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

Subject: Duke Energy Carolinas, LLC
Oconee Nuclear Station, Units 1, 2, and 3
Docket Numbers 50-269, 50-270, and 50-287,
Renewed Operating Licenses DPR-38, DPR-47, and DPR-55
Licensing Basis for the Protected Service Water System - Responses to Request for Additional Information - Supplement 1

References:

1. Letter from John Boska, Senior Project Manager, Division of Operating Reactor Licensing, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, to T. Preston Gillespie, Vice President, Oconee Nuclear Station, Duke Energy Carolinas, LLC, "Request for Additional Information (RAI) Regarding the License Amendment Requests (LARs) for the Licensing Basis for the Protected Service Water System," June 11, 2012.

2. Letter from T. Preston Gillespie, Vice President, Oconee Nuclear Station, Duke Energy Carolinas, LLC, to the U.S. Nuclear Regulatory Commission, "Licensing Basis for the Protected Service Water System - Responses to Request for Additional Information," dated July 11, 2012.

By letter dated June 11, 2012, Duke Energy Carolinas, LLC (Duke Energy) formally received a Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) (Reference 1) associated with the design and licensing bases for the proposed Protected Service Water (PSW) system. Duke Energy responded to 41 of the 53 RAI items by letter dated July 11, 2012 (Reference 2).

The Enclosure to this letter provides the responses to the remaining 12 RAI items (125, 128, 139, 140, 141, 142, 144, 145, 147, 148, 160, and 162) from the June 11, 2012, NRC letter. The Attachment provides supplemental information for three (3) of the RAI responses. In addition, the response to RAI item 141 is based on analysis that requires validation. Upon completion of the validation, Duke Energy will provide a follow-up response on RAI item 141 by August 17, 2012.

If you have any questions in regard to this letter, please contact Stephen C. Newman, Regulatory Compliance Senior Engineer, Oconee Nuclear Station, at (864) 873-4388.

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NRR

I declare under penalty of perjury that the foregoing is true and correct. Executed on July 20, 2012.

Sincerely,

TPGillespie
T. Preston Gillespie, Jr.
Vice President
Oconee Nuclear Station

Enclosure - Responses to RAI Items
Attachment - RAI Item Supplemental Information

cc: (w/enclosure/attachment)

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Enclosure

Duke Energy Responses to RAI Items

RAI 125 [EEEB16]

In a letter dated December 16, 2011, enclosure 3, tab 2, in response to RAI 43, the licensee referenced its submittal dated August 31, 2010, and a previous RAI 2-27. In its August letter, the licensee stated that the loading on the PSW transformer, switchgears, and load centers will be answered in a future RAI response submittal. However, the staff's review of the licensee's responses dated December 7, 2010, December 16, 2011, and January 20, 2012, did not find any discussion regarding equipment loading. Provide a table showing the PSW system worst case electrical loadings at 13.9 kV, 4.16 kV, and 600 V buses, and all equipment, bus, and breaker design ratings demonstrating that the worst-case loadings are within the design rating of the associated equipment/bus/breaker.

Duke Energy Response:

A sketch and applicable tables listing electrical equipment loading versus equipment ratings for PSW 13.8 KV, 4.16 KV and 600 V buses is provided in the RAI #125 supplemental information section of the Attachment to this letter. The data in the tables is based on current PSW design information. While some of the values may change minimally with design completion, the Duke Energy QA Program and associated design processes ensure that potential nonconformances with equipment design ratings will be resolved prior to placing the equipment in service.

RAI 128 [EEEB19]

In its letter dated December 16, 2011, in response to the staff's RAI 63, the licensee referenced calculation OSC-9190, Revision 0, "PSW 125 V DC Power System Analysis." Provide a summary table showing all DC loads, required minimum voltage, maximum rated voltage, and the calculated available voltages at the equipment terminal demonstrating that in all cases, the calculated voltages are bounded by the minimum and maximum rated voltage.

Duke Energy Response:

The requested information is provided in the data table in the Attachment to this letter. The data contained in the table demonstrates that the calculated voltages are bounded by the minimum and maximum rated voltages except as noted by note 6 of the table.

RAI 139 [EMCB4]

In addition to the seismic analysis discussion included in Section 9.7.1.2.5.2 of the March 16, 2012 letter, for the proposed PSW system credited piping and pipe supports; HVAC system components and component supports, ducts and duct supports; which are important to safety and/or need to be seismically qualified, please provide technical evaluation discussions which address the structural analyses or evaluations performed and include, but not limited to, the following.

a) Structural analysis methodology, validated assumptions and criteria.
b) Structural design inputs which as minimum include loads and load combinations utilized in the structural analyses.

   The response to RAI EMCB-4(b) should include guidance and criteria utilized such as whether the design response spectra is developed in accordance with RG 1.6 and RG 1.92 for combining modal responses; whether RG 1.61 is used for damping ratios; other regulatory guidance, FSAR or SRP sections.

In addition, please discuss guidance and criteria for monitoring of piping vibration levels during startup testing mentioned in UFSAR Section 9.7.1.2.5.3 of the March 16, 2012 letter and whether it is in accordance with ASME OM-SG Part 3, UFSAR or other approved guidance. Also discuss monitoring of piping thermal motion to verify adequate clearance and restriction of movements.

c) Discussion of the results of the structural analyses and evaluations. Please include quantitative summaries of maximum stresses with a comparison to code of record allowable stresses. Include only maximum stresses and data at critical locations (i.e. pipe anchors, equipment nozzles, penetrations, component connections, tie-ins to existing piping, etc). For penetrations and equipment nozzles provide a summary of loads compared to specific allowable values for the penetrations and nozzles.

d) Describe the method and criteria used for the interface between piping which is required to be seismically qualified and non-seismically qualified piping.

e) Describe how the interaction between seismic and non-seismic PSW SSCs (including piping) has been considered.

Duke Energy Response:

a) Structural Analysis consists of the following:

- Structural Design of new and/or existing pipe supports for the PSW project is in accordance with American Institute of Steel Construction (AISC) Manual of Steel Construction, 6th Edition per Oconee UFSAR Section 3.9.3.4.2, and Oconee specifications OS-0027.00-00-0001 "Design Specification for Class A, B, C, D and F Pipe Supports and Restraints," Revision 14, and OSS-0027.00-00-0002, "Procedures, Supplemental Requirements and Tolerances for Fabrication of Pipe Supports and Restraints," Revision 26, using hand calculations. Additionally, some analyses also utilize GTStrudl finite element modeling analysis for qualification of the members using the AISC Manual of Steel Construction 7th Edition (Per RAI 137, the equations used from the 7th edition have been reconciled with the 6th edition). Attachment of new and/or existing piping supports to existing structures is evaluated in accordance with specification OSS-0027.00-00-0009, "Specification for the Evaluation of Support/Restraints and Equipment Structural Attachment Loads at Oconee Nuclear Station (Including Keowee Hydro Station)," Revision 1.

- New and/or existing cable tray, and conduit supports affected by the PSW project are evaluated using linear elastic analysis in accordance with the Seismic Qualification Users Group (SQUG) methodology as described in specification OSS-0254.00-00-4019 "Design Basis Specification for the Cable Tray Supports," Revision 5. Additional guidance is given in EPRI 7151-D, "Cable Tray and Conduit System Seismic Evaluation Guidelines." In general, cable tray supports are evaluated for dead load, vertical capacity, ductility, and lateral load as detailed in Generic Implementation Procedure (GIP) 3A Sections 8.3.1, 8.3.2, 8.3.3 and 8.3.4, respectively. Additionally, field run electray/cable tray that is 6" by 6" or smaller, and ½" diameter through 4" field run conduits may be supported in accordance with specification OSS-0218.00-00-0025 "Specification for the Installation of Field Run Cable Support Systems," Revision 12. Un-resolved seismic interaction concerns for cable tray, electray, and conduit is addressed as part of the final design process for the cable tray, electray, and conduit runs. Furthermore, attachment of new and/or existing cable tray supports to existing structures is evaluated in accordance with specification OSS-0027.00-00-0009, "Specification for

the Evaluation of Support/Restraints and Equipment Structural Attachment Loads at Oconee Nuclear Station (Including Keowee Hydro Station)," Revision 1. Existing Oconee cable tray supports in the Auxiliary Building were reviewed and evaluated as part of the resolution of Unrestricted Safety Issue (USI) A-46. Bounding cases of raceway supports were evaluated in Oconee Calculation OSC-6734 "EQE International A-46/IPEEE Seismic Evaluation: Analytical Review of Raceway Supports," Revision 0, using the SQUG GIP 3A criteria.

