the discharge hose. The hose can be routed via many paths depending upon conditions following the initiating event. Installed wall penetrations in the Unit 1 Low Pressure Feedwater heater bay provide a short path to a Flow Control Station (FCS) in the Turbine Building (TB) or via multiple normal access doors. An operator stationed at the FCS can direct flow as instructed to both Unit Reactors, the connected Unit Fuel Pools, and to the ECCS room coolers, which provide a path for flow/pressure control and hose freeze protection. The FCS area was analyzed to be a lower dose area during a Severe Accident. Hoses connect the FCS to the four wall penetrations from TB to the Reactor Building (RB) using quick connection hardware. The two hoses providing water to the RPVs will be instrumented with portable flow meters. Inside the RB, the SAWA flow path is from the RB/TB penetrations to the RHR system FLEX connections, Spent Fuel Pool (SFP) return FLEX connection, and either unit ECCS Room Cooler FLEX connection. Reactor water supply flow and Suppression Pool levels are monitored, and flow rate is adjusted by using valves at the FCS. Communication is established between the MCR and the FCS. Attachment 4 contains a one-line diagram of the SAWA flow path.

The SAWA electrical loads are included in the FLEX Diesel Generators (DG) loading calculation. The FLEX DGs located north of the TB are a considerable distance away and shielded by concrete walls from the discharge of the HCVS on the east side of the RB. See Attachment 6 for applicable locations. Refueling of the FLEX DGs is accomplished from the Unit 2 EDG Fuel Oil Storage Tank, which is immediately east of the FLEX DG deployment area, or the Unit 1 EDG Fuel Oil Storage Tank via hose through the length of the TB ground level.

Evaluations for projected SA conditions (radiation / temperature) indicate that personnel can complete the initial and support activities without exceeding the ERO-allowable dose for equipment operation or site safety standards.

Electrical equipment and instrumentation is powered from the existing station batteries, and from AC distribution systems that are powered from the FLEX generator(s). The battery chargers are also powered from the FLEX generator(s) to maintain the battery capacities during the Sustained Operating period.

Section II: List of Acronyms

AC	Alternating Current
AOV	Air Operated Valve
APCVS	Augmented Primary Containment Vent System
BDBEE	Beyond Design Basis External Event
QCNPS	Quad Cities Nuclear Power Station
BWROG	Boiling Water Reactor Owners' Group
CAP	Containment Accident Pressure
DC	Direct Current
ECCS	Emergency Core Cooling Systems
ELAP	Extended Loss of AC Power
EOP	Emergency Operating Procedure
EPG/SAG	Emergency Procedure and Severe Accident Guidelines EPRI Electric Power Research Institute
ERO	Emergency Response Organization
FAQ	Frequently Asked Question
FCS	Flow Control Station
FIP	Final Integrated Plan
FLEX	Diverse & Flexible Coping Strategy
FSB	FLEX Storage Building
GPM	Gallons per minute
HCVS	Hardened Containment Vent System
ISE	Interim Staff Evaluation
ISG	Interim Staff Guidance
JLD	Japan Lessons Learned Project Directorate
MAAP	Modular Accident Analysis Program
MCR	Main Control Room
N_2	Nitrogen
NEI	Nuclear Energy Institute
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
OIP	Overall Integrated Plan
PCPL	Primary Containment Pressure Limit

RCIC	Reactor Core Isolation Cooling System
RHRS	Residual Heat Removal System
RM	Radiation Monitor
ROS	Remote Operating Station
RPV	Reactor Pressure Vessel
SA	Severe Accident
SAMG	Severe Accident Management Guidelines
SAWA	Severe Accident Water Addition
SAWM	Severe Accident Water Management
SBGT	Standby Gas Treatment System
SFP	Spent Fuel Pool
SRV	Safety-Relief Valve
UFSAR	Updated Final Safety Analysis Report
VAC	Voltage AC
VDC	Voltage DC
WW	Wetwell

Section III: Phase 1 Final Integrated Plan Details

Section III.A: HCVS Phase 1 Compliance Overview

Quad Cities Station modified the existing hardened Wetwell vent path installed in response to NRC Generic Letter 89-16 to comply with NRC Order EA-13-109.

Section III.A.1: Generic Letter 89-16 Vent System

QCNPS installed an Augmented Primary Containment Vent system (APCVS) in response to NRC Generic Letter 89-16, under Plant Modifications M04-1-90-003 for Unit 1 and M04-2-90-003 for Unit 2. The description of the vent system below is common to both units. The APCVS is a non-safety related system which is used to reduce the Primary Containment pressure in the event of loss of Primary Containment cooling capability. The system is manually initiated during the Loss of Long Term Decay Heat Removal Capabilities transient. Prior to reaching the PCPL, the system is initiated. The venting sequence ceases once the Primary Containment has decreased to an acceptable level (QCOP 1600-13, Reference 32). The APCVS is a subsystem of the overall Primary Containment Purge and Vent system, and it shares many of the same components and piping. The APCVS also physically interfaces with the Radwaste Ventilation Exhaust Duct. The APCVS uses the vent duct as the release point to the main chimney.

Operation of the APCVS is directed by the Emergency Operating Procedures. The APCVS is comprised of piping, round duct, square duct, air operated valves, and the associated electrical components for operation and indication. The APCVS is designed for 62 psig at 309 °F. The air operated valves each have an accumulator for a backup air supply. The system piping is shown in Quad Cities Station P&IDs M-34 and M-76. The piping begins at the suppression chamber main exhaust and the drywell main exhaust lines. It is routed through the Reactor Building into the Turbine Building through an 18" diameter vent and purge duct. The APCVS vent valve, AO 1(2) -1699-6, is located in an 8" diameter branch line connected upstream of the vent and purge system pre-filters. This 8" line is cross-tied between the two units and is routed below the turbine main floor, passes through the Turbine Building exterior wall, and penetrates the radwaste ventilation exhaust duct which flows to the main chimney. The controls for the APCVS are in the MCR. The APCVS mode switch, three keylock containment isolation valve (CIV) override switches, and annunciation of override of the CIV's are on the 901(2)-5 panel. The APCVS vent valve control switch is on the 901(2)-3 panel.

<u>Section III.A.2</u>: EA-13-109 Hardened Containment Vent System (HCVS)

The EA-13-109 compliant HCVS system utilizes a portion of the GL-89-16 Wetwell vent system. A new, independent, vent line for each Unit is installed downstream of the existing inboard Wetwell Primary Containment Isolation Valves (PCIV) 1(2)-1601-60. The HCVS vent system is initiated, operated and monitored from the MCR. A ROS has been installed on the Mezzanine level of the Turbine Building and provides a means to manually operate the HCVS Wetwell vent. The controls available at the ROS are accessible and functional under a range of plant conditions, including severe accident conditions. The description provided herein applies to both Unit 1 and Unit 2. Table 2 contains the evaluation of the acceptability of the ROS location with respect to severe accident conditions.

The new HCVS ties into the existing Pressure Suppression System piping with an 18" by 18" by 12" tee downstream of the 1(2)-1601-60 inboard PCIV as described above. New 12" vent piping, including Air-Operated Outboard PCIV 1(2)-1699-98, is installed in the Reactor Building. The piping is installed through the Reactor Building wall and continues outside to the roof area above Reactor Building. The HCVS pipe penetrates the Reactor Building wall at Column Line N. A 12" rupture disc, 1(2)-1603-2, is provided downstream of the new PCIVs. Each of the rupture discs, set at 20 PSID, will serve as a passive Secondary Containment isolation boundary. The 12" piping between the PCIV and the Rupture Disc is normally vented to the Reactor Building via three-way valve, 1(2)-1605-14, to ensure any leakage past the PCIV does not burst the rupture disc. The three-way valve is normally locked in position and is manually unlocked and re-positioned at the ROS to initiate HCVS operation.

The new HCVS valves are supplied with motive force from new portable Nitrogen bottles. The new Nitrogen gas supply subsystem with manual controls is located at the Remote Operating Station (ROS) in the Turbine Building. The subsystem consists of two Nitrogen bottles at a nominal pressure of 2640 psig, and routes gas supply lines to the actuators of HCVS valves AOV 1(2)-1601-60 and AOV 1(2)-1699-98 in the Reactor Building. An isolation valve, 1(2)-1604-33A/B, is provided for each Nitrogen bottle. A pressure gauge, 1(2)-1604-50, provides local indication of Nitrogen bottle pressure. A ball valve, 1(2)-1604-31, is upstream of the pressure regulating valve, 1(2)-1604-32, which is normally shut. Downstream is a relief valve, 1(2)-1604-30. Downstream of the relief valve, the system branches to supply Nitrogen through three-way solenoid operated valves: SOV 1(2)-1604-20A for AOV 1(2)-1699-98, and SOV 1(2)-1604-10A for AOV 1(2)-1601-60. In case a SOV fails to open, a bypass around the SOV is provided using three-way ball valves, 1(2)-1604-10B and 1(2)-1604-20B. Downstream of the SOVs are speed control valves, 1(2)-1604-13 and 1(2)-1604-23, to adjust the opening times of AOV 1(2)-1601-60 and AOV 1(2)-1699-98, respectively. Ball valves 1(2)-1604-14 and 1(2)-1604-24 are the last components in the Nitrogen supply lines at the ROS. These valves are normally locked shut in the standby condition and serve as secondary containment isolation valves.

The new Argon Purge subsystem is designed to prevent hydrogen detonation downstream of PCIV 1(2)-1699-98. The Argon Purge subsystem is located at the Remote Operating Station (ROS) in the Turbine Building. The subsystem consists of sixteen Argon bottles at a nominal pressure of 2640 psig, and routes gas supply lines to the piping between the PCIV and the rupture disc. Isolation valves, 1(2)-1605-18A/B, are installed for each bank of eight Argon bottles. Pressure gauge 1(2)-1605-45 provides local indication, and pressure indicator PI 1(2)-1605-47 provides MCR indication of Argon bottle pressure. Downstream of the Argon bottles is SOV 1(2)-1605-25A. This SOV is operated by a keylocked switch in the MCR, and when opened supplies Argon to the inlet of pressure regulating valve 1(2)-1605-17. A bypass around the SOV is provided using ball valve 1(2)-1605-25B. Overpressure protection is provided by relief valve 1(2)-1605-15. The next downstream component is three-way ball valve 1(2)-1605-14.

Pipe supports are installed for the 12" vent line inside and outside the Reactor Building. External to the Reactor Building, the vent pipe is also supported by a structural steel tower, which itself is supported via through-bolts into the N-line wall of the Reactor Building at Column Lines 10 and 11 at EL 647'-6" and 690'-6". Additionally, pipe supports are installed for the small-bore Argon and Nitrogen lines. Equipment anchorage/mounting is installed for the electrical components and instruments.

There is a new 125 VDC dedicated battery with rack, battery charger, transfer switch, distribution panel and the required cabling in raceways to provide power to the HCVS. The battery is a flooded vented lead acid battery with a total of 60 cells sufficient to support a 24-hour duty cycle. The HCVS battery bank is installed in the Turbine Building at El. 611'-6" between columns H and G and 11 and 12. The battery feeds a common wall mounted Unit 1 & 2 125VDC distribution panel.

The distribution panel supplies power to MCR Panel 901(2)-55 and the local HCVS Radiation Monitor Rack, 1(2)-1603-21. This battery bank is maintained by a dedicated battery charger, which is fed through a transfer switch from its normal source, Regular Lighting Cabinet (RLC) #14. New power cabling is routed from 480V RLC #14 to the HCVS transfer switch, and from the transfer switch to the HCVS battery charger. New cabling is also routed from the charger to the HCVS distribution panel.

New cabling is installed to the valve limit switches and solenoids for valve controls from the Main Control Room (MCR) Panel 901(2)-55. New cable is routed from the HCVS Vent line temperature (RTD) element to the HCVS vent line temperature transmitter 1(2)-1603-11. New instrumentation cabling is routed from the HCVS Vent Line Temperature transmitter and the Argon Gas Pressure transmitter to the HCVS indicators mounted at MCR Panel 901(2)-55. Two new Coaxial cables are routed from the local HCVS Radiation Detector to the RM-1000 Radiation Monitor/Display mounted at a cabinet next to the ROS rack.

The HCVS Radiation Detector is located along the HCVS pipe near the exit of the Reactor Building. Cabling is routed to the ROS panel radiation monitor, 1(2)-1603-21, and is further routed from the ROS panel to MCR Panel 901(2)-55. The HCVS temperature indication and Argon purge supply pressure indication loops are powered by a 125VDC-to-24VDC converter, 1(2)-1606-24, which is rated for 200 watts output power. The HCVS temperature indication and Argon purge supply pressure indication instrumentation cabling is also routed to MCR Panel 901(2)-55.

MCR Panel 901(2)-55 houses the HCVS electrical power control switches, the indicating lights for the PCI valves, the Argon purge SOV power supply, 125VDC to 24VDC instrumentation power supply, the HCVS vent line radiation indicator, vent line temperature indicator, and the Argon purge line pressure indicator. A 20A load side breaker feeds the HCVS equipment at MCR Panel 901-55, and a separate 15A load side breaker feeds the local Radiation Monitor cabinet 1(2)-1603-21. New cabling is routed from a 125VDC distribution panel 20A breaker to Local Panel 2201-25A. Grounding of the HVCS and subsystems equipment is to the existing plant ground.

The final HCVS utilization does not contain any new electrical circuitry for bypassing isolation signals. The Remote Operating Station allows manual operation of bypass lines around the solenoid valves to directly open the PCIVs with compressed nitrogen, so no electrical signal overrides are needed.

The Main Control Room is the primary operating station for the HCVS. During an ELAP, electric power to operate the vent valves will be provided by a battery with a capacity to supply required loads for at least the first 24 hours. Before the battery is depleted, the FLEX/SAWA diesel generator will supplement and recharge the battery to support operation of the vent valves. The ROS is designated as the alternate control location and method. Since the ROS does not require any electrical power to operate, the valve solenoids do not need any additional backup electrical power. Attachment 2 shows the HCVS vent flow path.

Existing Wetwell Level Transmitters, 1(2)-1641-5A(B), and Drywell Pressure Transmitters, 1(2)-1641-6A(B), are used to supply Control Room indicators for the HCVS system. MCR Panel 901(2)-55 contains power switches that turn on electrical power to the panel, solenoids, and PCI valve indicating lights. This panel also contains the 125VDC to 24VDC instrumentation power supply, the HCVS vent line radiation indicator 1(2)-1603-22, vent line temperature indicator 1(2)-1603-12, and Argon purge line pressure indicator 1(2)-1605-47. The control switches 1(2)-1604-10A, 1(2)-1604-20A, and 1(2)-1605-25A, are low profile, key-locked selector switches. The indication lights (for open and closed indication) are GE 125VDC (2000 ohm) type ET-16 lights.

Three Weschler type VX-252 (Typical) Analog Indicators are used on MCR panel 901(2)-55 to monitor argon gas bottle pressure, HCVS temperature, and HCVS radiation. The HCVS controls and indicators at MCR Panel 901(2)-55 will not be energized during normal operation. Locked power control switch, 1(2)-1604-15, will be maintained in the "off" position during normal operation and the operator will turn the key-locked switch to the "on" position to power the panel indicators and controls. Individual key-operated position selector switches 1(2)-1605-25A located on the HCVS panel can then be utilized to actuate the SOVs, thus allowing actuation of the containment isolation valves and purging system.

Once power has been aligned to MCR Panel 901(2)-55, the operators can operate the HCVS vent valves, monitor HCVS vent valve position, vent pipe temperature, effluent radiation level, and argon purge pressure.

Drywell pressure and Torus level are always available on other MCR panels and are powered by the Station Safety-Related Batteries through the Essential Services bus.

The ROS consists of manual valves, piping and instrumentation necessary to operate the HCVS outside of the MCR. Pressure gauge 1(2)-1604-50 provides local indication of Nitrogen bottle pressure. Argon subsystem pressure gauge 1(2)-1605-45 provides local Argon pressure indication. Manual valves at the ROS allow operators to directly port nitrogen to the actuators of HCVS isolation vent valves and use argon to purge the HCVS vent pipe.

Table 1 contains a complete list of instruments available to the operators for operating and monitoring the HCVS.

The HCVS radiation monitor uses a 125VDC input power. The instruments to be powered for the 24-hour period are powered by circuits fed through the 125VDC input power. The following are the final electrical design highlights:

1. The valves' limit switches provide direct position indication to the MCR 901(2)-55 panel and are powered from the HCVS 125 VDC battery 0-8370.
2. The Radiation Monitor 1(2)-1603-21 is powered from the installed 125VDC HCVS battery, 0-8370.
3. The battery voltage is indicated on battery charger 0-8370-1 located on the Unit 2 Turbine Building Mezzanine floor, adjacent to the 125VDC battery rack.
4. The backup power to the 125VDC HCVS battery charger is from 480V MCC 19-3 which can be supplied from a FLEX diesel generator and can be transferred at the transfer switch location on the Unit 2 Turbine Building Mezzanine floor adjacent to the 125VDC battery rack. As all HCVS components and valve control are powered from the HCVS battery, the restoration of power to the battery charger will also repower all required components as follows:
    a. Solenoids associated with the Primary Containment air-operated valves.
    b. The Argon purge solenoid valves.
    c. MCR position indication lights for the HCVS vent valves.
    d. The HCVS radiation detection monitoring equipment.

e. The 125VDC to 24VDC power supply to the other instruments and MCR indication.