- New and/or existing Heating, Ventilation, and Air Conditioning (HVAC) supports affected by the PSW project is evaluated in accordance with specification OSS-0235.00-00-0015, "Design Specification for HVAC Support and Restraint," Revision 4. Attachment of new and/or existing HVAC supports to existing structures is evaluated in accordance with specification OSS-0027.00-00-0009, "Specification for the Evaluation of Support/Restraints and Equipment Structural Attachment Loads at Oconee Nuclear Station (Including Keowee Hydro Station)," Revision 1. Refer to calculation OSC-10581, "Structural/Seismic Analysis on Fan Mounting for the Oconee PSW Building," Revision D6, and OSC-10661, "Structural/Seismic Analysis of Ductwork, Hangers and Supports," Revision 0, which provides a detail analysis of the HVAC system and components in the PSW Building and Auxiliary Building, respectively.
- The following supplements codes and standards cited for the structural attachment of equipment within the PSW Building in proposed UFSAR section 9.7.1.2.5.2 of the March 16, 2012 letter: The attachment of equipment housed within the PSW building is evaluated for worst-case resultant seismic loads by summing forces/moments produced by the vertical seismic acceleration and the controlling horizontal (east/west or north/south) seismic acceleration based on pertinent PSW Building developed in-structure response spectra presented in calculation OSC-9506, "Generation of SSE In-Structure Seismic Response Spectra for the PSW Building," Revision 0, acceleration magnitude, and attachment geometry (see Section 3.7.2.5 of the Oconee UFSAR). Critical damping values are as specified in Section 3.7.1.3 of the Oconee UFSAR. The design of concrete expansion anchors used to attach new and/or existing equipment are in accordance with specifications OSS-0020.00-00-0004, "Specification for the Design, Installation, and Inspection of Concrete Expansion Anchors," Revision 6 and OSS-0020.00-00-0006, "Specification for the Design, Installation, and Inspection of Hilti Concrete Anchors," Revision 5.

b) Structural Design Inputs

The Oconee Nuclear Station (ONS) is a two directional earthquake motion according to the UFSAR, Section 3.7.2.5. Therefore, the PSW structures, systems and components (SSCs) have been analyzed for maximum horizontal component (either X or Z) and the vertical component (Y) for seismic loads applied simultaneously.

<u>Loads</u>

- **Dead** loads consist of the weight of the structure plus all equipment and materials permanently fastened to, and supported by, the structure/component.
- **Live** loads are the loads produced by the use and occupancy of the building or structure. They include the weight of all movable loads, including personnel, tools, miscellaneous equipment, movable partitions, cranes, hoists, parts of dismantled equipment, and stored material.

- **Seismic** design response spectra as specified in Section 3.7.1.1 of the Oconee UFSAR. Critical damping values as specified in Section 3.7.1.3 of the Oconee UFSAR. Components of earthquake motion applied as specified in Section 3.7.2.5 of the Oconee UFSAR.
- **Tornado** loadings conform to Regulatory Guide 1.76, Revision 1

(Note: The PSW system is not credited for mitigation of station damage from turbine missiles; therefore, turbine missiles are not considered in the design of PSW structures, systems, or components.)

Load Combinations

- Pipe Stress (Refer to specification OS-0027B.00-00-001, "Specification for Class A, B, C, D, E, F, G and H Piping Analysis for Code Compliance," Revision 10)
  - Normal (Primary Stresses)

    Pressure + DL
  - Thermal Expansion (Secondary Stresses)

    T + OBE anchor motion if not included in the upset combination.
  - Upset

    Larger of:

    Pressure + DL + OBE (N-S + Vert.) + DYNS

    Or

    Pressure + DL + OBE (E-W + Vert.) + DYNS

    Or

    Pressure + DL + DYNT
  - Faulted

    Larger of:

    Pressure + DL + SSE (N-S + Vert.) + DYNS

    Or

    Pressure + DL + SSE (E-W + Vert.) + DYNS

    Or

    Pressure + DL + DYNT

Where,

DL = Dead Load
T = Thermal Expansion
DYNS = Relief valve load steady state (as applicable)
DYNT = Relief valve load transient (as applicable)
OBE = Operational Basis Earthquake
SSE = Safe Shutdown Earthquake
DBE = Design Basis Earthquake (equals SSE)

- Pipe Supports (Refer to Specification OS-0027.00-00-001, "Design Specification for Class A, B, C, D and F Pipe Supports and Restraints," Revision 14.)

  - Normal

    Hydro

    Or

    Thermal (use greater of hot or cold load)

    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Friction (as applicable - see Section I-2.3)

  - Upset

    Thermal (use greater of hot or cold load)

    + OBE or Wind (as applicable)
    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Steam/Water Hammer (as applicable)

    Or

    Thermal (use greater of hot or cold load)

    + OBE or Wind (as applicable)
    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Relief Valve (Steady State)
    + Steam/Water Hammer (as applicable)

    Or

    Thermal (use greater of hot or cold load)

    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Relief Valve (Transient)
    + Wind (as applicable)
    + Steam/Water Hammer (as applicable)

  - Faulted

    Thermal (use greater of hot or cold load)

    + DBE (2 x OBE) or Tornado (as applicable)
    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Steam/Water Hammer (as applicable)

    Or

    Thermal (use greater of hot or cold load)

    + DBE (2 x OBE) or Tornado (as applicable)
    + Pressure (as applicable)
    + Weight (Dead + Live Loads)
    + Relief Valve (Steady State)
    + Steam/Water Hammer (as applicable)

Or

Thermal (use greater of hot or cold load)

+ Pressure (as applicable)
+ Weight (Dead + Live Loads)
+ Relief Valve (Transient)
+ Tornado (as applicable)
+ Steam/Water Hammer (as applicable)

- HVAC Supports (Refer to Specification OSS-0235.00-00-0015, "Design Specification for HVAC Support and Restraint," Revision 4.)

  - Normal

    DW
  - Upset

    DW ± OBE
  - Faulted

    DW ± SSE

  Where,

  DW = Dead Weight of ductwork plus dead weight of the S/R.
  OBE = Operating Basis Earthquake loading determined by multiplying the appropriate OBE acceleration by the participating mass.
  SSE = Safe Shutdown Earthquake loading determined by multiplying the appropriate SSE acceleration by the participating mass.

For the Regulatory Guides and standards used to develop the PSW Building Response Spectra that was used to calculate PSW Building Pipe Stress, refer to RAI-141 Response. All other pipe stress analyses used existing design base spectra per specification OS-027B.00-00-0002, "Specification for the Seismic Displacements and Response Spectra for the Turbine, Auxiliary, Reactor, and Standby Shutdown Facility Buildings," Revision 8.

The piping is analyzed for design temperature per applicable codes. The resultant thermal movement is accounted for in pipe support design. This QA-1 piping is installed under the Duke Energy quality control program and QC completes inspection of the tolerances on all supports once the system is water solid to verify design tolerances are met.

Duke Energy obtained baseline vibration data for the pump assemblies prior to delivery. The pumps will also be monitored during testing. The Oconee Piping Analysis Engineering Manual, Instruction #13 for Piping Vibration (PAEM-013) and the Duke Engineering Modification Process require vibration monitoring of systems in accordance with ASME OM-SG Part 3.

c) The PSW piping is designed in accordance with Oconee piping system Class F (OS-027B.00-00-0001, "Specification for Class A, B, C, D, E, F, G and H Piping Analysis for Code Compliance," Revision 10) and is qualified per Code U.S.A.S. B31.1.0 (1967). The safety related piping is analyzed using the SUPERPIPE piping analysis program to evaluate the piping stresses and to develop support loads due to deadweight, thermal, and earthquake effects. Results provided by the model are compared to Code allowable values to determine acceptability and reported in Oconee stress calculations OSC-9206 "Protected Service Water Main Header / CCW Min Flow, Prob. No: 4-PSW-01," Revision 3, OSC-9512, "Protected Service Water from PSW Pump Room to Units 1 & 2 Steam Generators, Problem

No.: 4-PSW-02," Revision 0 and OSC-9241, "Protected Service Water HPI Pump Motor Cooling Line, Problem No.: 4-14B-04," Revision 0.

- Maximum stress load capacity ratio (L/C) for U.S.A.S. B31.1.0 (1967) Code equations range from 0.70 to 0.85 < 1.0 (i.e., adequate margins exist).
- Equipment nozzles L/C range from 0.15 to 0.75 < 1.0, as judged against vendor allowables (i.e., adequate margins exist).
- Valve accelerations are less than values specified in Section 5.2 of Oconee Specification OS-027B.00-00-0001 (2.5 g's OBE).
- Provisions for relative seismic anchor movements between structures are considered at penetrations.
- Anchors of the modeled PSW piping systems are considered at equipment nozzles and penetrations as applicable.

The PSW safety shower/eye-wash station located in the PSW Building is designed in accordance with Oconee piping system Class D, QA Condition 4 (OS-027B.00-00-0001) and is qualified per Code U.S.A.S. B31.1.0 (1967). Results provided by the SUPERPIPE model are compared to Code allowable values to determine acceptability and reported in Oconee stress calculations OSC-9906, "PSW Building Battery Room Shower Eye-Wash Station Piping Analysis, Problem No.: 4-27-02," Revision 0. Applicable code provisions have been satisfied.

The PSW fire protection piping located in the PSW Building is designed in accordance with Oconee piping system Class G & H, QA Condition 3 (OS-027B.00-00-0001) and is qualified per Code U.S.A.S. B31.1.0 (1967). Results provided by the SUPERPIPE model are compared to Code allowable values to determine acceptability and reported in Oconee stress calculations OSC-9938, "Pipe Stress Calculation for PSW Building Fire Protection, Problem No.: 1-14A-14," Revision 0. Applicable code provisions have been satisfied.

SUPERPIPE is procured from Areva (Framatome-ANP) as QA-1, SDQA Category B software. The validation and verification of the software is by the vendor, Areva, under their QA program. A copy of Areva's SUPERPIPE QA Manual may be found in Duke Energy's in-house verification document COM-0203.C6-17-0042. See SDQA-70024-COM for further information.

d) Refer to Oconee Specification OS-027B.00-00-0001, Section 4.3.4.6 for overlapped analysis between seismic and non-seismic piping. Overlapped piping is considered in Oconee stress calculations OSC-9206 and OSC-9512 by selecting sufficient overlap regions based on piping geometry and support configurations. As a minimum, the overlap region must include five effective restraints in each of the orthogonal directions.

e) Pipe support loads generated by Oconee stress calculations OSC-9206, OSC-9512, and OSC-9241 are transmitted to the Mod/Support Design Group for further evaluation. The interaction between the piping systems and surrounding supporting structures are assessed in the applicable support calculations. Additionally, structures are classified and designed for seismic events per specification OSS-0254.00-00-4010, "Design Basis Specification for the Seismic Design," Revision 3, section 3.2.1. This classification provides protection against unacceptable interactions in that the most critical structures, required to prevent the uncontrolled release of radioactivity, are classified as Class 1 and have the most extensive seismic design. Less critical structures whose failure would not directly result in an uncontrolled release of radioactivity; but, which could adversely affect an orderly shutdown, maintenance of the reactor in a safe condition or power generation are classified as Class 2

and also designed for seismic events. The remaining structures, which are not essential to orderly shutdown, maintenance of the reactor in a safe condition or power generation, are classified as Class 3 and are not designed for seismic events. Therefore, Class 1 and 2 interactions are considered seismic PSW SSCs and Class 3 is Non-seismic.

(Note: Unless noted otherwise in the response to this RAI, all specifications referenced are existing specifications that meet the current licensing basis of Oconee Nuclear Station).

RAI 140 [EMCB5]

Section 3.2.1.1.1 of the Oconee Nuclear Station (ONS) Updated Final Safety Analysis Report (UFSAR) describes Class 1 structures as those structures, systems and components (SSCs) which prevent uncontrolled release of radioactivity and are designed to withstand all loadings without loss of function. According to the ONS UFSAR mark-up included in the licensee's letter dated March 16, 2012, the protected service water (PSW) building has a seismic classification of Category 1 and it is designated as a Class 1 structure.

a) Provide a detailed description of the design criteria and load combinations for structural design and stability analysis of the PSW building and demonstrate compliance with Section 3.1.2 of the ONS UFSAR;

b) Provide a detailed description of the type of foundation(s) and supporting rock/soil/backfill strata, as applicable, used in the design of the PSW building;

c) Provide further information relative to the design features and mitigative measures that have been incorporated in the design and construction of the PSW building to control groundwater infiltration;

d) Provide a detailed explanation of the load path from the PSW building superstructure to the foundation elements and to the subgrade;

e) Provide the factor of safety against overturning, sliding and floatation and associated acceptance criteria for all applicable design loading conditions; and

f) Provide the maximum soil bearing pressure and the associated allowable limits for all applicable design loading conditions.

<u>Duke Energy Response:</u>

a. The PSW Building is designed for Natural Phenomena as specified in the UFSAR Section 3.1.2. Load combinations and structural design criteria are given in specification OSS-0292.00-00-0001, Specification for Design and Implementation Support of the Protected Service Water System, Revision 2. (Note: The PSW system is not credited for mitigation of station damage from turbine missiles; therefore, turbine missiles are not considered in the design of PSW structures, systems, or components.)

<u>Load Combinations</u>

Load Combinations which govern the design of the PSW Building are as specified in NUREG-0800, Standard Review Plan (SRP) 3.8.4 [DRAFT], Revision 2, American Concrete Institute (ACI) 349-97 (as supplemented by Regulatory Guide 1.142), and

American National Standards Institute (ANSI)/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4.

(Note: Governing load combinations are the same as those presented in ACI 349-97 as supplemented by RG 1.142 as they are in SRP 3.8.4. The load factors presented in SRP 3.8.4 in some instances exceed those within ACI 349-97/RG 1.142 for load cases which do not govern the design of the PSW Building. In either case the enveloping load combination is used. (The same applies for ANSI/AISC N690-1984 vs. SRP 3.8.4) The Strength Design Method was used for concrete and Allowable Stress Design was used for steel. Separate load combinations were used for the analysis of steel and concrete.)

Structural Design Criteria

Loads

- Dead loads consist of the weight of the structure plus all equipment and materials permanently fastened to, and supported by, the structure/component.
- Live loads are the loads produced by the use and occupancy of the PSW Building. They include the weight of all movable loads, including personnel, tools, miscellaneous equipment and stored material. (Note: Pipe loads within the PSW Building are incorporated within the live loads, which were included in the analysis and design of the PSW Building. This is consistent with the load combinations used in SRP 3.8.4 as pipe loads have the same load factors as live loads.)
- The design wind velocity is 95 mph. The applied wind pressures are computed by the means outlined in American Society of Civil Engineers (ASCE) Paper No. 3269 which states that the equivalent static force on the building is equal to the dynamic pressure (q) times the drag coefficient (C_d) multiplied by the elevation area (ONS UFSAR Section 3.3.1).
- Seismic design response spectra are as specified in Section 3.7.1.1 of the Oconee UFSAR. Critical damping values are as specified in Section 3.7.1.3 of the Oconee UFSAR. Components of earthquake motion applied as specified in Section 3.7.2.5 of the Oconee UFSAR. See response to RAI 141 for specific information on development of seismic response spectra for PSW Building.
- Tornado loadings conform to Regulatory Guide 1.76, Revision 1.