Attachments 3 and 3a contain one-line diagrams of the HCVS electrical distribution system.

The wetwell vent up to, and including, the second containment isolation barrier is designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components.

The hardened vent piping between the wetwell and the Reactor Building roof, including boundary isolation valve 1(2)-1699-98, is designed to the UFSAR system design pressure of 62 psig at 350 °F.

NEI 13-02 suggests a 350°F value for HCVS design temperature based on the highest Primary Containment Pressure Limit (PCPL) among the Mark I and II plants. Per QGA 200 Rev. 010, the PCPL value for Quad Cities Station is 53 psig, and the Quad Cities Station containment design pressure is 56 psig (Reference UFSAR Section 6.2.1.1 and Table 6.2-1). Per NEI 13-02, it is acceptable to assume saturation conditions in containment (2.4.3.1), so these design parameters are acceptable.

To prevent leakage of vented effluent to other parts of the Reactor Building or other systems (Standby Gas Treatment), boundary valves 1(2)-1601-24 and 1(2)-1601-63 must be closed before wetwell venting. Valves 1(2)-1601-24 and 1(2)-1601-63 are the only boundary between the HCVS and the interfacing SBGT system. These valves are normally closed, fail closed, and are not required to change state to perform their safety related containment isolation function; therefore, they can be assumed to be closed when required. Valves 1(2)-1601-24 and 1(2)-1601-63 are part of the In-Service Testing (IST) program, and are leak tested in accordance with 10CFR50, Appendix J. This is acceptable for prevention of inadvertent cross-flow of vented fluids per HCVS-FAQ-05.

HCVS features to prevent inadvertent actuation include key lock switches 1(2)-1604-10A, 1(2)-1604-20A, and 1(2)-1605-25A in the MCR, and locked closed valves 1(2)-1604-14 and 1(2)-1604-24 at the ROS, which are acceptable methods of preventing inadvertent actuation per NEI 13-02.

As required by EA-13-109, Section 1.2.11, the HCVS shall be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation. The wetwell vent is designed to prevent air/oxygen backflow into the discharge piping to ensure the flammability limits of hydrogen, and other non-condensable gases, are not reached. The Quad Cities Station HCVS design meets the above requirements through the Argon purge system. The detailed analysis of the Argon purge system is contained in calculation QDC-1600-M-2190 (Reference 33).

The HCVS radiation monitor with ion chamber detector is qualified for the ELAP and external event conditions. In addition to the RM, a temperature element is installed on the vent line to allow the operators to monitor operation of the HCVS. Electrical and controls components are seismically qualified and include the ability to handle harsh environmental conditions (although they are not considered part of the site Environmental Qualification (EQ) program).

<u>Section III.B</u>: HCVS Phase 1 Evaluation Against Requirements:

The functional requirements of Phase 1 of NRC Order EA-13-109 are outlined below along with an evaluation of the Quad Cities Station response to maintain compliance with the Order and guidance from JLD-ISG-2015-01. Due to the difference between NEI 13-02, Revision 0 and Revision 1, only Revision 1 will be evaluated. Per JLD-ISG-2015-01, this is acceptable as Revision 1 provides acceptable guidance for compliance with Phase 1 and Phase 2 of the Order. (Italicized content below taken from EA-13-109, Attachment 2).

1. HCVS Functional Requirements

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

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

<u>Evaluation:</u>

The operation of 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 32), 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 station. A list of the remote manual actions performed by plant personnel to open the HCVS vent path is in the following table:

Table 3-1: HCVS Operator Actions

(Unit 1 Actions Listed. Unit 2 actions use corresponding Unit 2 equipment.)

Primary Action	Primary Location/ Component	Notes
Open HCVS vent path		
Energize the HCVS power supply to the HCVS components.	With breaker #8 at the HCVS Dist. Panel in the "On" position, turn the key-locked hand switch 1-1604-15 at MCR Panel 901-55 to the "On" position.	
Pressurize motive gas supply (N2) header and purge gas supply (Argon) headers.	Open manual bottle isolation valves.	
Enable the motive Gas supply (N2) for the HCVS valves.	Open manual isolation valve 1-1604-31 and unlock and open manual isolation valves 1-1604-14 and 1-1604-24 at the ROS.	Allows bottle pressure to reach the inlet of the solenoid valves.
Enable the purge gas supply (argon).	Unlock and reposition manual 3-way valve 1-1605-14 at the ROS.	Repositioning the 3-way valve closes the leakoff line and enables argon injection into the main vent line.
Check shut 1-1601-60 and the downstream PCIV 1-1699-98 on the containment vent.	MCR Panel 901-55 indicating lights indicating the "Close" position of the valves.	Precautionary steps – these valves are normally shut and fail shut.
Burst rupture disk.	Energize argon supply solenoid valve via turning the key-locked hand switch 1-1605-25A at MCR Panel 901-55 to the "Purge" position.	Alternate control via manual valves at the ROS. A reduction in pressure at PI 1-1605-35 signals successful rupture disc bursting.
Open HCVS inboard PCIV (1-1601-60).	Energize motive gas solenoid valve via turning key-locked hand switch 1-1604-10A at MCR Panel 901-55 to the "Open" position.	Alternate control via manual valves at the ROS.

Primary Action	Primary Location/ Component	Notes
Open HCVS outboard PCIV (1-1699-98).	Energize motive gas solenoid valve via turning key-locked hand switch 1-1604-20A in MCR Panel 901-55 to the "Open" position.	Alternate control via manual valves at the ROS. MCR vent radiation (RI 1-1603-22), temperature (TI 1-1603-12), Drywell pressure (PI 1-1640-11A(B)), and Wetwell level (LI 1-1640-10A(B)) indication provides confirmation of successful venting.
Close HCVS vent path		
Close HCVS outboard PCIV (1-1699-98).	De-energize motive gas solenoid valve via turning key-locked hand switch 1-1604-20A in MCR Panel 901-55 to the "Close" position.	Alternate control via manual valves at the ROS.
Purge HCVS vent Piping.	Energize argon supply solenoid valve turning the key-locked hand switch 1-1605-25A in MCR Panel 901-55 to the "Purge" position (for required length of time).	Alternate control via manual valves at the ROS. The purge should be initiated immediately following closure of the 1-1699-98 PCIV. The minimum required purge duration is based on Analysis No. QDC-1600-M-2190. A drop-in argon bottle pressure should be observed at the ROS (PI 1-1605-45) or MCR (PI 1-1605-47) to confirm a successful purge.

Primary Action	Primary Location/ Component	Notes
Actions required by t = 24 hours		
Align power to the HCVS battery charger.	1)At the HCVS Transfer Switch by throwing the switch to the ALTERNATE position. 2) Align the Flex DG such that it feeds 480V MCC 19-3 (Cub. C5). 3) At 480V MCC 19-3 Cub. C5 turn the breaker handle to the "On" position.	
Replace nitrogen gas bottles and argon bottles.	ROS	

Permanently installed electrical power and pneumatic supplies are available to support operation and monitoring of the HCVS for a minimum of 24 hours. No portable equipment needs be moved in the first 24 hours.

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/SAWA generators and nitrogen bottles provide this motive force. These actions will be completed in less than 24 hours. However, the HCVS can be operated for at least 24 hours without any supplemental gas or electric power.

The above set of actions conform to the guidance in NEI 13-02 Revision 1 Section 4.2.6 for minimizing reliance on Operator actions and are acceptable for compliance with Order element A.1.1.1. These were identified in the OIP and subsequent NRC ISE.

Table 3-2: Failure Evaluation

Functional Failure	Failure Cause	Alternate Action	Failure with Alternate Action Prevents Containment Venting?
Fail to Vent (Open) on Demand	Valves fail to open/close due to loss of normal AC power/DC batteries.	None required – system SOVs utilize dedicated 24-hour power supply.	No
	Valves fail to open/close due to depletion of dedicated power supply.	Recharge system with FLEX portable generators.	No
	Valves fail to open/close due to complete loss of power supplies.	Manually operate backup pneumatic supply/vent lines at ROS.	No
	Valves fail to open/close due to loss of normal pneumatic supply.	No action needed. Valves are provided with dedicated motive force capable of 24-hour operation.	No
	Valves fail to open/close due to loss of alternate pneumatic supply (long term).	Replace bottles as needed and/or recharge with portable air compressors.	No
	Valve fails to open/close due to SOV failure.	Manually operate backup pneumatic supply/vent lines at ROS.	No
Fail to stop venting (Close) on demand	Not credible as there is not a common mode failure that would prevent the closure of at least 1 of the 2 valves needed for venting. Both valves designed to fail shut.	N/A	No

Functional Failure	Failure Cause	Alternate Action	Failure with Alternate Action Prevents Containment Venting?
Spurious Opening	Not credible as key-locked switch prevents mispositioning of the downstream HCVS PCIV and additionally, power and DC power for the solenoid valve is normally deenergized.	N/A	No
Spurious Closure	Valves fail to remain open due to depletion of dedicated power supply.	Recharge system with provided portable Generators.	No
	Valves fail to remain open due to complete loss of power supplies.	Manually operate backup pneumatic supply/vent lines at ROS.	No
	Valves fail to remain open due to loss of alternate pneumatic supply (long term).	Replace bottles as needed and/or recharge with portable air compressors.	No

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

Evaluation:

Primary control of the HCVS is accomplished from the MCR. Alternate control of the HCVS is accomplished from the ROS located in the Turbine Building at EL. 619' in Unit 1 and EL. 611' elevation in Unit 2. FLEX actions that will maintain the MCR and ROS habitable were implemented in response to NRC Order EA-12-049 (Reference 33). These include:

In accordance with QOA 5750-15 (Reference 34), alternate cooling consisting of providing an alternate air flow to the MCR via a pre-staged portable fan is implemented to maintain the Main Control Room temperature below 120°F. Table 2 contains a thermal evaluation of all the operator actions that may be required to support HCVS operation. The relevant environmental area evaluations contained in or referenced in

ECs 392257 and 400666 (References 36 and 37) demonstrate that the final design meets the order requirements to minimize the plant operators' exposure to occupational hazards.

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

Evaluation:

Primary control of the HCVS is accomplished from the MCR. 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 (Ref. 62).

Alternate control of the HCVS is accomplished from the ROS. The ROS was evaluated for radiation effects due to a severe accident and determined to be acceptable. The ROS is in a low dose area during normal operation. During an accident, shielding is provided from containment and the HCVS pipe by several feet of intervening concrete shield walls, Reactor Building Walls and concrete floors as evaluated in analysis QDC-0000-M-2199 (Ref. 39). The shielding, combined with the duration of actions required at the ROS, show the ROS to be an acceptable location for alternate control.

Table 2 contains a radiological evaluation of the operator actions that may be required to support HCVS operation in a severe accident. There are no abnormal radiological conditions present for HCVS operation without core damage. The evaluation of radiological hazards demonstrates that the final design meets the order requirements to minimize the plant operators' exposure to radiological hazards.

The HCVS vent is routed away from the MCR such that building structures provide shielding, thus the MCR is the preferred control location (Ref. 59). If venting operations create the potential for airborne contamination in the MCR, the ERO will provide personal protective equipment to minimize any operator exposure.

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

Evaluation:

Primary control of the HCVS is accomplished from the main control room. Under the postulated scenarios of order EA-13-109 the control room is adequately protected from excessive radiation dose and no further evaluation of its use is required (Ref. 62).

Alternate control of the HCVS is accomplished from the ROS on the Mezzanine level of the Turbine Building. The ROS is in an area evaluated to be accessible before and during a severe accident.

For ELAP with injection, the HCVS Wetwell vent will be opened to protect the containment from overpressure. The operator actions and timing of those actions to perform this function under ELAP conditions were evaluated as part of Quad Cities Station response to NRC Order EA-12-049 as stated in Quad Cities Station RS-13-025, dated February 28, 2013 (Ref. 40).

Table 2 contains a thermal and radiological evaluation of all the operator actions at the MCR or alternate location that may be required to support HCVS operation during a severe accident. The relevant environmental area evaluations contained in or referenced in ECs 392257 and 400666 (Refs. 36 and 37) demonstrate that the final design meets the order requirements to minimize the plant operators' exposure to occupational and radiological hazards.

Table 1 contains an evaluation of the controls and indications that are or may be required to operate the HCVS during a severe accident. The evaluation demonstrates that the controls and indications are accessible and functional during a severe accident with a loss of AC power and inadequate containment cooling.

1.2 The HCVS shall include the following design features:

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

<u>Evaluation:</u>

The Quad Cities Station HCVS Wetwell vent path is designed for venting steam/energy at a nominal capacity of 1% of 2957 MWt thermal power at a pressure of 53 psig. This pressure is the lower of the containment design pressure and the PCPL, per QGA 200 (Ref. 41). The detailed analysis of the HCVS venting capacity is contained in calculations QDC-1600-M-2188 (Unit 1) and QDC-1600-M-2247(Unit 2) (Refs. 42 and 43). These analyses used a RELAP5 model to consider compressible flow assuming discharge of steam only. The steaming rate was determined using 1% decay heat and h_{fg}. Therefore, Requirement 1.2.1 of Attachment 2 to NRC Order EA-13-109 is met. The decay heat absorbing capacity of the suppression pool and the selection of venting pressure were made such that the HCVS will have sufficient capacity to maintain containment pressure at or below the lower of the containment design pressure (56 psig) or the PCPL (53 psig). This calculation of containment response is contained in QC-MISC-018 (Ref. 44) and shows that containment is maintained below the design pressure once the vent is opened, even if it is not opened until PCPL.

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

Evaluation:

The Wetwell vent exits the Primary Containment through the existing 18" vent valve 1(2)-1601-60 and associated 18" piping. The discharge is routed through the new 12" vent valve 1(2)-1699-98, located in the RB at EL. 632', and associated 12" piping then exiting the RB at EL. 644' where the pipe turns vertical to the release point at the top of the stack. As shown on M-991A-1, Sheet 3 and M-1023A-1, Sheet 4 (References 45 and 46), the top of each of the HCVS stacks is at EL. 744'-2" and the top of the roof parapet is at EL. 739'-2". All effluents are exhausted above each unit's RB. This discharge point was extended approximately five feet above each unit's Reactor Building parapet wall such that the release point will vent away from emergency ventilation system intake and exhaust openings, main control room location, location of HCVS portable equipment, access routes required following an ELAP and BDBEE, and emergency response facilities. Not having power for MCR ventilation and emergency filter trains is not a factor. During an ELAP event, there is no motive force to move source term contaminants into the MCR envelope except for natural circulation. Adequate protective clothing and respirators are available near the MCR to address contamination issues. Thus, no evaluation is required for use of the MCR for Severe Accident conditions, in accordance with HCVS-FAQ-01.

Part of the HCVS-FAQ-04 guidance is designed to ensure that vented fluids are not drawn immediately back into any emergency ventilation intakes. Such ventilation intakes should be below a level of the pipe by 1 foot for every 5 horizontal feet.

The MCR emergency intake in the ELAP event is at the 628-ft. elevation which is approximately 117 feet below the HVCS pipe outlet. This requires 23.4 ft of separation. This MCR emergency intake is located on the Service Building Roof and the HCVS vent is off the side of the Reactor Building and provides greater than 23.4 ft of separation.

The vent pipe extends approximately 5 ft. above the parapet wall of the RB roof. This satisfies the guidance for height from HCVS-FAQ-04.

HCVS-WP-04 provides criteria that demonstrate robustness of the HCVS pipe. Quad Cities Station meets all the requirements of this white paper. This evaluation documents that the HCVS pipe is adequately protected from all external events and no further protection is required.

Quad Cities Station 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 HCVS-WP-04 in that:

1. There are no portions of exposed piping below 30 feet above grade. Considering that the plant is located at a low point of the surrounding area, a review of the area topographic map has been performed to verify that the 30-foot height requirement is met. As described in EC 392256 (Reference 35), there are two areas located at grade elevation less than 30 feet from the pipe elevation (berm between ISFSI Pad and Hydrogen Tank Farm and berm located near security shooting range). These areas remain under strict administrative control to eliminate placement of any large missiles within the vicinity.
2. The exposed piping greater than 30 feet above grade has the following characteristics:
   a. The total vent pipe exposed area is approximately 175 square feet for Unit 2 (less for Unit 1) based on Drawings M-991A-1, Sheet 3 and M-1023A-1, Sheet 4 (References 45 and 46), which is less than 300 square feet.
   b. The pipe is made of schedule STD carbon steel versus plastic and the pipe components have no small tubing susceptible to missiles.
   c. There are no obvious sources of missiles located in the proximity of the exposed HCVS components.
3. Hurricanes are not screened for Quad Cities Station.

Due to actions taken to ensure there are no potential missiles within 0.5 miles of the vent pipe, crimping of the pipe due to tornado borne missiles is not credible. Based on the above description of the vent pipe design, the Quad Cities Station HCVS vent pipe design meets the order requirement to be robust with respect to all external hazards including wind-borne missiles.

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

Evaluation:

The HCVS for Units 1 & 2 are fully independent of each other. Therefore, the status at each unit is independent of the status of the other unit.

Valves 1(2)-1601-24 and 1(2)-1601-63 are the boundary between the HCVS and the interfacing SBGT system. These valves are normally closed, fail closed, and are not required to change state to perform their safety related containment isolation function; therefore, they can be assumed to be closed when required. Valves 1(2)-1601-24 and 1(2)-1601-63 are part of the IST program and are leak tested under 10CFR50, Appendix J as part of the containment boundary in accordance with HCVS-FAQ-05.

Based on the above description, the Quad Cities Station design meets the requirements to minimize unintended cross-flow of vented fluids within a unit and between units on site.

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

Evaluation:

Operators unlock valves at the ROS and verify the rupture disc is burst for initial system initiation. Following initiation, the HCVS is designed for sustained manual operation from the MCR panel 901(2)-55. The ROS is readily accessible for system initiation, and provides back-up controls as described and evaluated in the response under Order Element 1.2.5.

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

Evaluation:

To meet the requirement for an alternate means of operation, a readily accessible alternate location, called the ROS was added. The ROS contains manually operated valves that supply pneumatics to the HCVS flow path valve actuators so these valves may be opened without power to the valve actuator solenoids and regardless of any containment isolation signals that may be actuated. This provides a diverse method of valve operation improving system reliability.

The location for the ROS is in the Turbine Building at 619' elevation for Unit 1, and the Turbine Building at 611' elevation for Unit 2. Refer to the sketch provided in Attachment 6 for the HCVS site layout. The controls available at the ROS location are accessible and functional under a range of plant conditions, including severe accident conditions with due consideration to source term and dose impact on operator exposure, extended loss of AC power (ELAP), inadequate containment cooling, and loss of reactor building ventilation. Table 1 contains an evaluation of all 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 contains a thermal and radiological evaluation of all the operator actions that may be required to support HCVS operation during a loss of AC power and severe accident and demonstrates that these actions will be possible without undue hazard to the operators. Attachment 6 contains a site layout showing the location of these HCVS actions.

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

Evaluation:

HCVS-WP-01 contains clarification on the definition of "dedicated and permanently installed" with respect to the order. In summary, it is acceptable to use plant equipment that is used for other functions, but it is not acceptable to credit portable equipment that must be moved and connected for the first 24-hours period of the ELAP.

The FLEX/SAWA generators will be started and loaded, thus there will be no need to use other power sources for HCVS wetwell venting components during the first 24 hours. However, this order element does not allow crediting the FLEX/SAWA generators for HCVS wetwell venting components until after 24 hours. Therefore, backup electrical power required for operation of HCVS components in the first 24 hours will come from the dedicated 125VDC battery. This battery is permanently installed on the Turbine Building mezzanine floor, where it is protected from screened-in hazards and has sufficient capacity to provide this power without recharging. Calculation QDC-1600-E-2200 (Reference 47) demonstrated that the 125VDC battery capacity is sufficient to supply HCVS wetwell venting components for 24 hours. At 24 hours, FLEX/SAWA generators can be credited to repower the station instrument busses and/or the battery charger to recharge the 125VDC battery, hydrogen gas control during recharging and room temperature control per the response to order EA-12-049. Calculation QDC-7300-E-2099 (Ref. 48) included the 125VDC battery charger in the FLEX DG loading calculation, so there is no additional load on the FLEX/SAWA DG and they can carry HCVS wetwell venting components electrical loads. 125VDC battery voltage status will be indicated on the new battery charger 0-8370-1 so that operators will be able to monitor the status of the 125VDC battery. Attachments 3 and 3a contain diagrams of the HCVS electrical distribution system. Cable deployment from the FLEX/SAWA DGs to 480V buses 18/19 and 28/29 is shown on Attachment 6d.

Pneumatic power for the inboard HCVS 1(2)-1601-60 valve actuator is normally provided by the instrument air system with backup pneumatic power provided from the HCVS nitrogen gas system. Pneumatic power for the outboard HCVS 1(2) 1699-98 actuator is provided by the HCVS nitrogen gas system. The instrument air system supply to the 1(2)-1601-60 PCIV is modified to include a poppet valve that provides the interface between the HCVS nitrogen gas system and the existing instrument air system. Following an ELAP event and the loss of instrument air, the nitrogen gas system provides operating pneumatics to the hardened wetwell vent valves. Therefore, for the first 24 hours post-ELAP initiation, pneumatic force will be supplied from the HCVS nitrogen gas system bottle racks located at the ROS on the Mezzanine level of the Turbine Building. Calculations QDC-1600-M-2212 (Unit 1) and QDC-1600-M-2249 (Unit 2) (References 49 and 50) demonstrate that the installed nitrogen bottles have the capacity to supply the required motive force to those HCVS valves needed to maintain flow through the HCVS effluent piping for 24 hours without replenishment, considering procedurally controlled minimum bottle pressures and the minimum number of valve cycles in 24 hours per HCVS-WP-02 guidance. A pressure gauge 1(2)-1604-50 provides local indication of Nitrogen bottle pressure.

1.2.7 The HCVS shall include a means to prevent inadvertent actuation.

Evaluation:

Emergency operating procedures provide clear guidance that the HCVS is not to be used to defeat containment integrity during any design basis transients and accidents. In addition, the HCVS was designed to provide features to prevent inadvertent actuation due to equipment malfunction or operator error. Also, these protections are designed such that any credited containment accident pressure (CAP) that would provide net positive suction head to the emergency core cooling system (ECCS) pumps will be available (inclusive of a design basis loss-of-coolant accident). However, the ECCS pumps will not have normal power available because of the ELAP.

The containment isolation valves must be open to permit vent flow. The physical features that prevent inadvertent actuation are key-locked MCR Panel 901(2)-55 switches (1(2)-1604-15, 1(2)-1604-10A, 1(2)-1604-10B), and locked-closed manual isolation valves at the ROS for the Argon (1(2)-1605-14) and Nitrogen subsystems (1(2)-1604-14 and 1(2)-1604-24). These design features meet the requirement to prevent inadvertent actuation of the HCVS.

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

Evaluation:

The HCVS includes indications for HCVS valve position, vent pipe temperature, effluent radiation levels, and Argon purge pressure in the MCR, as well as information on the status of supporting systems which are 125VDC HCVS battery voltage and nitrogen pressure at the ROS.

This monitoring instrumentation provides the indication from the MCR per Requirement 1.2.4. If the FLEX/SAWA DGs do not energize the emergency busses, the Wetwell HCVS and required containment instrumentation will be supplied by the 125VDC Station battery and are designed for sustained operation during an ELAP event using the FLEX equipment.

HCVS instrumentation performance (e.g., accuracy and range) need not exceed that of similar plant installed equipment. Additionally, radiation monitoring instrumentation accuracy and range is sufficient to confirm flow of radionuclides through the HCVS.

The HCVS instruments, including valve position indication, vent pipe temperature, radiation monitoring, and support system monitoring, are seismically qualified as indicated on Table 1 and they include the ability to handle harsh environmental conditions (although they may not be considered part of the site Environmental Qualification program).

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

Evaluation:

The HCVS radiation monitoring system consists of an ion chamber detector coupled to a process and control module, 1(2)-1603-21. The process and control module is located at the ROS locations in the Unit 1 Turbine Building EL. 611' and the Unit 2 Turbine Building EL. 611'. The RM 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 ROS locations. Both components are qualified for the seismic requirements. Table 1 includes a description and qualification information on the radiation monitor.

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

Evaluation:

The Wetwell vent, up to and including the second containment isolation valve, is designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators, and containment isolation valve position indication components.

The new and existing hardened vent piping, between the Wetwell and the vent release point, including valve 1(2)-1699-98, are designed to 62 psig at 350 °F, which meets or exceeds existing design basis conditions and beyond design basis conditions per NEI 13-02. Existing PCIV 1(2)-1601-60 is not rated for this 350 °F design temperature. However, the valve is acceptable for severe accident conditions based on the steam saturation temperature at the Quad Cities Station PCPL as evaluated in ECs 392257 and 400666 (Refs. 36 and 37).

HCVS piping and components have been analyzed and shown to perform under severe accident conditions using the guidance provided in HCVS- FAQ-08 and HCVS-WP-02. QDC-0000-M-2199 (Ref. 39) performs a dose assessment of the ROS/ROS travel paths and the HCVS equipment areas for conditions caused by the sustained operation of the HCVS under a beyond design basis severe accident. EC 392256, EC 392257, and EC 400666 (Refs. 35, 36, and 37) contain a summary of the evaluation of HCVS components for severe accident conditions.

Refer to EA-13-109, Requirement 1.2.11 for a discussion on designing for combustible gas.

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

Evaluation:

To prevent a detonable mixture from developing in the pipe, a purge system is installed to purge hydrogen (and other combustibles) from the pipe with argon after a period of venting and to purge oxygen from the pipe prior to resuming venting. The supply for the purge system is argon bottles mounted at the ROS. The argon supply lines are then routed to the HCVS vent line via tubing and connected to the line between the new PCIV and rupture disc. Repositioning the 3-way valve 1(2)-1605-14 closes the leakoff line and enables argon injection into the main vent line for initial system lineup. The system is manually initiated by operators following vent closure either remotely from the MCR (via hand switches controlling the 1(2)-1605-25A purge SOV) or from manual valves located at the ROS which bypass the purge SOV. A detailed analysis of the purge system for both units is included in Calculation QDC-1600-M-2190 (Reference 33). The use of a purge system meets the requirement to ensure the flammability limits of gases passing through the vent pipe will not be reached.

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

Evaluation:

The response under Order Requirement 1.2.3 explains how the potential for hydrogen migration into other systems, the Reactor Building, or other buildings is minimized.

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

Evaluation:

As endorsed in the ISG, sections 5.4 and 6.2 of NEI 13-02 provide acceptable method for satisfying the requirements for operation, testing, inspection, and maintenance of the HCVS.

Primary and secondary containment required leakage testing is covered under existing design basis testing programs. The HCVS outside the containment boundary is tested to ensure that vent flow is released to the outside with minimal leakage, if any, through the interfacing boundaries with other systems or units.

Quad Cities Station has implemented the following operation, testing and inspection requirements for the HCVS to ensure reliable operation of the system. These are from NEI 13-02, Table 6.1. The implementing modification packages contain these as well as additional testing required for post-modification testing.

Local Leak Rate Tests (LLRT) on the new PCIV (AO 1(2)-1699-98) will be performed in accordance with station procedure QCTS 0600-48 (Ref. 51) or equivalent.

Periodic Secondary Containment Boundary testing of the portions of the installation penetrating the RB walls is also required. This does not impact the current testing requirements for this function. The rupture disc is not an ASME or design basis "over-pressure protection" device. It is solely a leakage barrier for preventing containment leakage through PCIVs in a Design Basis LOCA from bypassing the Secondary Containment. Consequently, periodic testing is limited to verification that the rupture disc pressure boundary has not failed during design basis operation. Periodic testing is based on the Station's existing criteria for prevention of bypass leakage and rupture disc vendor recommendations where applicable.

An acceptance test of the battery's capacity was performed at the factory prior to shipment in accordance with IEEE 450-2010. Periodic tests have been scheduled.

Quad Cities Station utilizes the standard EPRI industry PM process (like the Preventive Maintenance Basis Database) for establishing the maintenance calibration and testing actions for HCVS/SAWA/SAWM components. The control program will include maintenance guidance, testing procedures, and frequencies established based on type of equipment and considerations made within the EPRI guidelines. Table 3-3 below is from CC-AA-118.

Table 3-3: Testing and Inspection Requirements

Description	**Frequency**
Cycle the HCVS valves[1] and the interfacing system valves not used to maintain containment integrity during operations.	Once per every[2] operating cycle.
Cycle the HCVS check valves not used to maintain containment integrity during unit operations.[3]	Once per every other[4] operating cycle.
Perform visual inspections and a walk down of HCVS components.	Once per operating cycle.
Functionally test the HCVS radiation monitors.	Once per operating cycle.
Leak test the HCVS.	(1) Prior to first declaring the system functional; (2) Once every three operating cycles thereafter; and (3) After restoration of any breach of system boundary within the buildings.
Validate the HCVS operating procedures by conducting an open/close test of the HCVS control logic from its control panel (primary and alternate) and ensuring that all interfacing system boundary[5] valves move to their proper (intended) positions.	Once per every other operating cycle.

[1] Not required for HCVS check valves.
[2] After two consecutive successful performances, the test frequency may be reduced to a maximum of once per every other operating cycle.
[3] Not required if integrity of check function (open and closed) is demonstrated by other plant testing requirements.
[4] After two consecutive successful performances, the test frequency may be reduced by one operating cycle to a maximum of once per every fourth operating cycle.
[5] Interfacing system boundary valves that are normally closed and fail closed under ELAP conditions (loss of power and/or air) do not require control function testing under this section. Performing existing plant design basis function testing or system operation that reposition the valve(s) to the HCVS required position will meet this requirement without the need for additional testing.

2. *HCVS Quality Standards:*

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

Evaluation:

The HCVS penetration and containment isolation valves are designed and installed consistent with the design basis of primary containment including pressure, temperature, radiation, and seismic loads.

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

Evaluation:

The 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.

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 contains a list of components, controls, and instruments required to operate HCVS and their qualification and evaluation against the expected conditions. All instruments are fully qualified for the expected seismic conditions so that they will remain functional following a seismic event.

<u>Section IV</u>: HCVS Phase 2 Final Integrated Plan Details

<u>Section IV.A</u>: The requirements of EA-13-109, Attachment 2, Section B for Phase 2

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

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

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

1. HCVS Drywell Vent Functional Requirements

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

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

2. Containment Venting Strategy Requirements

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

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

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

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

Because the order contains just three requirements for the containment venting strategy, the compliance elements are in NEI 13-02, Revision 1. NEI 13-02, Revision 1, endorsed by NRC in JLD-ISG-2015-01, provides the guidance for the containment venting strategy (B.2) of the order. NEI 13-02, Revision 1, provides SAWA in conjunction with Severe Accident Water Management (SAWM), which is designed to maintain the wetwell vent in service until alternate reliable containment heat removal and pressure control are established, as the means for compliance with part B of the order.

QCNPS has implemented Containment Venting Strategy (B.2) as the compliance method for Phase 2 of the Order and conforms to the associated guidance in NEI 13-02 Revision 1 for this compliance method.

Section IV.B: HCVS Existing System

There previously was neither a hardened drywell vent nor a strategy at QCNPS that complied with Phase 2 of the order.

Section IV.C: HCVS Phase 2 SAWA System and SAWM Strategy

The HCVS Phase 2 SAWA system and SAWM strategy utilize the FLEX mitigation equipment and strategies to the extent practical. This approach is reasonable because the external hazards and the event initiator (ELAP) are the same for both FLEX mitigation strategies and HCVS. For SAWA, it is assumed that the initial FLEX response actions are unsuccessful in providing core cooling such that core damage contributes to significant radiological impacts that may impede the deployment, connection, and use of FLEX equipment. These radiological impacts, including dose from containment and HCVS vent line shine, were evaluated and modifications made as necessary to mitigate the radiological impacts such that the actions needed to implement SAWA and SAWM are feasible in the timeframes necessary to protect the containment from overpressure related failure. To the extent practical, the SAWA equipment, connection points, deployment locations, and access routes are the same as the FLEX primary strategies so that a Unit that initially implements FLEX actions that later degrades to severe accident conditions can readily transition between FLEX and SAWA strategies. This approach further enhances the feasibility of SAWA under a variety of event sequences including timing.

QCNPS has implemented the containment venting strategy utilizing SAWA and SAWM. The SAWA system consists of a FLEX (SAWA) pump injecting into the Reactor Pressure Vessel (RPV), and SAWM consists of flow control at the FLEX (SAWA) pump along with instrumentation and procedures to ensure that the wetwell vent is not submerged (SAWM). Procedures have been issued to implement this strategy including revision 3 to the Severe Accident Management Guidelines (SAMG). This strategy has been shown via Modular Accident Analysis Program (MAAP) analysis to protect containment without requiring a drywell vent for at least seven days which is the guidance from NEI 13-02 for the period of sustained operation.