Codes and Standards

- Concrete: Subsection C of Regulatory Guide 1.142, Revision 2 (i.e., ACI 349-97 (except for Appendix B) as supplemented by Regulatory Guide 1.142 and supplemented by Regulatory Guide 1.199, November 2003).
- Structural steel and plates: Subsection II.2 of Standard Review Plan (SRP) Section 3.8.4 [DRAFT] Revision 2 (i.e., ANSI/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4).
- Anchoring components and structural supports in concrete: Subsection C of Regulatory Guide 1.199 (i.e., Appendix B (February 2001) to ACI 349-01 as supplemented by Regulatory Guide 1.199).
- Foundations: Subsection II.3 of SRP Section 3.8.5, Subsection II.4.a of SRP Section 3.8.5, DRAFT Revision 2 (including SRP Section 3.7.2, DRAFT Revision 3 methods for combining three components of earthquake to compute overturning moment), Subsection II.5 of SRP Section 3.8.5, and NUREG/CR-6896, February 2006.

- Structural acceptance criteria: Subsection II.5 of SRP Section 3.8.4, DRAFT Revision 2

Flood Design

The PSW Building is not designed for an external flood event associated with the postulated failure of upstream dams.

The PSW system is credited for the mitigation of high energy line break(s) in the Turbine Building that may result in internal flooding of the Turbine Building caused by a resulting failure of the Condenser Circulating Water (CCW) piping or expansion joint. The maximum water level resulting from the bounding CCW expansion joint failure is 795.0 ft., which would be contained within the Turbine Building. The grade level entrance of the PSW Building is 797.0 ft. Since the maximum internal flood level is below the grade level entrance to the PSW Building, the structure will remain unaffected by internal flooding in the Turbine Building.

b. The PSW Building foundation is supported by a continuous exterior spread footer with internal walls on spread footers and the battery room supported on a structural slab on grade, refer to drawing O-398-A2-101, PSW Building Foundation Plan Sections & Details. All footers (for internal and external walls) were cast monolithically or with intentionally roughened surfaces to ensure aggregate interlock within the concrete, and reinforcement is continuous throughout the footers, therefore all footers are interconnected. The east exterior wall footer is supported on concrete fill that extends below the adjacent CCW pipes. The north, south and west exterior walls, interior walls and battery room slab on grade are all founded on compacted structural fill, procured and placed in accordance with ONS specifications and design documents; refer to drawing O-398-A2-100, PSW Building General Notes & Reference Drawings.

c. The PSW Building is water resistant up to Elevation 797'-0" the equipment operating elevation. Waterstops are installed at slab to wall construction joints with the foundation walls being a continuous placement. Refer to drawings O-398-A2-101, PSW Building Foundation Plan Sections & Details, and O-398-A3-401, PSW Building Foundation Sections & Details, Sheet 1, for details and locations.

Where High Pressure Service Water (HPSW) and Plant Drinking Water (PDW) piping penetrates the foundation walls link seals are provided, as shown on drawing O-398-A2-401, PSW Building Elevation Sections & Details. There are two floor drains in the PSW Building, one common for the two battery rooms and one in the cable spreading area below the equipment operating elevation. The battery room drain is within a trench, the top of which is Elevation 797'-0", so that any water backing up through the stormwater system is contained within the trench, while the cable spreading area floor drain has a backflow preventor to isolate it from the outside stormwater system. Along the north end of the west exterior foundation wall, core bores were made after the foundation was constructed, for placement of electrical conduits. These penetrations and conduits are sealed in accordance with Duke Energy procedures using an RTV foam sealant. Along the north foundation wall, a portion of the existing wall concrete was hydrolazed to allow the placement of PSW Ductbank segment 9. This segment was provided after the PSW Building foundation had been constructed to provide spare electrical conduit raceway capacity for future engineering changes. The area hydrolazed had a new waterstop placed along the bottom with non-shrink grout placed around the perimeter of the removed concrete area. Finally, the outside surface of the foundation wall and the perimeter of ductbank segment 9 intersecting the wall were coated with a bitumastic sealant. Details of this are shown on drawing O-398-A3-404A,

PSW Building North Foundation Wall Segment 9 Ductbank Intersection Sections and Details.

The HPSW and PDW pipes are non-seismically designed outside of the PSW Buildings. As stated in the RAI 139 response the HPSW pipe and supports are QA-3/QA-4 (Fire Protection/Seismic Category II) and the PDW pipe and supports are QA-4 (Seismic Category II), therefore they are both seismically designed inside the PSW Building. Piping penetrations into the PSW Building are designed for differential movement by providing a pipe sleeve with a flexible linkseal as a water barrier. This design ensures adequate flexibility exists to accommodate any differential movement between the piping and the PSW Building concrete structure during a seismic event. Additional information on the details of these penetrations is provided in RAI 146.

d. The PSW Building is a reinforced concrete structure with a combination reinforced concrete and steel grating operating floor. The roof is supported on 4 sides by the exterior reinforced concrete walls. The concrete slabs are supported by a series of walls and beams around their perimeters at regular intervals. The steel grating is supported on steel floor framing members which span between exterior reinforced concrete walls and interior walls, all which are supported by reinforced concrete strip footings. The main steel girders are supported at their midspans by steel columns. All interior and exterior reinforced concrete walls and steel columns are supported directly on reinforced concrete strip footings which are in contact with the soil foundation. The bottoms of the footings are at 7.75' below grade.

   The battery room on the South end of the building is a slab on grade. The center wall is supported directly on a strip footing approximately 2 feet below grade and the perimeter exterior walls rest on a foundation 7.75' below grade.

   The PSW Building was not designed using a simplified analysis for concrete design (one/two way slab). Internal forces and moments in the roof were determined by a 3D Finite Element Analysis (FEA) utilizing STAAD-PRO. These internal forces and moments were used to select reinforcement based on the criteria of ACI 349-97. At the center of the roof the slab will behave as a one way slab, and at the North and South ends the roof will behave as a two way slab. The enveloping moments from each span (North-South and East-West) were used to conservatively determine appropriate reinforcement throughout the entire roof.

   The FEA model included large openings in walls and slabs, and modeled all concrete and steel structural members within the PSW Building. Lateral forces will be resisted by exterior and interior concrete walls and slabs as well as the main floor girders which span East to West in the PSW Building. Larger wall spans are designed with adequate reinforcement to resist lateral forces without additional support from other structural members.

   (Note: fc' = 5,000 psi and fy = 60,000 psi for reinforced concrete design)

e. The required overturning Factor of Safety is 1.5 for OBE and Wind, 1.1 for SSE and Tornado per SRP 3.8.5, Section II.5. The factor of safety against overturning for the PSW Building exceeds this criteria.

   The required sliding Factor of Safety is 1.5 for the Operational Basis Earthquake (OBE) and Wind, 1.1 for SSE and Tornado per SRP 3.8.5 Section II.5. The factor of safety against sliding for the PSW Building exceeds this criteria.

   The water table in the area of the PSW Building is located at Elev. 752'-0" per OSC-9227, Report of Geotechnical Exploration for Protected Service Water System and Natural Phenomenon Barrier System Projects. The groundwater elevations are based upon

observational wells from June 2007 and historical data collected for the construction of the Radwaste Building in May 1980. The PSW Building foundation is located at Elev. 788'-3." The base of the foundation is 36'-3" above the water table in this area, therefore flotation is not considered (Reference drawings O-398-A2-100A, PSW Building Reference Specs, Schedules & Details, and O-398-A2-101, PSW Building Foundation Plan Sections & Details, for foundation elevations).