Section IV.C.1: Detailed SAWA Flow Path Description

The flow paths are similar to the alternate FLEX flow path (using the Discharge Bay as a water source) except that the fire hoses are run from the Discharge Bay through penetrations in the Turbine and Reactor Building walls to reach the primary FLEX Storz connections to permanent plant piping in the Reactor Building (in lieu of routing hoses around the plant to the Reactor Building Trackway). Capability to maintain FLEX flow paths on the opposite unit is accounted for in this configuration. The SAWA system, shown on Attachment 4, consists of a FLEX pump injecting into the RPV and SAWM consists of flow control at the FLEX pump along with wetwell level indication to ensure that the wetwell vent is not submerged (SAWM). The SAWA injection starts with the FLEX/SAWA Portable Pump at the Discharge Bay, then to a distribution manifold staged inside the Turbine Building, then through the flow meter on the flow meter cart to wall penetrations at the Reactor Building. From the wall penetrations inside the Reactor Building, the flow path runs via fire hoses to Condensate Transfer/Fill System piping connections which lead to the Residual Heat Removal (RHR) system. The RHR connections tie to the Reactor Coolant (RCS) system, then to the RPV. The external equipment (hoses and pump) are stored in the FLEX Storage Building (FSB) which is protected from all hazards. Some Turbine Building equipment is stored on the ground floor (El. 595') area between column lines G/H and 13/15. This area was evaluated for seismic hazards in EC 622071 (Ref. 52). The area is located directly below the Unit 2 ROS (evaluated per Section III) and has similar protection from external tornado/tornado missile hazards. Remaining hoses/fitting components are stored in the Reactor Building which is protected from all hazards. BWROG generic assessment, BWROG-TP-15-008, provides the principles of Severe Accident Water Addition to ensure protection of containment. This SAWA injection path is qualified for the all the screened-in hazards (Section III) in addition to severe accident conditions.

Section IV.C.2: Severe Accident Assessment of Flow Path

Per FLEX Support Guidelines (FSGs) procedures QCOP 0050-05 and QCOP 0050-07 (Refs. 53 and 54), prior to seven hours post-RCIC failure Operations will deploy the FLEX/SAWA Portable Pump (suction from the Discharge Bay or Manhole 1-13) and fire hoses from the FLEX/SAWA Portable Pump to the distribution manifold, the flow meter cart, then to the Reactor Building wall penetrations.

The actions inside the Reactor Building where there could be a high radiation field due to a severe accident will be to deploy fire hoses from the H-Line penetrations to the Storz connections and to open the Storz connection valves and system valves. The action to open valves inside the Reactor Building can be performed before the dose is unacceptable, under the worst-case scenario within the first hour, after the loss of RPV injection. This time was validated as part of the Time Sensitive Action validation for EA-13-109. Procedure QCOA 6100-04 Station Blackout, Attachment 4, Extended Loss of AC Power (ELAP) Actions (Ref. 55) directs early accomplishment of actions that must be done early in the severe accident event where there is a loss of all AC power and a loss of all high-pressure injection to the core. In this event, core damage is not expected for at least one hour so that there will be no excessive radiation levels or heat related concerns in the RB when the the hoses are deployed and valves are operated. The other SAWA actions all take place outside the RB, in the MCR, at the Discharge Bay or Manhole 1-13, Turbine Building, FSB, and the deployment pathways. Since these locations are outside the RB, they are shielded from the severe accident radiation by the thick concrete walls of the RB (See EC 618753 (Ref. 38) for evaluation of environmental conditions for the various actions). Once SAWA is initiated, the operators will monitor the response of containment from the MCR to determine that venting and SAWA are operating satisfactorily, maintaining containment pressure low to avoid containment failure. Stable or slowly rising trend in wetwell level with SAWA at the minimum flow rate indicates water on the drywell floor up to the vent pipe or downcomer openings. After some period, as decay heat levels decrease, the operators will be able to reduce SAWA flow to keep the core debris cool while avoiding overfilling the Torus to the point where the wetwell vent is submerged.

<u>Section IV.C.3</u>: Severe Accident Assessment of Safety-Relief Valves

QCNPS has methods available to extend the operational capability of manual pressure control using SRVs as provided in the plant specific order EA-12-049 submittal. Assessment of manual SRV pressure control capability for use of SAWA during the Order defined accident is unnecessary because RPV depressurization is directed by the EPGs in all cases prior to entry into the SAGs.

<u>Section IV.C.4</u>: Available Freeboard Use

The freeboard between 14' and 29.5' elevation in the Wetwell provides approximately 950,000 gallons of water volume based on the Quad Cities Station Torus with a 30' minor diameter and a 109' major diameter. This elevation is the bottom of the vent pipe at Wetwell elevation 29.5'. BWROG generic assessment BWROG-TP-15-011 provides the principles of Severe Accident Water Management to preserve the Wetwell vent for a minimum of seven days. After containment parameters are stabilized with SAWA flow, SAWA flow will be reduced to a point where containment pressure will remain low while Wetwell level is stable or very slowly rising. The Quad Cities Station SAWA/SAWM design flow rates (400 GPM at 8 hours followed by 80 GPM from 12 hours to 168 hours) and above 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. A diagram of the available freeboard is shown on Attachment 1.

<u>Section IV.C.5</u>: Upper Range of Wetwell Level Indication

The upper range of wetwell level indication provided for SAWA/SAWM is 586'-6" elevation (30' by Torus level indication). This defines the upper limit of wetwell volume that will preserve the wetwell vent function as shown in Attachment 1.

Section IV.C.6: Wetwell Vent Service Time

Reference 27 in NEI 13-02, Revision 1 and BWROG-TP-15-011, which bound QCNPS conditions per Section IV.C.4, demonstrate that throttling SAWA flow after containment parameters have stabilized, in conjunction with venting containment through the wetwell vent, will result in a stable or slowly rising wetwell level. The references demonstrate that, for the scenario analyzed, wetwell level will remain below the wetwell vent pipe for greater than the seven days of sustained operation, allowing significant time for restoration of alternate containment pressure control and heat removal.

Section IV.C.7: Strategy Time Line

The overall accident management plan for QCNPS is developed from the BWROG Emergency Procedure Guidelines and Severe Accident Guidelines (EPG/SAG). As such, the SAWA/SAWM implementing procedures are integrated into the QCNPS SAMGs. EPG/SAG Revision 3, when implemented with Emergency Procedures Committee Generic Issue 1314, allows throttling of SAWA to protect containment while maintaining the wetwell vent in service. The SAMG flow charts direct use of the hardened vent as well as SAWA/SAWM when the appropriate plant conditions have been reached.

Using NEI 12-06, Revision 2, Appendix E, QCNPS has validated that the FLEX/SAWA portable pump can be deployed and commence injection in less than 8 hours. The studies referenced in NEI 13-02 demonstrated that establishing flow within 8 hours will protect containment. The initial SAWA flow rate will be at least 400 gpm. After a period of about 4 hours, in 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 wetwell level.

Based on NEI 13-02 generic analysis and Quad Cities Station specific parameters, the QCNPS SAWA flow could be reduced to 80 gpm after four hours of initial SAWA flow rate and containment would be protected. At some point, wetwell level will begin to rise indicating that the SAWA flow is greater than the steaming rate due to containment heat load such that flow can be reduced. While this is expected to be 4-6 hours, no time is specified in the procedures because the SAMGs are symptom-based guidelines.

Section IV.C.8: SAWA Flow Control

QCNPS will accomplish SAWA flow control using throttle valves connected to the Reactor Building H-Line wall penetrations to throttle flows and FLEX/SAWA Pump speed control. The operators at the pump and the flow meter cart will be in communication with the MCR via radios, and the exact time to throttle flow is not critical since there is a large margin between normal wetwell level and the level at which the wetwell vent will be submerged. The communications capabilities that will be used for communication between the MCR and the SAWA flow control location are the same as those evaluated and found acceptable for FLEX strategies. The communications capabilities have been tested to ensure functionality at the SAWA flow control and monitoring locations.

Section IV.C.9: SAWA/SAWM Element Assessment

Section IV.C.9.1: FLEX/SAWA Pump

QCNPS uses one of two portable diesel-driven pumps for FLEX and SAWA. The pumps can deliver the required SAWA/SAMG flow rates at the pressures required for RPV injection during an ELAP, as documented in Analysis QDC-0000-M-2097 (Reference 31). The pumps have been shown to be capable of the required flow rate to the RPV and the SFP for FLEX and for SAWA scenarios. The one required pump is stored in the FSB, where it is protected from all screened-in hazards and is in rugged, over-the-road, trailer-mounted units, and therefore will be available to function after a seismic event.

Section IV.C.9.2: SAWA Analysis of Flow Rates and Timing

The design flow rate of the QCNPS SAWA RPV supply is 400 gpm. This flow rate is equal to the Quad Cities Station RCIC design flow rate (Ref. UFSAR Section 5.4.6.1) as permitted by Section 4.1.1.2.2 of NEI 3-02. The initial SAWA flow will be injecting to the RPV within 8 hours of the loss of injection. For QCNPS Units 1 and 2, the reactor power level is 3016 MWt. The reference power level is 3514 MWt, equivalent to the reference plant rated thermal power level used in NUREG-1935, State of the Art Reactor Consequence Analysis (SOARCA). NUREG 1935 is Reference 9 of NEI 13-02 Revision 1.

Section IV.C.9.3: SAWA Pump Hydraulic Analysis

Calculation QDC-0000-M-2097 analyzed the FLEX/SAWA pumps and the lineup for RPV injection that would be used for SAWA. This calculation showed that the pumps have adequate capacity to meet the SAWA flow rate required to protect containment.

Section IV.C.9.4: SAWA Method of Backflow Prevention

The QCNPS SAWA flow path goes through existing check valves AO 1(2)-1001-68A (among other check valves) which provide a means of backflow prevention. Therefore, this order requirement is satisfied. These valves are tested as a part of the IST program in accordance with ASME OM requirements per Procedure QCTS 0820-13 (Ref. 56). Therefore, additional testing is not required in accordance with HCVS-FAQ-05 and NEI 13-02 Section 6.2.3.3. Thus, backflow is prevented by check valves in the SAWA flow path inside the Reactor Building.

Section IV.C.9.5: SAWA Water Source

The initial source of water for SAWA is the Discharge Bay. In the event of a Severe Accident on either Unit, the Discharge Bay will be available and used for SAWA/SAWM and FLEX actions. Manhole 1-13 located west of the Radwaste Building will be used as the water source for FLEX and SAWA/SAWM during Local Intense Precipitation (LIP) events if the Discharge Bay would be unavailable (due to high flood waters preventing pump deployment at this location). This long-term strategy of water supply was qualified for order EA-12-049 response and is available during a severe accident (See CC-QC-118 Attachment 5). Therefore, there will be sufficient water for injection to protect containment during the period of sustained operation.

Section IV.C.9.6: SAWA/SAWM Motive Force

Section IV.C.9.6.1: FLEX/SAWA Pump Power Source

The one required FLEX/SAWA pump is stored in the FSB where it is protected from all screened-in hazards. Other pumps are available on Site, as required by FLEX, but backup pumps are not required by the SAWA strategy. The FLEX/SAWA pumps are commercial portable pumps rated for long-term outdoor use in emergency scenarios. The pumps are diesel-driven by an engine mounted on trailer with the pump. The pumps will be refueled by the FLEX refueling equipment that has been qualified for long-term refueling operations per EA-12-049. The action to refuel the FLEX/SAWA pumps was evaluated under severe accident conditions in Table 2 and demonstrated to be acceptable. Since the one required pump is stored in a protected structure, is qualified for the environment in which it will be used, and will be refueled by a qualified refueling strategy, it will maintain the SAWA flow needed to protect primary containment as per EA-13-109.

Section IV.C.9.6.2: DG loading calculation for SAWA/SAWM equipment

Table 1 shows the electrical power source for the SAWA/SAWM instruments. The new flow meters are battery powered and do not require a power feed. Instrumentation to monitor suppression pool level and drywell pressure LI 1(2)-1640-10A(B) and PI 1(2)-1640-11A(B) will be credited for monitoring of the HCVS Phase 2 and are included in the analysis for FLEX DG loading, QDC-7300-E-2099 (Ref. 48).

The FLEX load on the FLEX DG per EA-12-049 was evaluated in calculation QDC-7300-E-2099. This calculation demonstrated that the total running load is 303.5 kVA with a lagging overall power factor of 0.727 (221 kW, 208 kVAR). The total kW and kVA loading is less than the machine rating of 500 kW and 625 KVA. Additionally, there is excess margin greater than 15%. The additional loads on the FLEX DG for SAWA/SAWM consist of MOVs that are required to be repositioned to open the RPV supply flow path. However, these electrical loads are already considered as part of the FLEX strategy and included in the analysis. The FLEX generator was qualified to carry the rest of the FLEX loads as part of Order EA-12-049 compliance.

Section IV.C.10: SAWA/SAWM Instrumentation

Section IV.C.10.1: SAWA/SAWM instruments

Table 1 contains a listing of all the instruments needed for SAWA and SAWM implementation. This table also contains the expected environmental parameters for each instrument, its qualifications, and its power supply for sustained operation.

Section IV.C.10.2: Describe SAWA Instruments and Guidance

The drywell pressure and wetwell level instruments, used to monitor the condition of containment, are pressure and differential pressure detectors that are safety-related and qualified for post-accident use. These instruments are referenced in Severe Accident Guidelines for control of SAWA flow to maintain the wetwell vent in service while maintaining containment protection. These instruments are on busses included in the FLEX generator loading calculations for EA-12-049 (Ref. 48). Note that other indications of these parameters may be available depending on the exact scenario.

The SAWA flow meters are digital flow meters mounted on the flow meter cart and are battery powered and do not require a power feed.

No containment temperature instrumentation is required for compliance with HCVS Phase 2. However, most 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. SAMG strategies will evaluate and use drywell temperature indication if available consistent with the symptom-based approach. NEI 13-02 Revision 1 Section C.8.3 discusses installed drywell temperature indication.

Section IV.C.10.3: Qualification of SAWA/SAWM instruments

The drywell pressure and wetwell level instruments are pressure and differential pressure detectors that are safety-related and qualified for post-accident use. These instruments are qualified per RG-1.97 Revision 2 (UFSAR Section 7.5) as post-accident instruments and are therefore qualified for EA-13-109 events.

The SAWA flow meters are rated for continuous use under the expected ambient conditions, so they will be available for the entire period of sustained operation. Furthermore, since the meters are deployed inside the Turbine Building, there is no concern for any effects of radiation exposure to the flow instruments as evaluated in EC 618753 (Ref. 38).

Section IV.C.10.4: Instrument Power Supply through Sustained Operation

QCNPS FLEX strategies will restore the containment instruments (containment pressure and wetwell level) necessary to successfully implement SAWA. The strategy will be to use the FLEX DG to re-power the safety related 480 VAC busses to restore the battery chargers, MOVs, and the instrument buss. Since the FLEX generators are refueled per FLEX strategies for a sustained period of operation, the instruments will be powered for the sustained operating period.

Section IV.C.11: SAWA/SAWM Severe Accident Considerations

Section IV.C.11.1: Severe Accident Effect on SAWA Pump and Flowpath

Since the FLEX/SAWA Pump is stored in the FSB and will be operated from outside the Reactor Building either at the Discharge Bay or east of Manhole 1-13 such that the Off-Gas Building provides shielding from the HCVS vent pipe, there will be no issues with radiation dose rates at the FLEX/SAWA Pump control location and there will be no significant dose to the FLEX/SAWA Pump, as evaluated in EC 618753 (Ref. 38).

Inside the Reactor Building, the SAWA flow path consists of piping that will be unaffected by the radiation dose and hoses that have been evaluated for the integrated dose effects over the period of Sustained Operation. The hoses and Reactor Building routing utilized at QCNPS meet the HCVS-OGP-009 generic criteria for qualification for radiological conditions. Analysis QDC-0000-M-2223 (Ref. 58) provides peak dose rates for the Reactor Building ground floor, which are significantly below the order of magnitude included in the HCVS-OGP-009 criteria. These hoses are qualified for the temperatures expected in the areas in which they will be run, per EC 618753. Therefore, the SAWA flow path will not be affected by radiation or temperature effects due to a severe accident.

Section IV.C.11.2: Severe Accident Effect on SAWA/SAWM instruments

The SAWA/SAWM instruments are described in section IV.C.10.3, that section provides severe accident effects.

Section IV.C.11.3: Severe Accident Effect on personnel actions

Section IV.C.2 describes the Reactor Building actions within the first 7 hours. The actions including access routes outside the Reactor Building that will be performed after the first use of the vent during severe accident conditions (assumed to be 7 hours per HCVS-FAQ-12) 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. These routes and areas were evaluated in Analysis QDC-0000-M-2223, as outlined in EC 618753.

As part of the response to Order EA-12-049, QCNPS performed GOTHIC calculations of the temperature response of the Reactor during the ELAP event. Since the core materials are contained inside the primary containment during a severe accident, the temperature response of the Reactor Building and Turbine Building is driven by the loss of ventilation and ambient conditions and therefore will not change. Thus, the FLEX GOTHIC calculations are acceptable for severe accident use. In addition, all operator actions in the Reactor Building are completed within 1 hour such that there will be no excessive radiation levels or heat related concerns in the Reactor Building and no evaluation of Reactor Building radiological habitability is necessary per HCVS-FAQ-12.

Table 2 provides a list of SAWA/SAWM operator actions as well as an evaluation of each for suitability during a severe accident. Attachment 6 shows the approximate locations of the actions.

After the SAWA hoses and valves are aligned inside the RB, the operators can control SAWA/SAWM as well as observe the necessary instruments from outside the RB. The thick concrete RB walls (below EL. 690' level) as well as the distance to the core materials mean that there is no radiological concern with any actions outside the RB. Therefore, all SAWA controls and indications are accessible during severe accident conditions as evaluated in Analysis QDC-0000-M-2223 (Ref. 58) and outlined in EC 618753 (Ref. 38).