(Note: Information contained in Figure 2-41 of the Oconee UFSAR represents groundwater at elevation 792'-0." Numerous groundwater wells have been installed since 1966 and observations over the years support the data presented in OSC-9227. The information from Figure 2-41 also represents groundwater before construction of Oconee Nuclear Station.)

f. The allowable soil pressure is calculated in OSC-9227, Report of Geotechnical Exploration for Protected Service Water System and Natural Phenomenon Barrier System Projects. The values presented for the PSW Building range from 5.85 ksf (Normal loads) to 10.69 ksf (Faulted Loads - SSE). Analysis of PSW Building foundation loads for all load cases are calculated in OSC-9230, PSW Building Structural Analysis, and the design passes with adequate design margin.

RAI 141 [EMCB6]

According to the licensee's letter dated March 16, 2012, the ONS UFSAR mark-up included Section 9.7.1.2.5.1 which states the following:

"The design response spectra for the new structures correspond to the expected maximum bedrock acceleration of 0.1g (MHE). The design response spectra were developed in accordance with Regulatory Guide 1.122 (Reference 15). The dynamic analysis is made using the STAAD-PRO computer program. The structure is built on structural fill. A ground motion time history was developed based on the soil properties and amplified response spectra generated at elevations of significant nodal mass."

Provide the following:

a) Considering that the PSW building is described as founded on the structural fill, provide a detailed description of rock motion, anchoring point for the input motion, and material properties of soil profile(s) overlaying bedrock (thickness, shear wave velocity, and other relevant material properties.) Also, discuss the response amplification calculation process that was used to determine the free-field horizontal and vertical ground motion at the PSW building.
b) Provide a detailed description of the procedures used for the seismic analysis of the PSW building and to develop the in-structure response spectra (floor design response spectra). If different from the methods and acceptance criteria outlined in the NRC standard review plan (SRP) 3.7.1 and 3.7.2, identify those differences and provide justification that the PSW building is adequately designed, using these alternative methods, to withstand the effects of earthquake loads.
c) Confirm and provide further information that STAAD-PRO and all features of this software related to the dynamic response analysis and static analysis have been verified and validated by its provider in compliance with 10 CFR Part 50, Appendix 8 and 10 CFR Part 21. Also, provide documentation which demonstrates that the software provider has been audited and approved as an Appendix 8 supplier.
d) Describe the method of combination of modal responses and spatial components used in the PSW building seismic response analysis. If different from the methods outlined in

the NRC Regulatory Guide (RG) 1.92, identify those differences and discuss how these alternative methods provide assurance that the PSW building is adequately designed to withstand the effects of earthquake loads.

Duke Energy Response:

a) Detailed Description of Rock Motion

The acceleration time history used to analyze the seismic response of the soil profile beneath the PSW Building is the El Centro N/S time history scaled to a peak acceleration of 0.10g; refer to OSC-7944 (MACTEC Calculation No. OCO-36), "Shake Analyses for Response Spectra for the PSW Building." The instrument that recorded this particular accelerogram was attached to the El Centro Terminal Substation Building's concrete floor, and is generally considered as representative of rock outcrop motion.

Anchoring Point of the Input Motion

The horizontal and vertical spectral acceleration curves were anchored at a spectral acceleration value of 0.272g at the period of 0.01 second for both 2-percent and 5-percent damping considered in the SHAKE 91 analyses. The value of 0.272g represents the maximum seismic acceleration to be experienced by an infinitely rigid structure with infinitely high natural frequency located at the ground surface, refer to OSC-7944.

Material Properties of Soils

The soil/rock profile and the associated parameters used in the site response analyses of the PSW Building are shown below (refer to OSC-7941 (MACTEC Calculation No. OCO-31), "Shear Wave Velocities and Moduli for the PSW Building." Structural fill constitutes the upper 23 feet of the soil profile. Beneath the fill, the soil profile gradually transitions into rock. Bedrock was estimated to be at a depth that exceeds 80 feet beneath the existing ground surface.

Layer Name	Depth (ft)	Elevation (ft)	Moist Unit Weight (pcf)	Sat. Unit Weight [b] (pcf)	V_s Best Estimate (ft/sec)	Poisson's Ratio, υ	G (ksf)	E (ksf)	V_s Lower Range (ft/sec)	V_s Upper Range (ft/sec)
Fill	0 – 16	Surface – 779	121[a]	-	897	0.30	3024	7861	732	1099
	16 – 23	779 – 772	122[a]	-	897	0.30	3049	7926	732	1099
Residual Soil	23 – 43	772 – 752	125	-	1042	0.40	4215	11802	851	1276
	43 – 51	752 – 744	-	127[cc]	1042	0.40	4282	11991	851	1276
Partially Weathered Rock	51 - 65	744 – 730	-	135[cc]	1674	0.40	11749	32896	1367	2050
Weathered Rock	65 - 75	730 – 720	-	160	2559	0.40	32539	91109	2089	3134
Transitional Rock	75 - 80	720 715	-	170	4659	0.40	114598	320875	3804	5706
Rock	80+	<715	-	170	6942	0.40	254426	712394	5668	8502

[a] Average of results from Borings B-5, NAR_x-16, NAR_x-21.
[b] Average Water Table Elevation at Elevation 752 for Site Response Analysis (see Calculation OCO 32, Determination of Groundwater Depth and Elevations). Fill γ same as Table 1, page 2 of 3, Calculation OCO 41. Residual Soil γ same as Table 1, page 3 of 3, Calculation OCO 41.
[cc] From Table 7, LETCo, 1981.

$$G_{ksf} = \frac{UnitWeight}{32.2} \cdot V_s^2 \cdot 0.001$$

$$E_{ksf} = 2 \cdot G_{ksf} \cdot (1 + \nu)$$

UpperRange

$$V_s = \left[G_{ksf} \cdot 1000 \cdot 1.5 \cdot \frac{32.2}{UnitWeight}\right]^{\frac{1}{2}}$$

LowerRange

$$V_s = \left[\frac{G_{ksf} \cdot 1000}{1.5} \cdot \frac{32.2}{UnitWeight}\right]^{\frac{1}{2}}$$