The FLEX/SAWA pump and monitoring equipment are operated from outside the TB at ground level. The QCNPS FLEX response ensures that the FLEX/SAWA pump, FLEX DGs, and other equipment can all be run for a sustained period by refueling. All the refueling locations are in shielded or protected areas so that there is no radiation hazard from core material during a severe accident. The monitoring instrumentation includes the SAWA flow meter cart in the Turbine Building, and Wetwell level and containment pressure in the MCR.

<u>Section V</u>: HCVS Programmatic Requirements

<u>Section V.A</u>: HCVS Procedure Requirements

The following italicized sections are from EA-13-109, Attachment 2, Section 3.

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

<u>Evaluation:</u>

Procedures have been established for system operations when normal and backup power is available and during ELAP conditions. The implementing design change documents contain instructions for modifying the HCVS-specific procedures.

The HCVS and SAWA procedures have been developed and implemented following the Quad Cities Station process for initiating and/or revising procedures and contain the following details:

- appropriate conditions and criteria for use of the system,
- when and how to place the system in operation,
- the location of system components,
- instrumentation available,
- normal and backup power supplies,
- directions for sustained operation, including the storage location of portable equipment,
- training on operating the portable equipment, and
- testing portable equipment

Since Quad Cities Station relies on Containment Accident Pressure (CAP) to achieve net positive suction head (NPSH) for the Emergency Core Cooling System (ECCS) pumps, the procedures include precautions that use of the vent may impact NPSH (CAP) available to the ECCS pumps.

Quad Cities Station has implemented the BWROG Emergency Procedures Committee Issue 1314 that implements the Severe Accident Water Management (SAWM) strategy in the Severe Accident Management Guidelines (SAMGs). The following general cautions, priorities, and methods have been evaluated for plant specific applicability and incorporated as appropriate into the plant specific SAMGs using administrative procedures for EPG/SAG change control process and implementation. SAMGs are symptom-based guidelines and therefore address a wide variety of possible plant conditions and capabilities. While these changes are intended to accommodate those specific conditions assumed in Order EA-13-109, the changes were made in a way that maintains the use of SAMGs in a symptom-based mode while at the same time addressing those conditions that may exist under extended loss of AC power (ELAP) conditions with significant core damage including ex-vessel core debris.

Actual language that is incorporated into site SAMGs. Enclosed within the Technical Support Guidelines (TSG) Reference Manual, Rev. 6, for SAMG-1 Block #1, with the following statements:

- Water addition from external sources will tend to increase Torus level. Torus level must be maintained below 30 ft. to avoid submerging the Torus vent penetration.
- An initial injection rate of 400 gpm should be sufficient to stabilize core debris. Once core debris has been stabilized, the injection rate may be reduced to 80 gpm for prolonged heat removal and primary containment protection.

- Water addition from external sources more than the required rate will only reduce the time available to line up a reliable containment heat removal method before Torus level reaches the Torus vent penetration, with no likely benefit.

Cautions

- Adding water to hot core debris may pressurize the primary containment by rapid steam generation.
- Raising torus level above 30 ft. will result in loss of the torus vent path.

Priorities – With significant core damage and RPV breach, SAMGs prioritize the preservation of primary containment integrity while limiting radioactivity releases as follows:

- Stabilize core debris in the primary containment (by water addition).
- Operate drywell sprays (control drywell temperature, pressure, and radiation).

After Core Debris is stabilized:

- Cool debris in the primary containment (80 gpm should be sufficient to remove decay heat from core debris while preserving the torus vent path).
- Preserve torus vent capability (maintain injection from outside the primary containment as low as possible to avoid flooding the torus vent penetration).
- Operate Core Spray (cool any debris remaining in the PPV).
- Operate drywell Sprays (control drywell temperature, pressure, and radiation).

Methods – Identify systems and capabilities to add water to the RPV or drywell, with the following generic guidance:

- Use any available injection sources
  - o Inject into the RPV is possible
  - o Operate Core Spray if available
  - o Maintain injection from outside the primary containment as low as possible
- Increase injection slowly
- Verify Severe Accident Water Addition capability

Section V.B: HCVS Out-of-Service Requirements

Provisions for out-of-service requirements of the HCVS and compensatory measures have been included in procedure QCAP 1500-07 (Reference 54), Administrative Tracking Requirements for Unavailable FLEX, HCVS and SAWA Equipment.

NOTE: Out-of-service times and required actions noted below are for HCVS and SAWA functions. Equipment that also supports a FLEX function that is found to be non-functional must also be addressed using the out-of-service times and actions in accordance with the FLEX program.

The italicized portions below are drawn from the QCNPS Units 1 and 2 Overall Integrated Plan for Reliable Hardened Vents (RS-15-304) and based on the NEI 13-02 template.

The provisions for out-of-service requirements for HCVS/SAWA are applicable in Modes 1, 2, and 3:

- *If for up to 90 consecutive days, the primary or alternate means of HCVS/SAWA operation are non-functional, no compensatory actions are necessary.*
- *If up for to 30 days, the primary and alternate means of HCVS/SAWA operation or SAWA are non-functional, no compensatory actions are necessary.*
- *If the out-of-service times exceed 30 or 90 days as described above, the following actions will be performed through the corrective action program:*
    - *Determine the cause(s) of the non-functionality,*
    - *Establish the actions to be taken and the schedule for restoring the system to functional status and to prevent recurrence,*
    - *Initiate action to implement appropriate compensatory actions, and*
    - *Restore full HCVS functionality at the earliest opportunity not to exceed one full operating cycle.*

The HCVS system is functional when piping, valves, instrumentation, and controls, including motive force necessary to support system operation are available. Since the system is designed to allow primary control and monitoring or alternate valve control by Order criteria 1.2.4 or 1.2.5, allowing for a longer out-of-service time with either of the functional capabilities maintained is justified. A shorter length of time when both primary control and monitoring and alternate valve control are unavailable is needed to restore system functionality in a timely manner while at the same time allowing for component repair or replacement in a time frame consistent with most high priority maintenance scheduling and repair programs, not to exceed 30 days unless compensatory actions are established per NEI 13-02 Section 6.3.1.3.3.

SAWA is functional when piping, valves, motive force, instrumentation, and controls necessary to support system operation are functional.

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

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

<u>Section V.C</u>: HCVS Training Requirements

The following italicized section is from EA-13-109, Attachment 2:

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

<u>Evaluation:</u>

Personnel expected to perform direct execution of the HCVS have received necessary training in the use of plant procedures for system operations when normal and backup power is available and during ELAP conditions. The training will be refreshed on a periodic basis and as any changes occur to the HCVS. The personnel trained and the frequency of training was determined using a systematic analysis of the tasks to be performed using the Systems Approach to Training process.

In addition, per NEI 12-06, any non-trained personnel onsite will be available to supplement trained personnel.

Section V.D: Demonstration with other Post Fukushima Measures

Quad Cities Station will demonstrate use of the HCVS and SAWA systems in drills, tabletops or exercises as follows:

1. Hardened containment vent operation on normal power sources (no ELAP).
2. During FLEX demonstrations (as required by EA-12-049: Hardened containment vent operation on backup power and from primary or alternate locations during conditions of ELAP/loss of UHS with no core damage.) System use is for containment heat removal AND containment pressure control.
3. HCVS operation on backup power and from primary or alternate location during conditions of ELAP/loss of UHS with core damage. System use is for containment heat removal AND containment pressure control with potential for combustible gases.

Evaluation:

NOTE: Items 1 and 2 above are not applicable to SAWA.

The use of the HCVS and SAWA capabilities will be demonstrated during drills, tabletops or exercises consistent with NEI 13-06 and on a frequency consistent with 10 CFR 50.155(e)(4). Quad Cities Station will perform the first drill demonstrating at least one of the above capabilities by June 2022, which is within four years of the first unit compliance with Phase 2 of Order EA-13-109, or consistent with the next FLEX strategy drill or exercise. Subsequent drills, tabletops or exercises will be performed to demonstrate the capabilities of different elements of Items 1, 2 and/or 3 above that are applicable to Quad Cities Station in subsequent eight-year intervals. These requirements are captured in CC-AA-118.

Section VI: References

Number	Rev	Title	Location[6]
1. GL-89-16	0	Installation of a Hardened Wetwell Vent (Generic Letter 89-16), dated September 1, 1989	ML031140220
2. SECY-12-0157	0	Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments	ML12345A030
3. SRM-SECY-12-0157	0	Staff Requirements – SECY-12-0157 – Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments	ML13078A017
4. EA-12-050	0	Order to Modify Licenses with Regard to Reliable Hardened Containment Vents	ML12054A694
5. EA-13-109	0	Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions	ML13143A321
6. NEI 13-02	0	Industry Guidance for Compliance with Order EA-13-109, BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions	ML13316A853
7. NEI 13-02[7]	1	Industry Guidance for Compliance with Order EA-13-109, BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions	ML15113B318
8. HCVS-WP-01	0	Hardened Containment Vent System Dedicated and Permanently Installed Motive Force, Revision 0, April 14, 2014	ML14120A295 ML14126A374
9. HCVS-WP-02	0	Sequences for HCVS Design and Method for Determining Radiological Dose from HCVS Piping, Revision 0, October 23, 2014	ML14358A038 ML14358A040
10. HCVS-WP-03	1	Hydrogen/Carbon Monoxide Control Measures Revision 1, October 2014	ML14302A066 ML15040A038
11. HCVS-WP-04	0	Missile Evaluation for HCVS Components 30 Feet Above Grade	ML15244A923 ML15240A072
12. JLD-ISG-2013-02	0	Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions	ML13304B836
13. JLD-ISG-2015-01	0	Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions	ML15104A118
14. HCVS-FAQ-10	1	Severe Accident Multiple Unit Response	ML15273A141 ML15271A148

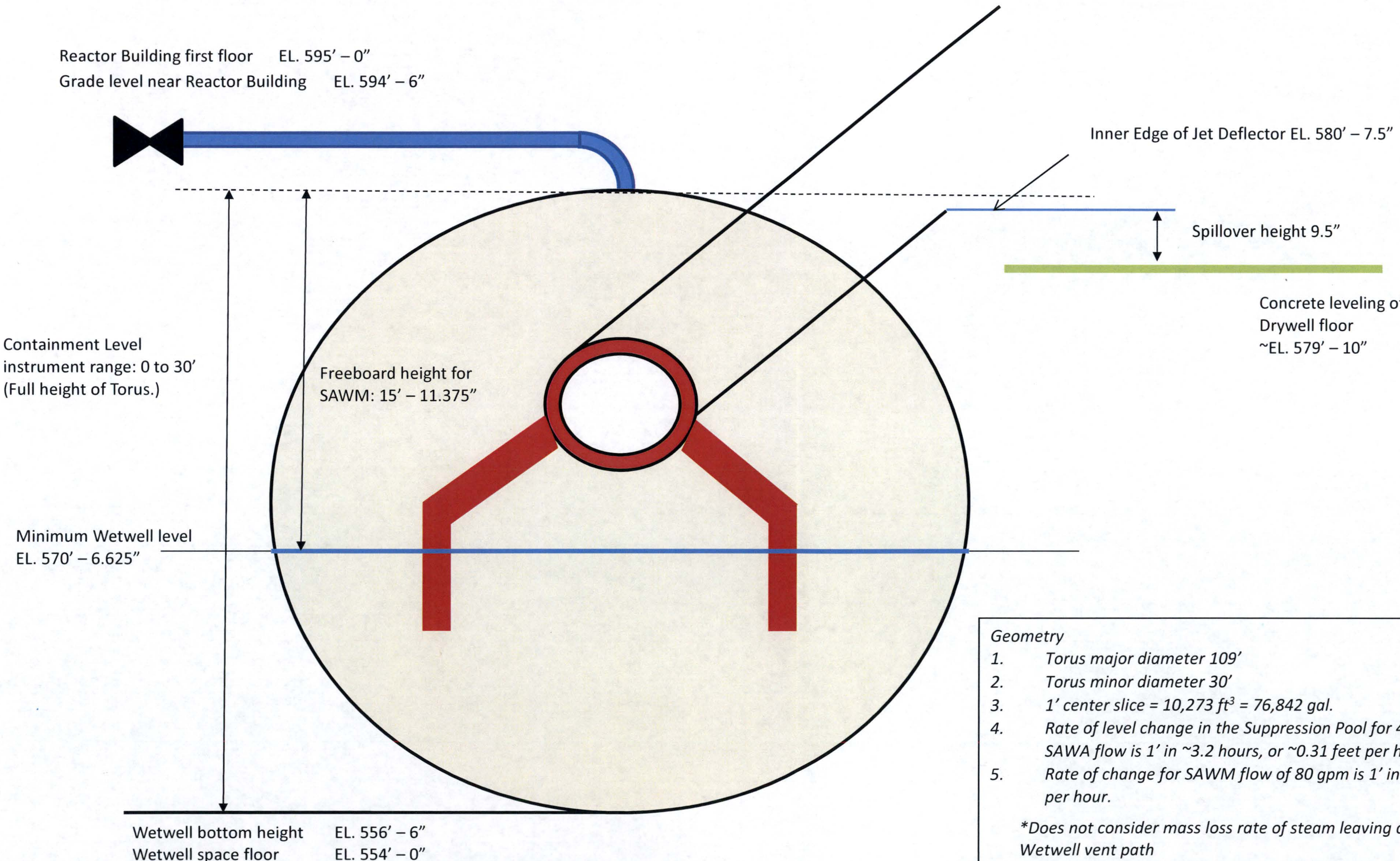
[6] Where two ADAMS accession numbers are listed, the first is the reference document and the second is the NRC endorsement of that document.
[7] NEI 13-02 Revision 1 Appendix J contains HCVS-FAQ-01 through HCVS-FAQ-09.

Number	Rev	Title	Location[6]
15. HCVS-FAQ-11	0	Plant Response During a Severe Accident	ML15273A141 ML15271A148
16. HCVS-FAQ-12	0	Radiological Evaluations on Plant Actions Prior to HCVS Initial Use	ML15273A141 ML15271A148
17. HCVS-FAQ-13	0	Severe Accident Venting Actions Validation	ML15273A141 ML15271A148
18. RS-14-063	0	HCVS Phase 1 Overall Integrated Plan (OIP)	
19. Phase 1 ISE	0	HCVS Phase 1 Interim Staff Evaluation (ISE)	ML15089A421
20. Phase 2 ISE	0	HCVS Phase 2 Interim Staff Evaluation (ISE)	ML17109A077
21. RS-14-306	0	First Six Month Update	
22. RS-15-152	0	Second Six Month Update	
23. RS-15-304	0	Combined HCVS Phase 1 and 2 Overall Integrated Plan (OIP)	
24. RS-16-110	0	Fourth Six Month Update	
25. RS-17-008	0	Fifth Six Month Update	
26. RS-17-069	0	Sixth Six Month Update	
27. RS-17-156	0	Seventh Six Month Update	
28. NEI 12-06	2	Diverse and Flexible Coping Strategies (FLEX) Implementation Guide	
29. EA-12-049	0	Issuance of Order to Modify Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, dated March 12, 2012.	ML12054A735
30. RG 1.97	2	Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Conditions During and Following an Accident	
31. QDC-0000-M-2097	1	PIPE FLO Analysis of FLEX and HCVS Phase II SAWA/SAWM Strategy	
32. QCOP 1600-13	31	Post-Accident Venting of the Primary Containment (H.7.b)	
33. QDC-1600-M-2190	0B	Hardened Containment Vent Purge System Design Calculation	
34. QOA 5750-15	13	Complete Loss of Control Room HVAC	
35. EC 392256	3	Unit 1Hardened Containment Vent System (Non-Outage Portion) as Required by NRC Order EA-13-109	
36. EC 392257	3	Unit 1 Hardened Containment Vent System (Outage Portion) as Required by NRC Order EA-13-109	
37. EC 400666	2	Hardened Containment Vent System as Required by NRC Order EA-13-109 – Unit 2	

Number	Rev	Title	Location[6]
38. EC 618753	1	Hardened Containment Vent System Phase II as Required by NRC Order EA-13-109 - Units 1 & 2	
39. QDC-0000-M-2199	0B	HCVS 7-Day Dose Analysis	
40. RS-13-025	0	Quad Cites Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)	
41. QGA 200	12	Primary Containment Control	
42. QDC-1600-M-2188	0	HCVS Vent Line Sizing Calculation	
43. QDC-1600-M-2247	0	UNIT 2 HCVS Vent Line Sizing Calculation	
44. QC-MISC-018	0	MAAP Analysis to Support HCVS Increased Design Margin	
45. M-991A-1 Sh. 3	A	Isometric of Hardened Containment Ventilation Piping (Unit 1)	
46. M-1023A-1 Sh. 4	A	Isometric of Hardened Containment Ventilation Piping (Unit 2)	
47. QDC-1600-E-2200	1	125 VDC Battery Sizing Calculation for Hardened Containment Vent System for 24-Hour Duty Cycle	
48. QDC-7300-E-2099	1	UNIT 1(2) 480 VAC FLEX Diesel Generator and Cable Sizing for Beyond Design Basis FLEX Event	
49. QDC-1600-M-2212	0A	HCVS Nitrogen Bottle Sizing and Pressure Regulator Set Point Determination (Unit 1)	
50. QDC-1600-M-2249	0	HCVS Nitrogen Bottle Sizing and Pressure Regulator Set Point Determination (Unit 2)	
51. QCTS 0600-48	21	Drywell Torus Purge Exhaust Local Leak Rate Test	
52. EC 622071	2	Seismic Interaction of Equipment Installed in Turbine Building for Hardened Containment Vent System	
53. QCOP 0050-05	3	FLEX-SAWA Fire Hose Deployment	
54. QCOP 0050-07	3	FLEX Generator and Pump Power Cable Deployment	
55. QCOA 6100-04	24	Station Blackout	
56. QCTS 0820-13	20	Seat Leakage Test for RHR Injection Pressure Isolation Valves CV 1(2)-1001-68A(B), MO 1(2)-1001-29 A(B)	
57. CC-QC-118	5	Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program	