Checked by: [signature]
Reviewed by: JRS 9/11/2007

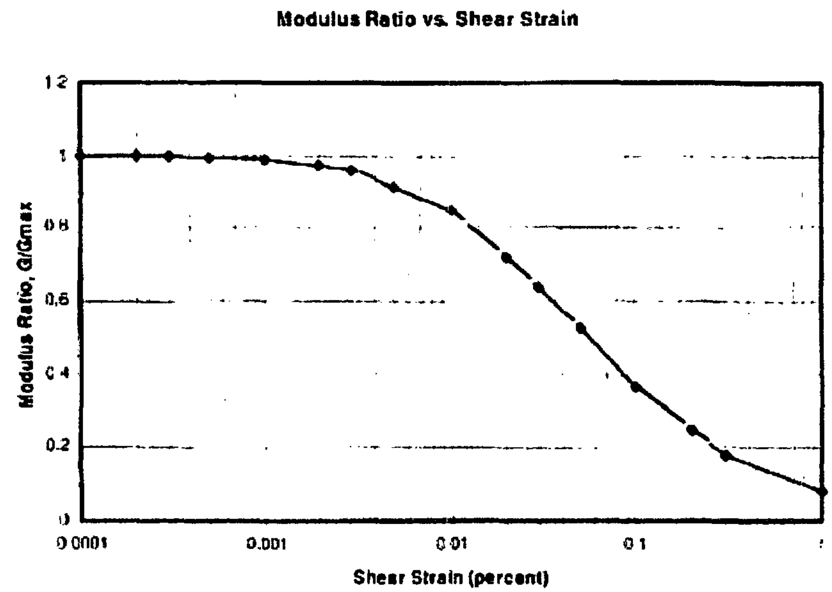
Response Analysis/Amplification

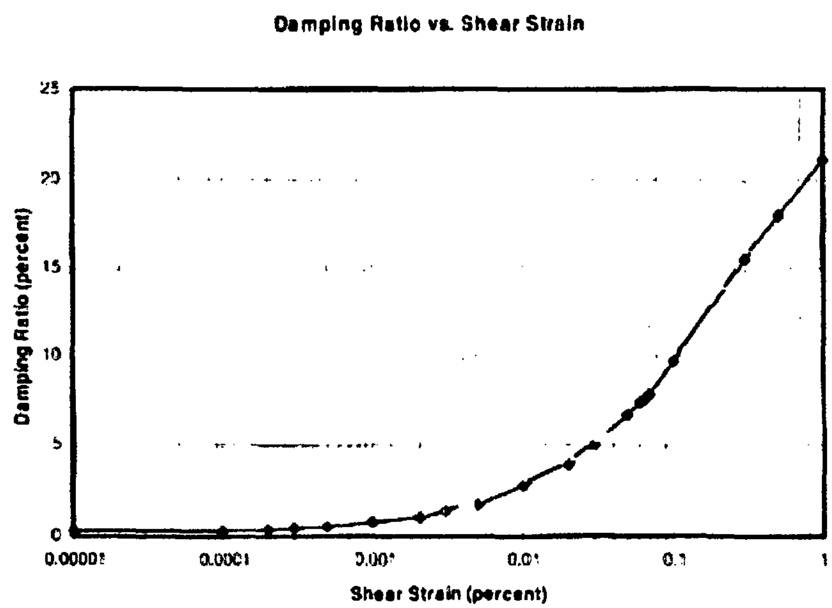
The El Centro N/S strong motion record was considered as the rock outcrop motion. The strong motion record was applied at the bedrock level (beneath the lowermost layer within the soil profile). The resulting maximum accelerations for the frequency range of 0.1 Hz to 100 Hz calculated by the SHAKE 91 software were used to construct the horizontal acceleration response spectra curves for 2-percent and 5-percent damping (calculation OSC-7944). The maximum ground surface acceleration values obtained also provide the strong-motion amplification when compared with the maximum acceleration value (0.1g) in the strong motion record used as input for the SHAKE 91 analyses.

The vertical response spectra curves (calculation OSC-7944) were developed for 2-percent and 5-percent damping values from the simplified horizontal envelope spectra curves constructed in accordance with the procedure in NRC Regulatory Guide 1.60, Rev. 1. The relationship of the vertical spectrum to the horizontal spectrum was developed by using the spectral amplification factors for the horizontal spectrum from Table 1 of the Regulatory Guide and the corresponding factors for the vertical spectrum from Table 2 of the Regulatory Guide to develop ratios of the vertical spectral accelerations to the horizontal spectral accelerations at the control points.

The modulus reduction and damping coefficient values were obtained as a function of the shear strain from Idriss (1990). These values are tabulated in calculation OSC-7944, (page 15). The plots of the tabulated values are shown below:

Figure 2
Modulus Ratio and Damping Ratios Used in Analyses





The modulus reduction and damping curves established in this calculation were used as input for SHAKE91 analyses performed for the same calculation. The very-small strain shear modulus values for the site soil/rock profile were obtained from calculation OSC-7941, as shown below:

Layer Name	Depth (ft)	Elevation (ft)	Moist Unit Weight (pcf)	Sat. Unit Weight [(b)] (pcf)	V_s Best Estimate (ft/sec)	Poisson's Ratio, ν	G (ksf)	E (ksf)	V_s Lower Range (ft/sec)	V_s Upper Range (ft/sec)
Fill	0 – 16	Surface – 779	121[(a)]	-	897	0.30	3024	7861	732	1099
	16 – 23	779 – 772	122[(a)]	-	897	0.30	3049	7926	732	1099
Residual Soil	23 – 43	772 – 752	125	-	1042	0.40	4215	11802	851	1276
	43 – 51	752 – 744	-	127[(cc)]	1042	0.40	4282	11991	851	1276
Partially Weathered Rock	51 - 65	744 – 730	-	135[(cc)]	1674	0.40	11749	32896	1367	2050
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Transitional Rock	75 - 80	720 715	-	170	4659	0.40	114598	320875	3804	5706
Rock	80+	<715	-	170	6942	0.40	254426	712394	5668	8502

(a) Average of results from Borings B-5, NAR_x-16, NAR_x-21.
(b) Average Water Table Elevation at Elevation 752 for Site Response Analysis (see Calculation OCO 32, Determination of Groundwater Depth and Elevations). Fill γ same as Table 1, page 2 of 3, Calculation OCO 41. Residual Soil γ same as Table 1, page 3 of 3, Calculation OCO 41.
(c) From Table 7, LETCo, 1981.

$$G_{ksf} = \frac{UnitWeight}{32.2} \cdot V_s^2 \cdot 0.001$$

$$E_{ksf} = 2 \cdot G_{ksf} \cdot (1 + \nu)$$

UpperRange

$$V_s = \left[G_{ksf} \cdot 1000 \cdot 1.5 \cdot \frac{32.2}{UnitWeight} \right]^{\frac{1}{2}}$$

LowerRange

$$V_s = \left[\frac{G_{ksf} \cdot 1000}{1.5} \cdot \frac{32.2}{UnitWeight} \right]^{\frac{1}{2}}$$

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Reviewed by: JRS 9/11/2007

The Poisson's Ratio values shown in the table were obtained from seismic Cone Penetration Test (CPT) and Cross-Hole Tests, whereas the Lower and Upper Range shear wave velocities were calculated from the Lower and Upper Range shear moduli by dividing and multiplying the best estimate shear moduli by 1.5, respectively, as described in ASCE Standard 4-98 (ASCE, 2000).

The effect of variations in the soil properties on the seismic response of the ground has been considered in the SHAKE91 analyses by the use of the Lower Range, Best Estimate, and Upper Range shear moduli of each layer within the soil profile. For each case, the SHAKE91 analyses were performed for 2-percent and 5-percent damping values. Soil profile (layer thicknesses) was considered to be the same in each case.

The same soil profile was also used in calculating the Subgrade Reaction Modulus (impedance function) values for the four modes of displacements (vertical, horizontal, rocking, and torsion) as discussed below. Lower Range, Best Estimate, and Upper Range shear moduli were also used in these calculations. Soil profile (layer thicknesses) was considered to be the same in each case.

The effect of layering on the subgrade modulus values was taken into account by the use of a technique developed by Christiano, et al. (1974). Prior to the application of this technique, the strain-adjusted shear modulus values of the soil layers due to the strains induced by the earthquake loading were calculated as a result of SHAKE91 analyses (calculation OSC-7944) for Low Range, Best Estimate, and Upper Range conditions. These values were used to calculate the impedance functions for all three cases as shown below.

The methodology detailed in Christiano, et al. (1974) was followed to compute the equivalent modulus of the layered soil under the foundation. In this procedure,

appropriate average subgrade modulus values are developed whereby each layer is weighted in accordance with the strain energy in that layer. This method quantifies the diminishing effect of the subsoil layers on the overall impedance of the foundation soil with increasing depth from the bottom of the foundations. Contribution of each layer to the Cumulative Strain Energy (ΔU_i) is calculated as the difference in the cumulative U_i values between the top and the bottom of each layer in the soil profile.

Christiano, et al. (1974) calculates the vertical stiffness of the foundation using the equation and the chart they developed as shown below:

$$k_v = \left[\sum \frac{(1-\nu_i)^2}{8a\mu_i} \Delta U_i \right]^{-1}$$

where

- kv = The vertical stiffness of the rigid foundation;
- a = The radius of the equivalent circular area of the foundation (same as R in ASCE 4-98);
- v_i = Poisson's ratio of the i^{th} layer;
- μ_i = The shear modulus of the i^{th} layer;
- ΔU_i = The strain energy coefficient change over the thickness of the i^{th} layer (difference in U values between the top and bottom of the layer;

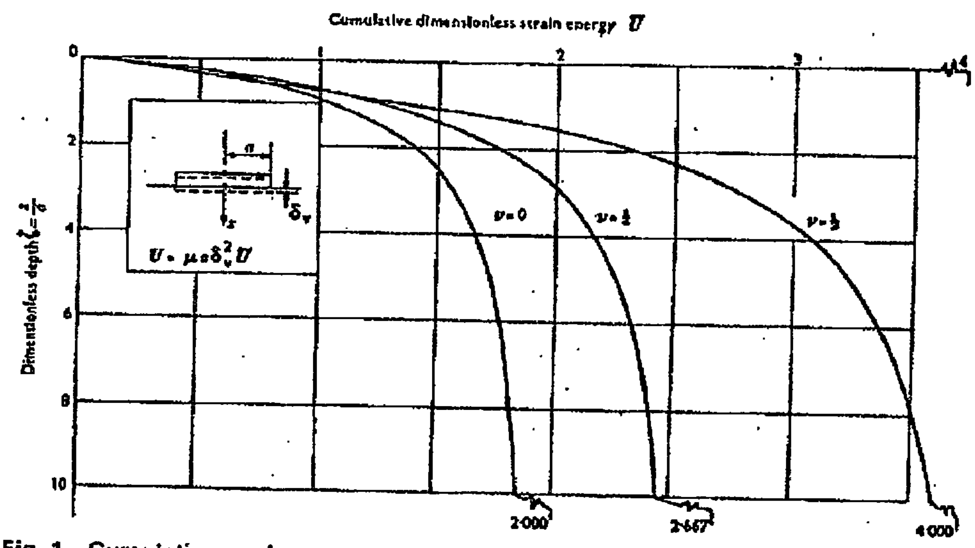


Fig. 1. Cumulative strain energy plotted against depth : vertical mode

For Poisson's Ratios intermediate between those in the above figure, linear interpolation is used.

The average shear modulus (μ_{avg}) for vertical loading is back-calculated from

$$\mu_{avg} = k_v \frac{(1 - \nu_{avg})}{4a}$$

The average Poisson's Ratio v_{avg} is computed as a layer-weighted value as

$$\nu_{avg} = \frac{\Sigma(\nu_i)\Delta U_i}{\Sigma \Delta U_i}$$

and the average soil damping β_{avg} can be computed as

$$\beta_{avg} = \frac{\Sigma(\beta_i)\Delta U_i}{\Sigma \Delta U_i}$$

where

β_{avg} = Soil material damping ratio, and
β_i = Soil material damping ratio of the i^{th} layer (strain-adjusted; from SHAKE91)

Christiano, et al. (1974) also provided impedance formulas and the Cumulative Dimensionless Strain Energy charts for horizontal, rocking, and torsional modes. The foundation impedance calculations for the PSW Building are provided in calculation OSC-10676 (MACTEC Calculation No. OCO-039). The following is an excerpt from calculation OSC-10676, regarding the extension of the methodology discussed above to horizontal, rocking, and torsional modes of vibration.

Equivalent Shear Modulus of Soil-Horizontal Mode

Christiano, et al. calculates the horizontal spring using their Equation 9 and their chart reproduced herein as Figure 2:

$$k_h = \left[\sum \frac{(2 - \nu_i)^2}{32 \cdot a \cdot \mu_i} \cdot \Delta U_i \right]^{-1} \qquad \text{(Christiano, et al., Equation 9)}$$

Where:

k_h = the horizontal stiffness of the rigid foundation:
a = the radius of the equivalent circular area of the foundation (same as R in Table 1):
ν_i = Poisson's ratio of the i^{th} layer from Table 6A

$\mu_i =$ the shear modulus of the i[th] layer (same as G in Table 1);
$\Delta U_i =$ the strain energy coefficient change over the thickness of the i[th] layer (difference in U values between the top and bottom of the layer as contained in Table 3, which was prepared by scaling from Figure 2).

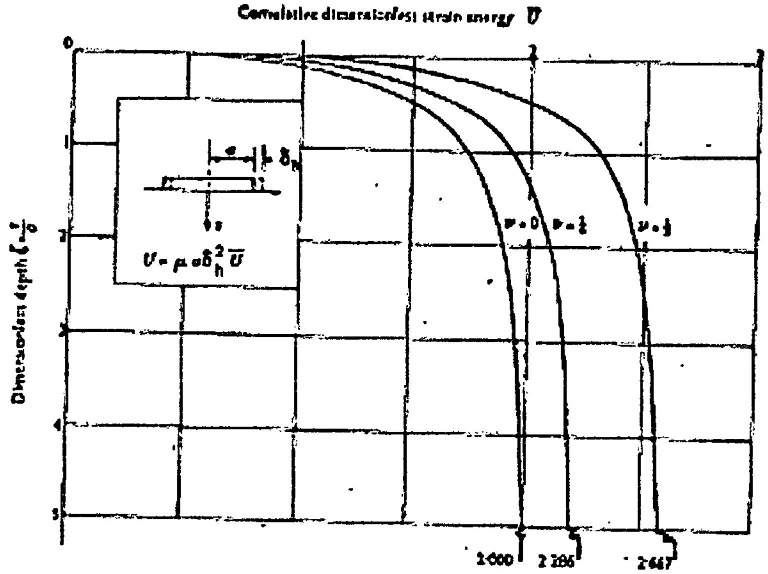


Fig. 2. Cumulative strain energy plotted against depth: horizontal mode

Figure 2 – Cumulative Strain Energy versus Depth, Horizontal Mode (Christiano, et al., 1974)

The average shear modulus (μ_{avg}) for horizontal loading is back-calculated from a rearrangement of the equation in Christiano, et al. for the half space.

$$\mu_{(avg)} = k_h \cdot \frac{(2 - \nu_{avg})}{8 \cdot a}$$

Equivalent Shear Modulus of Soil-Rocking Mode

Christiano, et al. calculates the rocking spring from their Equation 10 and their chart reproduced herein as Figure 3:

$$k_\theta = \left[\sum \frac{9 \cdot (1 - \nu_i)^2}{32 \cdot a^3 \cdot \mu_i} \cdot \Delta U_i \right]^{-1}$$ (Christiano, et al., Equation 10)

Where:

k_θ =	the rocking stiffness of the rigid foundation;
a =	the radius of the equivalent circular area moment of inertia of the foundation (same as R_L or R_S in Table 1);
μ_i =	the shear modulus of the i^{th} layer (same as G in Table 1);
ΔU_i =	the strain energy coefficient change over the thickness of the i^{th} layer (difference in U values between the top and bottom of the layer as contained in Table 4, which was prepared by scaling from Figure 3).