Number	Rev	Title	Location[6]
58. QDC-0000-M-2223	0A	HCVS Phase II 7-Day Dose Analysis	
59. HCVS-FAQ-01	1	HCVS Primary and Alternate Controls	
60. HCVS-FAQ-04	0	Release Point	
61. HCVS-FAQ-05	1	HCVS Control and Boundary Valves	
62. HCVS-FAQ-06	1	HCVS FLEX and HCVS Assumptions	
63. HCVS-FAQ-08	0	HCVS Instrument Qualification	
64. CC-AA-118	3	Diverse and Flexible Coping Strategies (FLEX), Spent Fuel Pool Instrumentation (SFPI), And Hardened Containment Vent System (HCVS) Program Document	
65. HCVS-OGP-009	0	HCVS Hose Radiological Evaluation	
66. 2014-02948	0	Reactor Building Temperature Analysis Resulting from Extended Loss of AC Power	
67. TRM	6	Technical Support Guidelines (TSG) Reference Manual	
68. EC 624618	0	Integrated Review of HCVS Actions	
69. EC 404409	0	Integrated Review of FLEX Actions	
70. RS-18-087	0	Report of Full Compliance with March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)	
71. RS-18-089	0	Report of Full Compliance with Phase 1 and Phase 2 of 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)	

<u>Attachment 1</u>: Phase 2 Freeboard Diagram

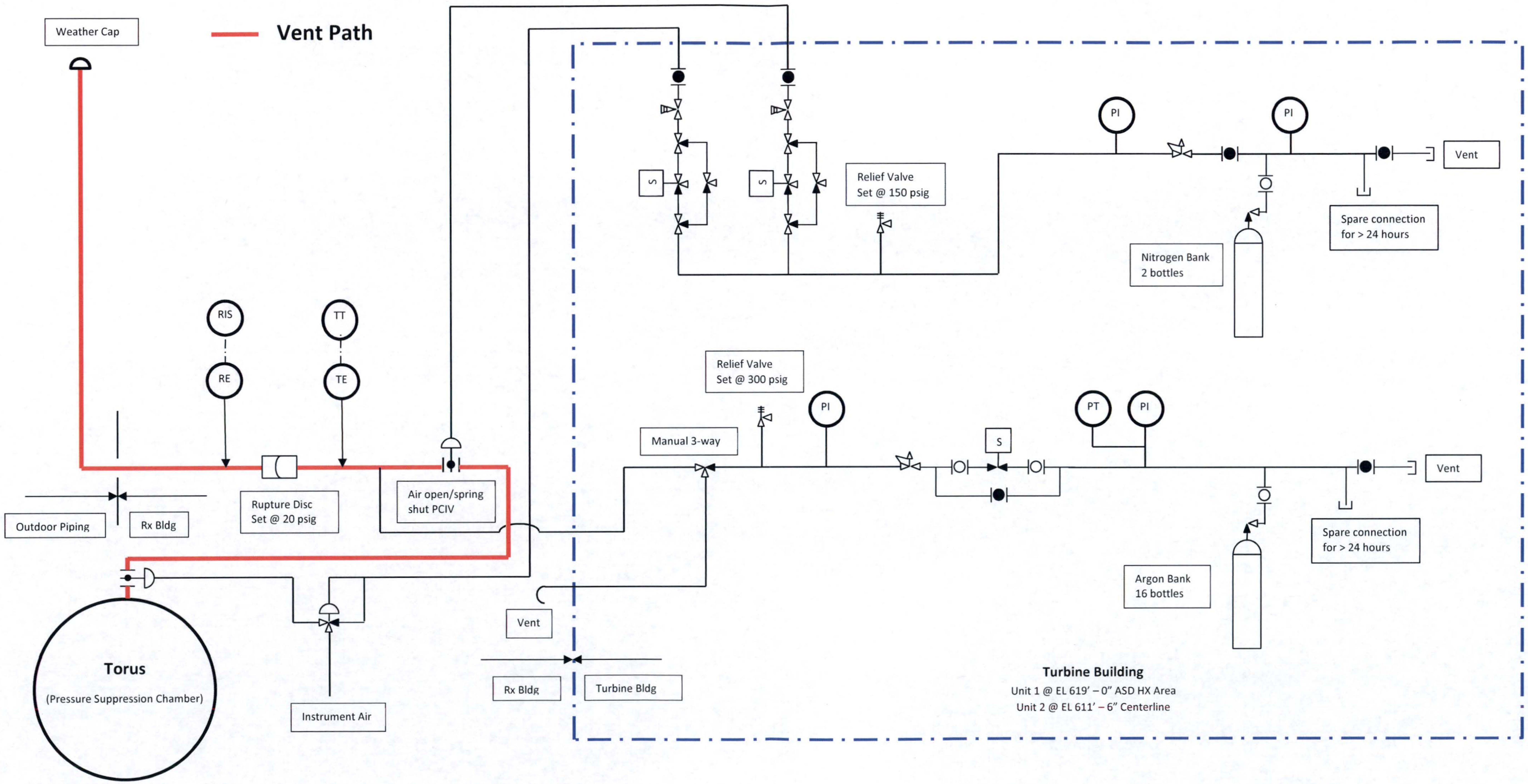


Geometry

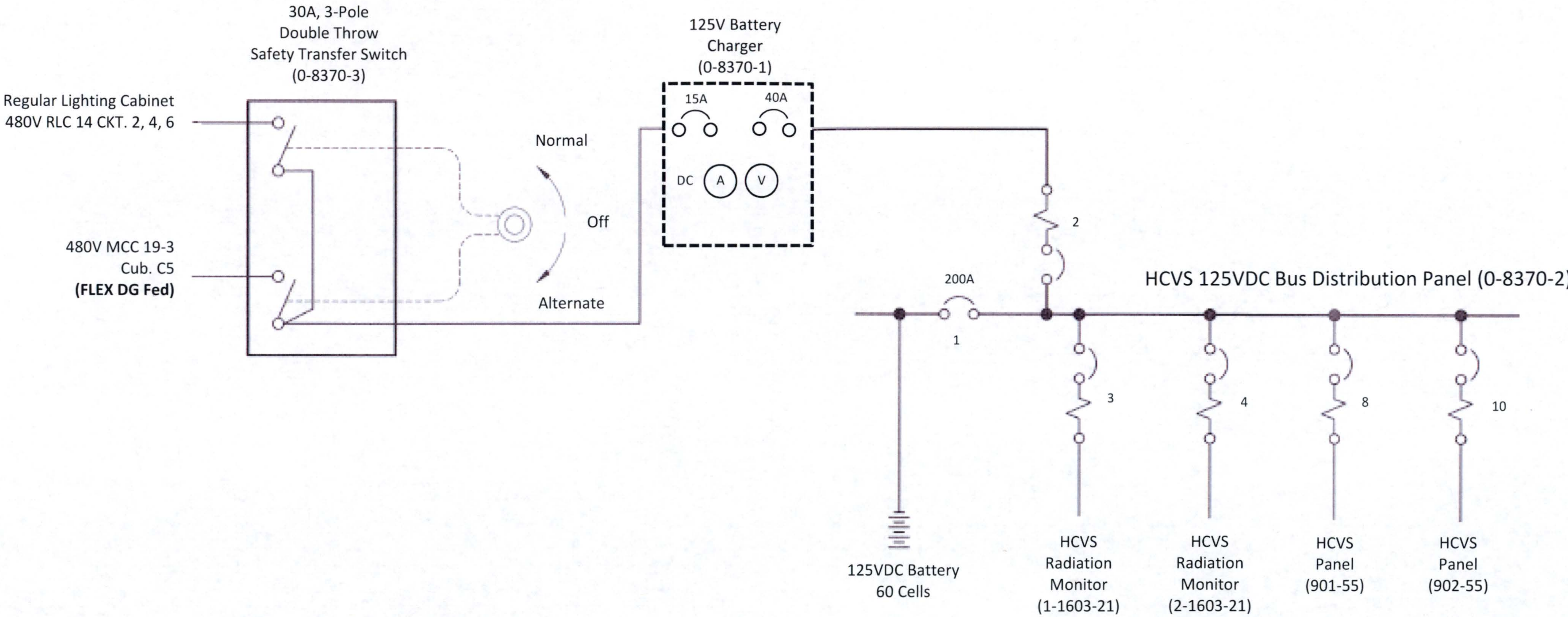
1. *Torus major diameter 109'*
2. *Torus minor diameter 30'*
3. *1' center slice = 10,273 ft^3 = 76,842 gal.*
4. *Rate of level change in the Suppression Pool for 400 gpm = 24,000 gph SAWA flow is 1' in ~3.2 hours, or ~0.31 feet per hour.*
5. *Rate of change for SAWM flow of 80 gpm is 1' in 16 hours, or 0.75* ***<u>inches</u>*** *per hour.*

**Does not consider mass loss rate of steam leaving containment through Wetwell vent path*

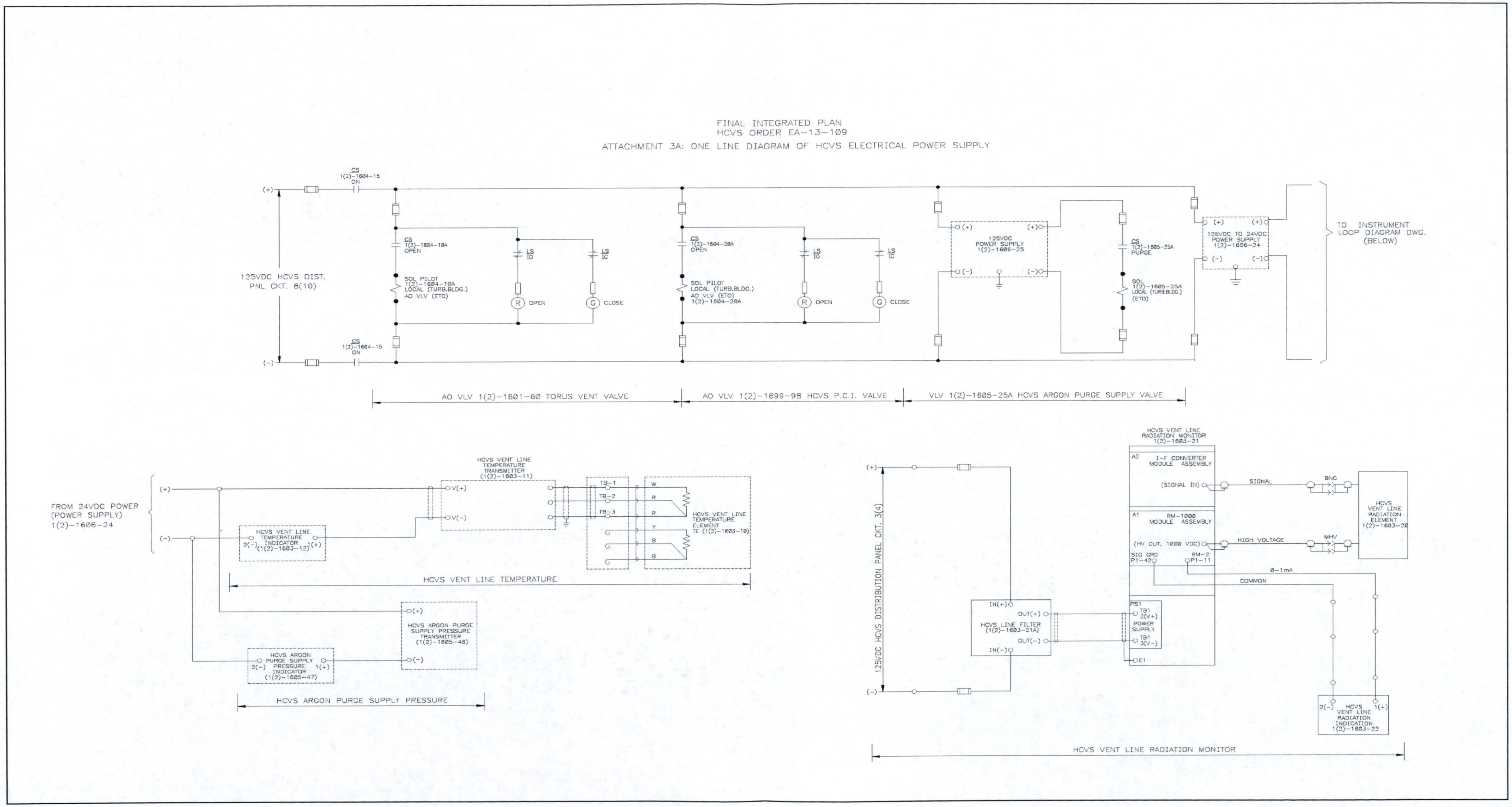
Attachment 2: One Line Diagram of HCVS Vent Path



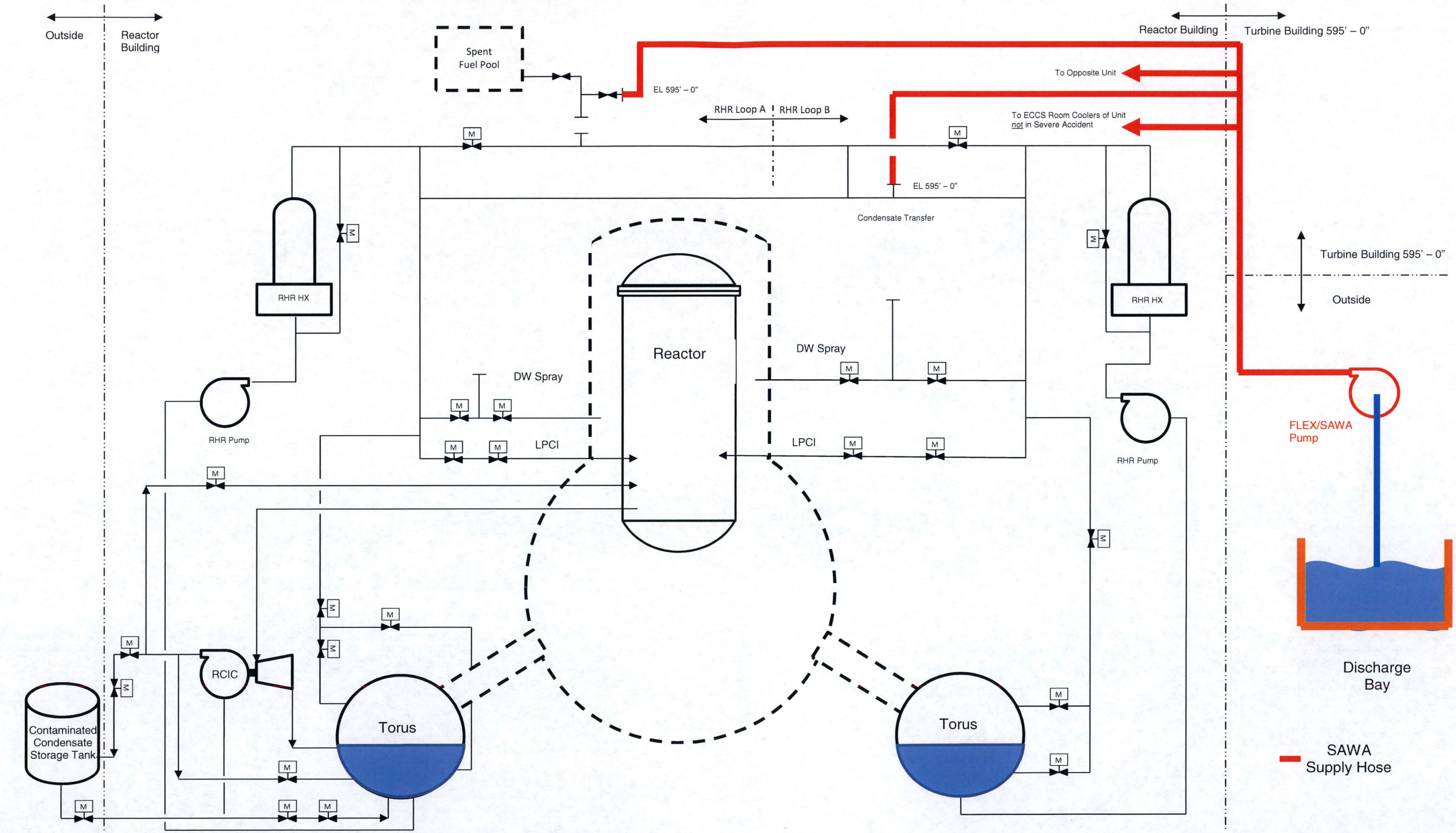
Attachment 3: One Line Diagram of HCVS Electrical Power Supply (Part 1 of 2)



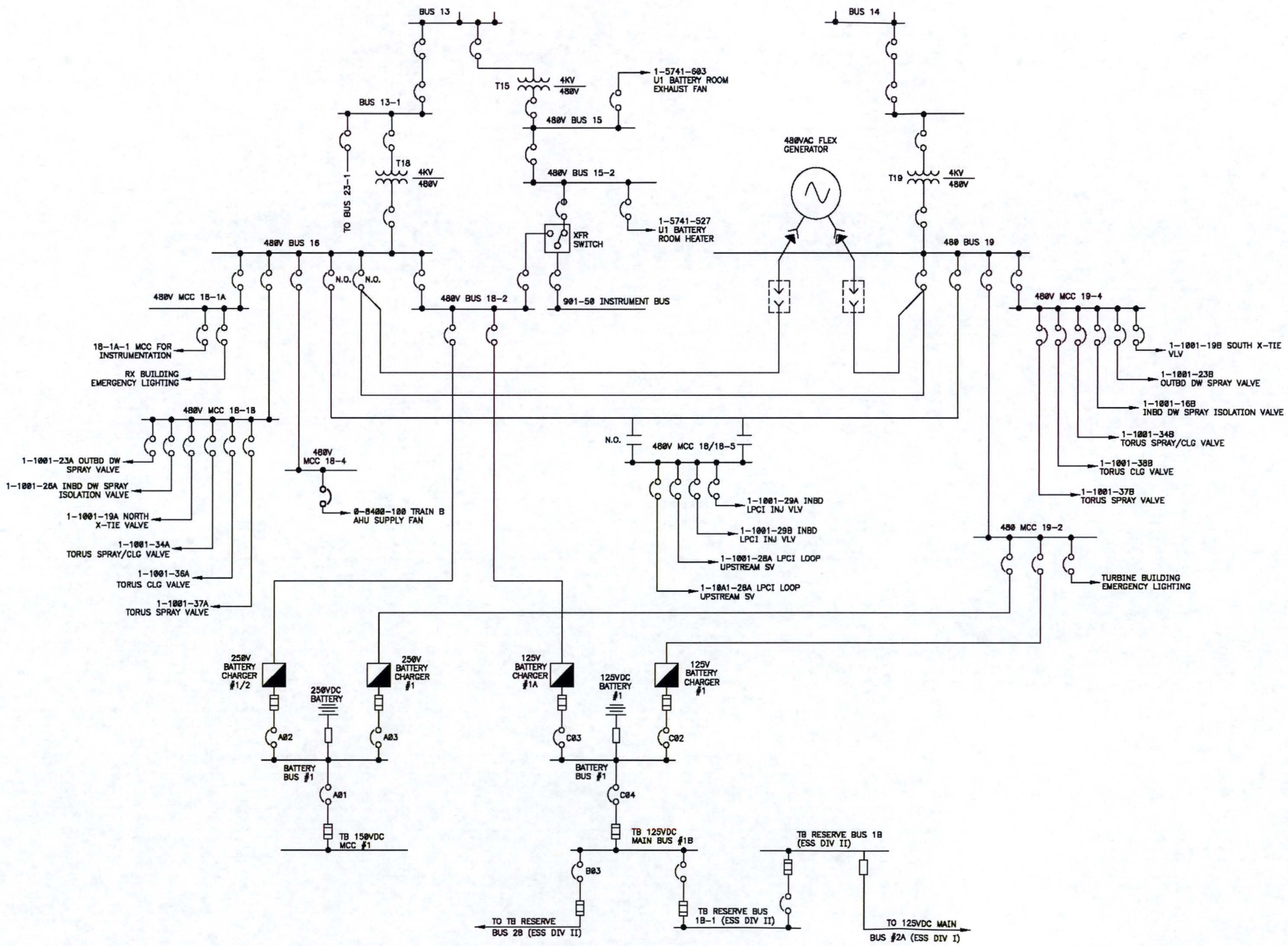
Attachment 3a: One Line Diagram of HCVS Electrical Power Supply (Part 2 of 2)



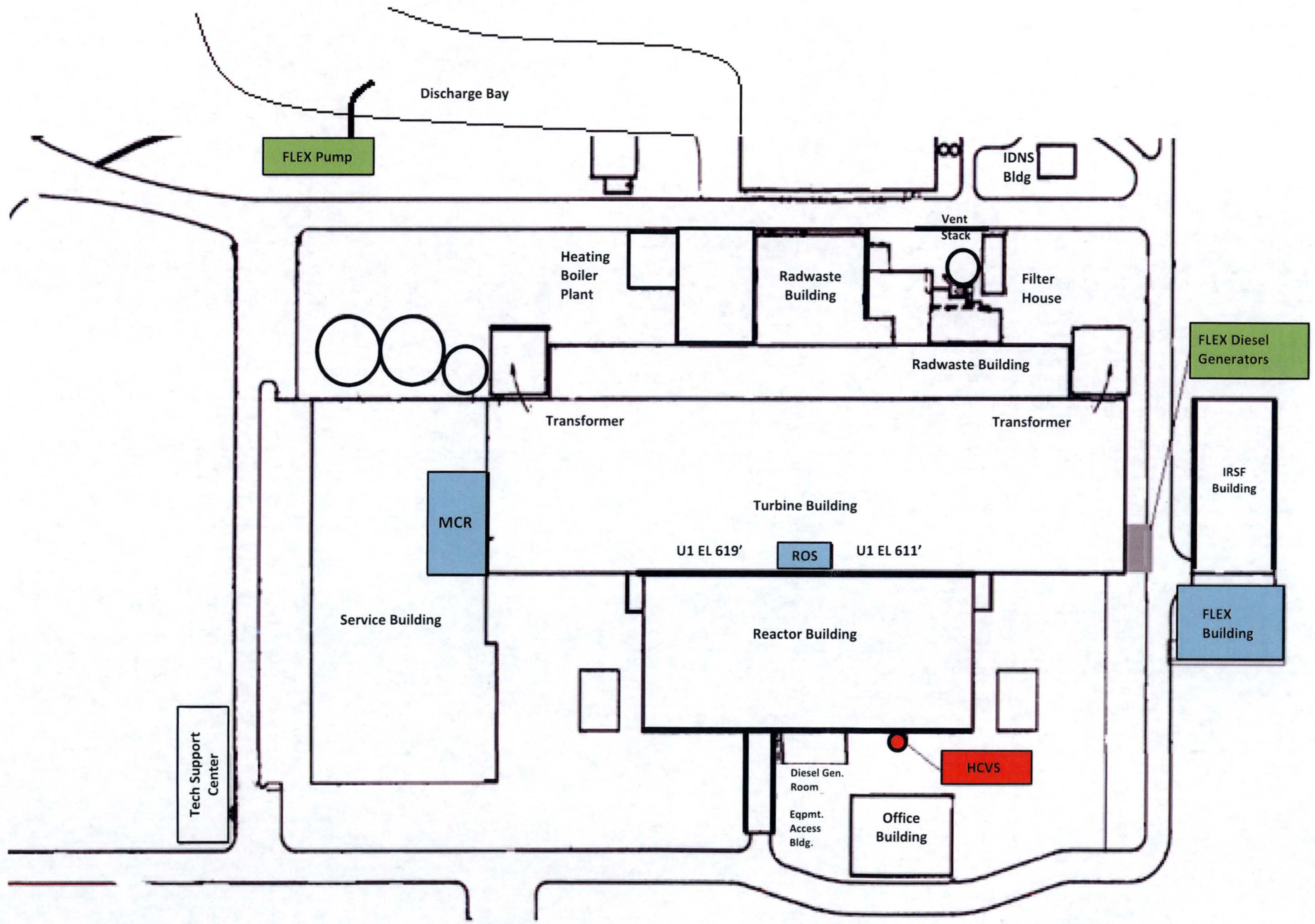
Attachment 4: One Line Diagram of SAWA Flow Path



<u>Attachment 5</u>: One Line Diagram of SAWA Electrical Power Supply



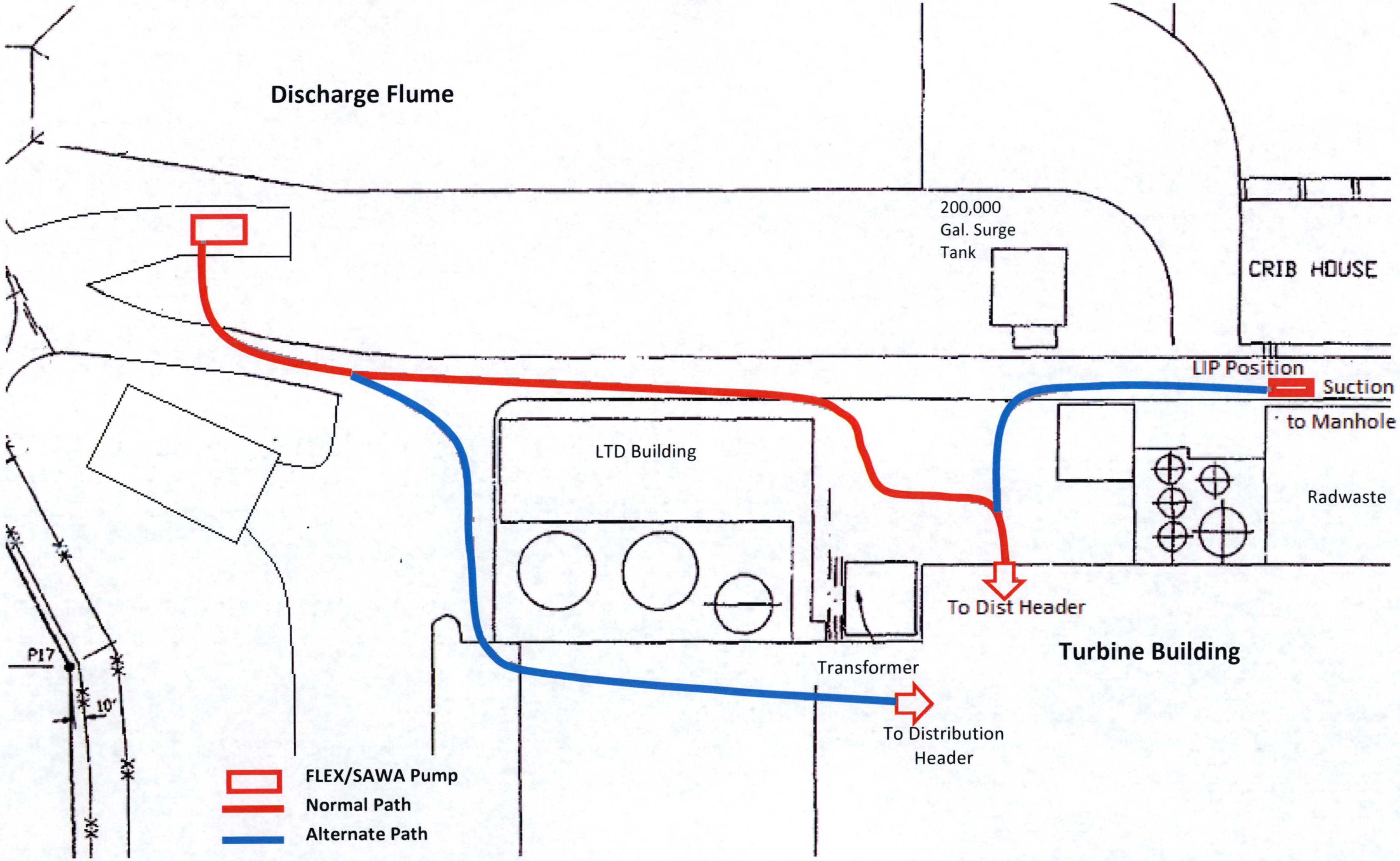
Attachment 6: Plant Layout Showing Operator Action Locations



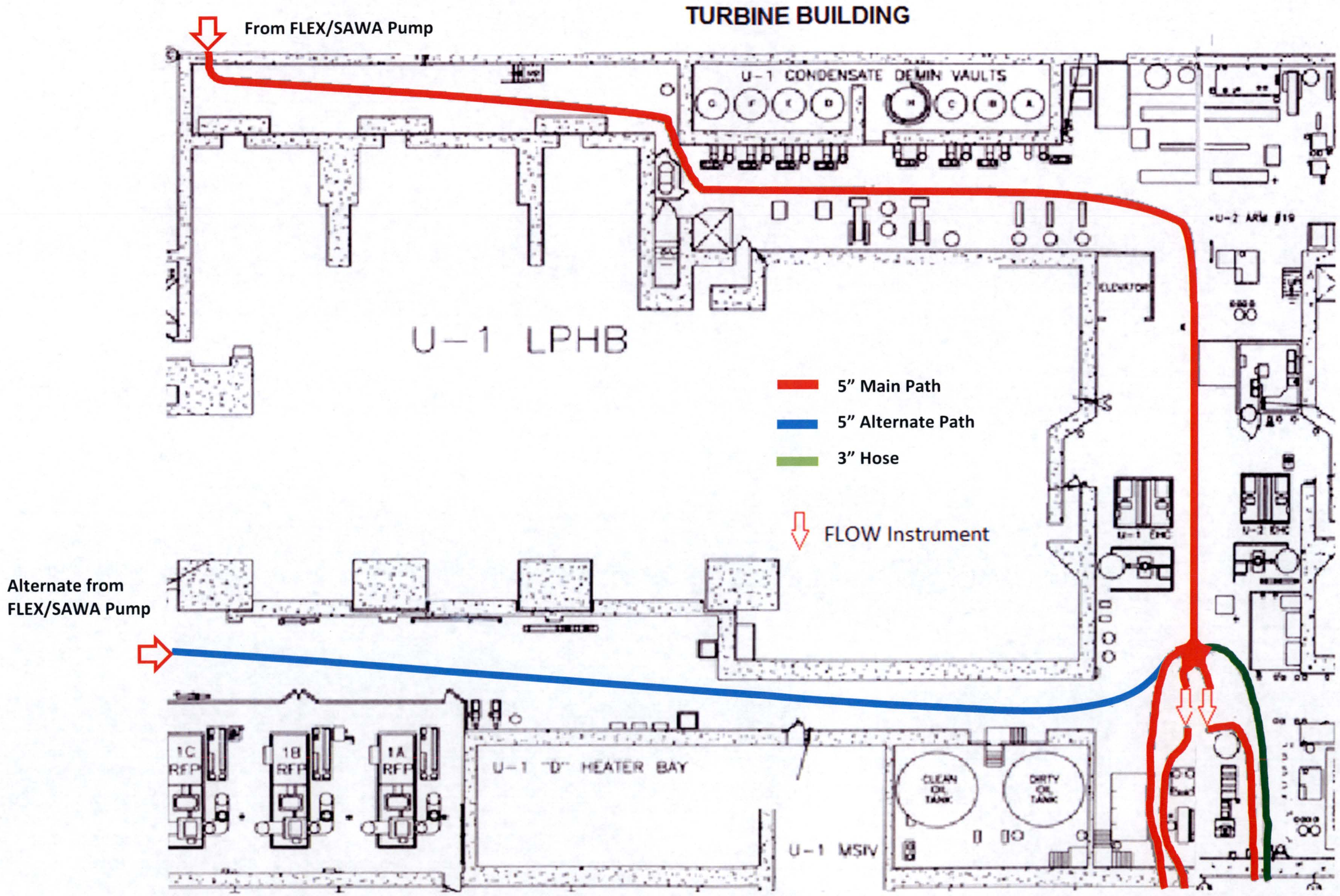
MCR – Command and Control, HCVS primary valve and purge control
ROS – HCVS alternate valve and purge control, Initial HCVS lineup, HCVS Battery

Attachment 6a: SAWA Hose Deployment – External

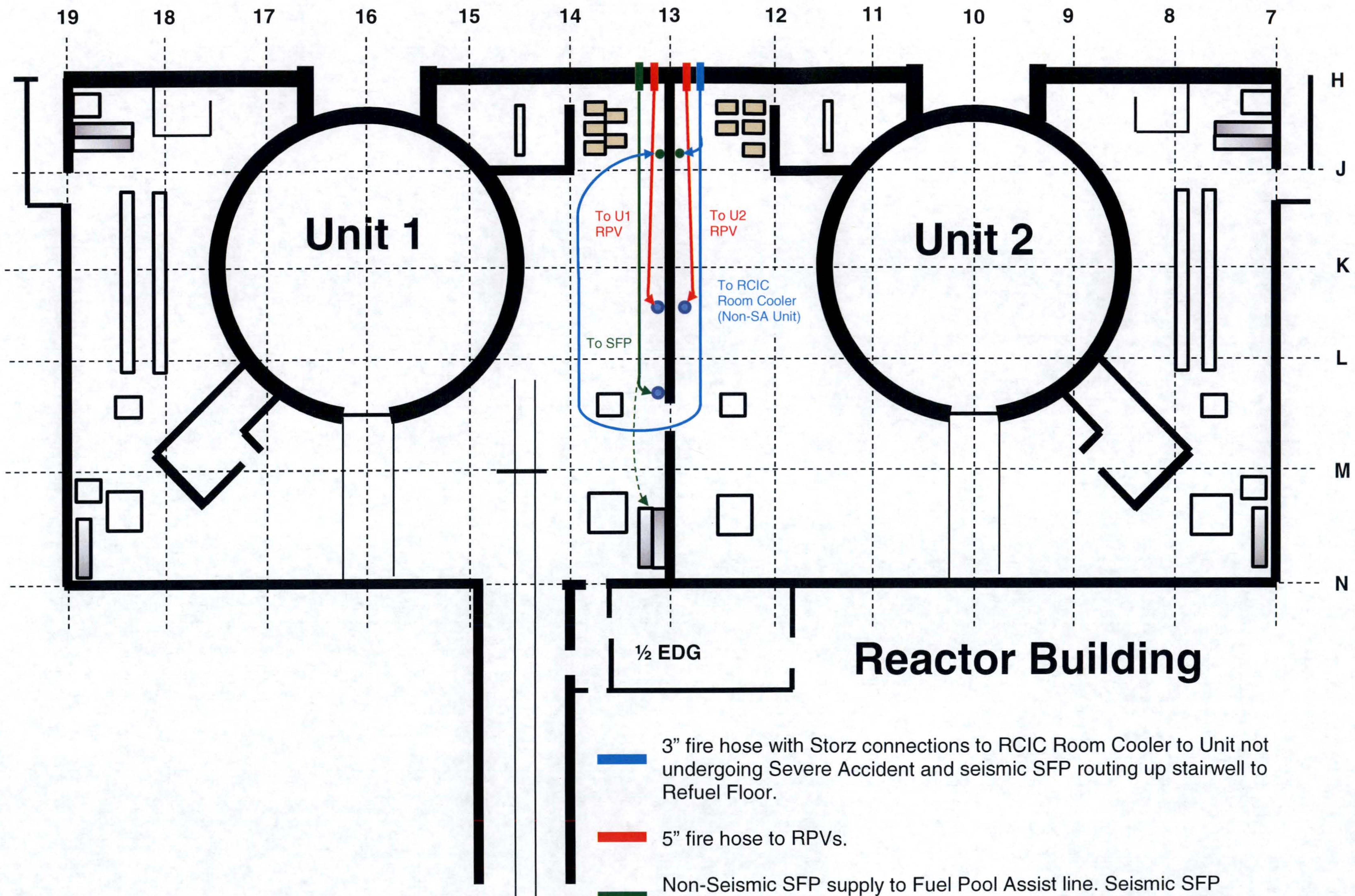
SAWA EXTERNAL EQUIPMENT DEPLOYMENT



Attachment 6b: SAWA Hose Deployment – Turbine Building



Attachment 6c: SAWA Hose Deployment – Reactor Building



3" fire hose with Storz connections to RCIC Room Cooler to Unit not undergoing Severe Accident and seismic SFP routing up stairwell to Refuel Floor.

5" fire hose to RPVs.

Non-Seismic SFP supply to Fuel Pool Assist line. Seismic SFP supply up the stairwell may be 5" or dual 3". The line must split to dual 3" to supply two spray monitors on the Fuel Floor.

Attachment 6d: Turbine Building 480 VAC Cable Deployment

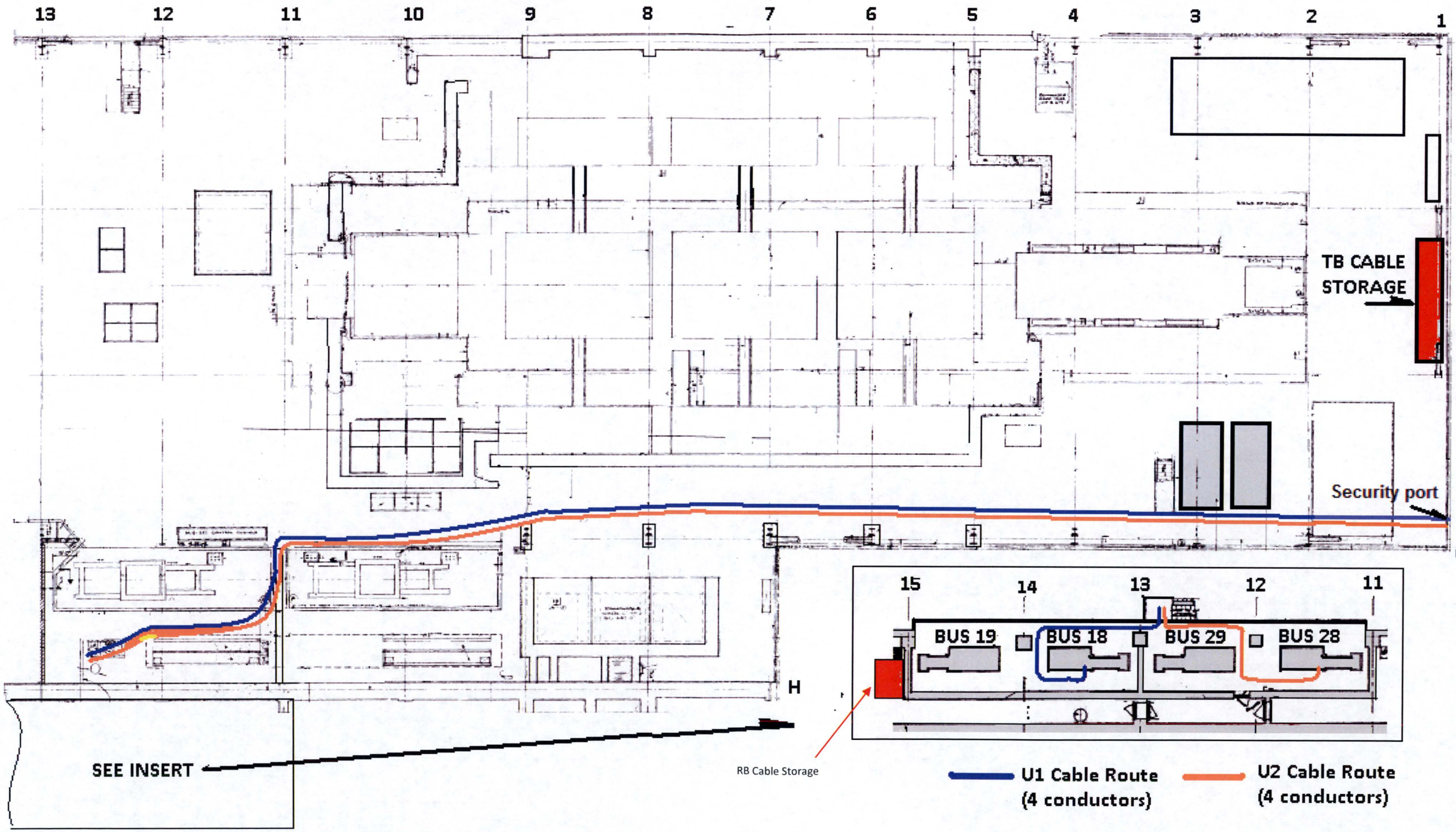


Table 1: List of HCVS Component, Control and Instrument Qualifications

Component Name	Equipment ID	Range	Location	Local Accident Temp	Local Accident Humidity	Local Radiation Level (TID)	Qualification[8]	Qualification Temp	Qualification Humidity	Qualification Radiation (TID)	Power Supply
Wetwell Vent Instruments and Components											
HCVS outdoor piping and supports	1(2)-1603-12" L	N/A	Outdoor	N/A	N/A	N/A	Deadweight and SSE seismic loading, piping thermal environmental conditions, ice loading, and tornado wind loadings	N/A	N/A	N/A	N/A
HCVS effluent temperature sensor	1(2)-1603-10	0-400°F	RB 622 13K (RB 623 M8)	50-301 °F	100%	3.6E+05 Rad	IEEE 323-1974,1983 IEEE 344-1975,1987	UP to 500°F	No electronics. Not susceptible.	3.00E+08 Rad	None required
HCVS effluent temperature transmitter	1(2)-1603-11	0-400°F	TB 619 15G (TB 611 13F)	120°F	***Ambient	<1.0E+03 Rad	IEEE 323-1974,1983 IEEE 344-1975,1987	158°F	90% (NC)	Class 1E Mild Environment ****	HCVS Battery bus Ckt. 8(10)
HCVS effluent temperature indication	1(2)-1603-12	0-400°F	MCR 901(2)-55	120°F	90%	**MCR	N/A; **MCR	N/A	N/A	N/A	HCVS Battery bus Ckt. 8(10)
HCVS Radiation Detector RE	1(2)-1603-20	1E-02 to 1E+04 Rad/hr	RB 622 13 K (RB 623 N8)	201 °F	100%	3.6E+05 Rad	IEEE-323-1974, IEEE-323-1983, IEEE-344-1987 IEEE-381-1977	350°F	100%	2.00E+08 Rad	125 VDC battery bus Ckt. 3(4)
HCVS Radiation Transmitter/ Monitor	1(2)-1603-21	1E-02 to 1E+04 Rad/hr	TB 619 15 G (TB 611 13F)	120°F	***Ambient	<1.0E+03 Rad	IEEE-323-1974, IEEE-323-1983, IEEE-344-1987 IEEE-381-1977	131°F	95%	1E+03 Rad	125 VDC battery bus Ckt. 3(4)
HCVS Radiation Indication	1(2)-1603-22	1E-02 to 1E+04 Rad/hr	MCR 901(2)-55	120°F	90%	**MCR	N/A; **MCR	N/A	N/A	N/A	125 VDC Battery bus Ckt 3(4)
Argon Purge Supply Pressure Transmitter and Indicator	1(2)-1605-46 and 1(2)-1605-47	0 – 3000 psig	TB 619 15G (13F) and MCR 901(2)-55	120°F	***Ambient and 90%	<1.0E+03 Rad and **MCR	IEEE 323, 344, & 381	200°F and N/A for MCR	100% and N/A for MCR	6.5E+06 Rad and N/A for MCR	HCVS Battery bus Ckt 8(10)
HCVS 125 VDC battery, charger,	0-8370 0-8370-1 0-8370-2	N/A	TB 595' 611.5'	50 - 120°F	91%	1.200E-01	Seismic Cat 1	125°F	91%	N/A	N/A

[8] See UFSAR for qualification code of record IEEE-323-1974 and IEEE-344-1975. Where later code years are referenced, this was reconciled in the design process.

Component Name	Equipment ID	Range	Location	Local Accident Temp	Local Accident Humidity	Local Radiation Level (TID)	Qualification[8]	Qualification Temp	Qualification Humidity	Qualification Radiation (TID)	Power Supply
distribution panel 480 VAC Feed	0-8370-3 MCC 19-3 Cub C5										
Drywell Pressure Transmitter	PT1(2)-1641-6A(B)	-5 to 250 Psig	RB 626'	N/A	N/A	N/A	IEEE 323-1974, IEEE 344-1975	RG 1.97 Cat 1	RG 1.97	RG 1.97	FLEX DG
Drywell Pressure Indication	1(2)-1640-11A(B)	-5 to 250 Psig	MCR	120°F	90%	**MCR	IEEE 323-1974, IEEE 344-1975	RG 1.97 Cat 1	RG 1.97	RG 1.97	FLEX DG
Wetwell Level Transmitters	LT1(2)-1641-5A(B)	0 to 30 Ft	RB 557'	N/A	N/A	N/A	IEEE 323-1974, IEEE 344-1975	RG 1.97 Cat 1	RG 1.97	RG 1.97	FLEX DG
Wetwell Level Indication	1(2)-1640-10A(B)	0 to 30 Ft	MCR	120°F	90%	**MCR	IEEE 323-1974, IEEE 344-1975	RG 1.97 Cat 1	RG 1.97	RG 1.97	FLEX DG
* Pneumatic valves	1(2)-1601-60 1(2)-1699-98	N/A	RB 591' RB 623'	301°F 201°F	100% 100%	2.2E+06	IEEE-344-1975	500°F 350°F	No electronics, not susceptible	8.60E+07 Rad	Nitrogen backup bottles for 24 hours, then FLEX air compressor
* ROS valves Nitrogen and Argon System	1(2)-1604(5)-Manuals 1(2)-1604(5)-SOVs	N/A	TB 619 (TB 611)	120°F	***Ambient	<1.0E+03 Rad	IEEE 323-1974, IEEE 344-1975	150°F	No electronics, not susceptible	N/A	Manual SOVs-125VDC HCVS Batt
SAWA flow instrument and readout	FI 1(2)-0050-01	2.21-736 gpm	Staged at TB 595' centerline near RB wall. (H-13)	32 - 120°F	N/A	8.8 mR/hr at TB H-13	Commercial instrument qualified for over the road use, therefore qualified per NEI 12-06	-4°F to 140°F	Not specified	N/A	Contained Battery

* Denotes non-required item, added for site-specific design.
** Denotes Control Building where local radiation levels are not applicable. Building has no significant radiation sources.
*** Denotes items at the ROS, which are at ambient conditions at the initiation of the event. Due to ventilation prior to the event, this will always be below outdoor atmospheric humidity.
**** The commonly used radiation threshold for concern for electronics that contain metal oxide semiconductors (MOS) is 10^3 rads (10 Gy) (US NRC Regulatory Guide 1.209). Radiation aging for electronic equipment not required to perform a safety-related function in a high-energy line break environment and subject to lifetime doses of less than 10^3 rads (10 Gy) is not required for mild qualification.

Table 2: Operator Actions Evaluation

Operator Action		Evaluation Time[9]	Validation Time	Location	Thermal conditions	Radiological Conditions	Evaluation
1	SAWA hose deploy and alignment RB valves	0-1 hour[10]	20 min	RB ground floor 1st and 3rd floor	Done in the first hour, so no concerns.	Done in the first hour, so no concerns.	Acceptable
2	Open RB/TB roof door for ventilation	0-1 hour[11]	5 min	RB refueling floor	Done in the first hour, so no concerns.	Done in the first hour, so no concerns.	Acceptable
3	Transfer AC cables from RB to TB	0-1 hour[11]	13 min	RB/TB 3rd floor	Done in the first hour, so no concerns.	Done in the first hour, so no concerns.	Acceptable
4	AC and DC Load shed	0-1 hour[11]	19 min 30 sec and 17 min 30 sec	RB 2nd floor	Done in the first hour, so no concerns.	Done in the first hour, so no concerns.	Acceptable
5	HCVS Valves TB lineup – ROS system lineup	≤ 7 hours (approx. venting start)	12 min 34 sec	ROS	<120°F EC-EVAL 398588	ROS MCR projected 7-day accumulated dose 1.2E-01 rads and 1.58E-03 rads per hr per QDC-0000-M-2199	Acceptable MCR is a preferred location based on HCVS-FAQ-1.
5	HCVS actuation	≤ 7 hours (approx. venting start)	5 Minutes (based on similar tasks)	Main control room	<120°F	MCR is removed from the vent pipes and RP actions will provide protection from any airborne activity	Acceptable MCR is a preferred location based on HCVS-FAQ-1.

[9] Evaluation timing is from NEI 13-02 to support radiological evaluations.
[10] Ref. 68.
[11] Ref. 69.

Operator Action		Evaluation Time[9]	Validation Time	Location	Thermal conditions	Radiological Conditions	Evaluation
6	Backup HCVS valve operation (if primary method fails)	≤ 7 hours (approximate venting start)	25 mins (based on ROV system lineup validation)	TB U1 619 (U2 611) elevation at Remote Operating Station	<120°F EC-EVAL 398588	ROS MCR projected 7-day accumulated dose 1.2E-01 rads and 1.58E-03 rads per hr per QDC-0000-M-2199	Acceptable
7	SAWA/ FLEX pump staging and hose connection	≤ 7 hours[11]	3 hrs. 20 mins	Turb Bldg and Outside, Pump setup at Discharge Bay (Manhole 1-13 for LIP)	Inside <120°F Outside, so ambient conditions	3.109E-01 Rad/hr per QDC-0000-M-2223	Acceptable
8	SAWA pump operation and refueling	>7 hours (maximum injection start time is 8 hours) [11]	3 hrs. 20 mins	Discharge Bay (Manhole 1-13 for LIP)	Outside, so ambient conditions	3.109E-01 Rad/hr per QDC-0000-M-2223	Acceptable
9	FLEX Generator connection, alignment, and begin operation	>7 hours (maximum injection start time is 8 hours) [11]	2 hrs. 50 mins	Turb. Bldg. and Outside,	Inside <120°F Outside, so ambient conditions	2.342E-02 Rad/hr per QDC-0000-M-2223	Acceptable
10	FLEX Generator continued operation and refueling	>24 hours	N/A - >24 hours	Outside TB2 and Discharge Bay (Manhole 1-13 for LIP)	Outside, so near ambient conditions	2.342E-02 Rad/hr per QDC-0000-M-2223	Acceptable