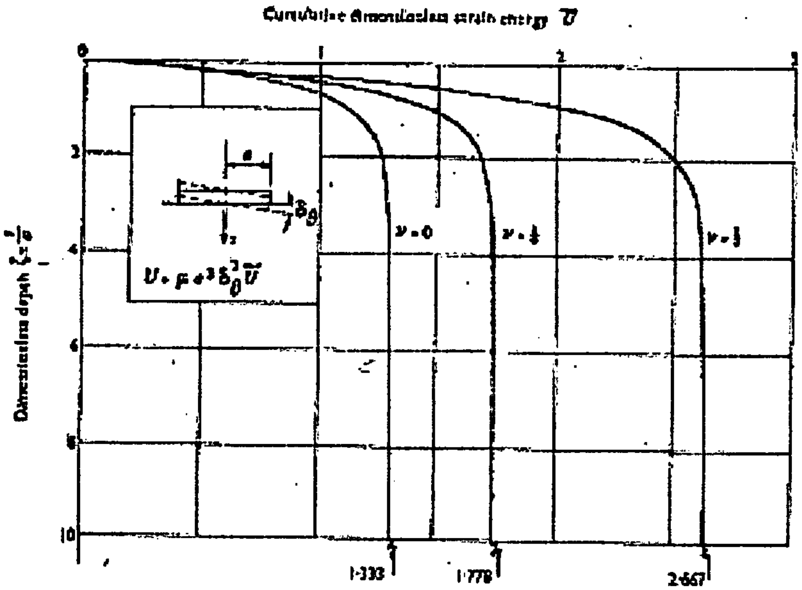


Fig. 3. Cumulative strain energy plotted against depth : rocking mode

Figure 3 – Cumulative Strain Energy versus Depth, Rocking Mode (Christiano, et al., 1974)

The average shear modulus (μ_{avg}) for rocking loading is back-calculated from a rearrangement of the equation in Christiano, et al. for the half space.

$$\mu_{(avg)} = k_\theta \cdot \frac{3 \cdot (1 - \nu_{avg})}{8a^3}$$

Equivalent Shear Modulus of Soil-Torsional Mode

Christiano, et al. calculates the torsional spring from their Equation 11 and their chart reproduced herein as Figure 4:

$$k_{\phi} = \left[\sum \frac{9}{128 \cdot a^3 \cdot \mu_i} \cdot \Delta U_i \right]^{-1}$$ (Christiano. et al.. Equation 11)

Where:

k_{ϕ} =	the torsional stiffness of the rigid foundation;
a =	the radius of the equivalent circular polar moment of inertia of the foundation (same as R_t in Table 1):
μ_i =	the shear modulus of the i^{th} layer (same as G in Table 1):
ΔU_i =	the strain energy coefficient change over the thickness of the i^{th} layer (difference in U values between the top and bottom of the layer as contained in Table 5. which was prepared by scaling from Figure 4).

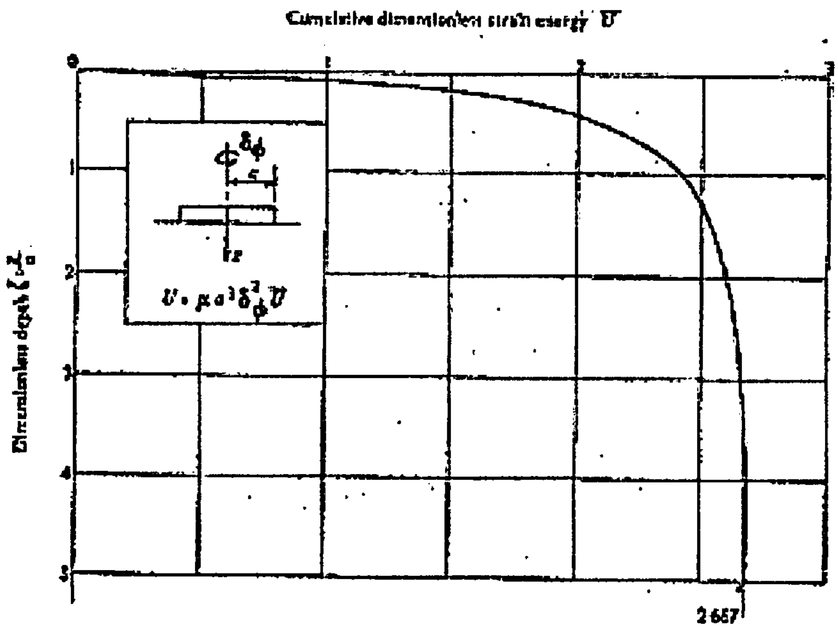


Fig. 4. Cumulative strain energy plotted against depth : twisting mode

Figure 4 – Cumulative Strain Energy versus Depth, Torsional Mode (Christiano, et al., 1974)

The average shear modulus (μ_{avg}) for torsional loading is back-calculated from a rearrangement of the equation in Christiano, et al. for the half space.

$$\mu_{(avg)} = k_{\phi} \cdot \frac{3}{16a^3}$$

b) The procedures used for the seismic analysis of the PSW Building are described in calculation OSC-9230, "PSW Building Structural Analysis," Rev.0. The Finite Element Analysis (FEA) is used to determine maximum design forces of various structural components of the PSW building and maximum foundation soil bearing stresses due to specified loading conditions. A total of five (5) three-dimensional (3-D) FEA models are developed using STAAD-PRO software package. The models consist of 4-noded plate

(shell) elements with 6 Degrees Of Freedom (DOF)/node, 2-noded beam elements with 6 DOF/node, and vertical and horizontal elastic springs representing Soil-Structure Interaction (SSI) characteristics.

The Safe Shutdown Earthquake (SSE) horizontal and vertical site specific design response spectra (5% damping ratio) of the PSW Building are determined in calculation OSC-9227, "Report of Geotechnical Exploration for Protected Service Water System and Natural Phenomenon Barrier System Projects", Rev. 0. According to specification OSS-027B.00-00-0002, "Seismic Displacements and Response Spectra for the Turbine, Auxiliary, Reactor and Standby Shutdown Facility Building," Rev. 8, the horizontal and vertical design spectra values for Operating Basis Earthquake (OBE) can be considered as one-half (1/2) of the corresponding SSE horizontal and vertical design response spectra values.

The PSW building SSE and OBE design response spectra (5% damping ratio) have been used as seismic input motion to perform dynamic linear response-spectrum analysis in order to determine maximum seismic response of PSW Building in three orthogonal directions X, Y, and Z (N-S, Vertical, and E-W, respectively).

The ONS is a two-directional earthquake motion plant according to UFSAR, Section 3.7.2.5. Therefore, the PSW building has been analyzed for the maximum horizontal component (either X or Z) and vertical component (Y) of earthquake applied simultaneously.

In other words, the maximum horizontal response spectrum (either X or Z) and vertical response spectrum (Y) are placed at the same load case and applied together to the PSW building FE model. Then modal responses are combined based on the Complete Quadratic Combination (CQC) method to determine maximum response for each seismic loading condition.

Four (4) FEA models are used in the seismic analysis of the PSW building. These models are identical with different seismic loading conditions. The seismic loading conditions for these models are as follows:

- OBE design spectra applied horizontal N-S and vertical directions
- OBE design spectra applied horizontal E-W and vertical directions
- SSE design spectra applied horizontal N-S and vertical directions
- SSE design spectra applied horizontal E-W and vertical directions

A fifth model is used for the Quasi-static linear analysis to determine the PSW structure response due to tornado generated wind pressure, missile impacts, and differential pressure loads, in addition to dead and live loads.

The first 60 modes of vibration were considered in the linear dynamic response-spectrum analyses that included more than 97% of total structural mass for all three orthogonal directions (X, Y, and Z) in seismic analysis (OSC-9230, Appendix B).

After performing the linear dynamic response-spectrum analyses for the four (4) seismic models and static analysis for the fifth model, then maximum responses of elements in each finite element model are linearly added according to load combinations presented in the calculation OSC-9230, Section 7.2 to determine maximum response of different structural components. The final forces for various structural components are presented in OSC-9230, Sections 9.2 and 9.3. No load combinations produced uplift. Accidental torsion was not explicitly considered in the analyses due to the behavior of the model under seismic load combinations. Under seismic load combinations the motion of the

PSW Building is such that the inherent eccentricity between the center of mass and the center of rigidity remains practically unchanged. In addition, all significant equipment loads were accounted for and accurately located in the model. Moreover, there is a minimum of twenty percent (20%) reserve capacity in the structural components resisting seismic force.

The developed finite element models and performed dynamic linear response-spectrum analyses are consistent with SRP 3.7.1 and SRP 3.7.2 requirements. There is no difference in approaches/requirements for seismic analysis presented in SRP 3.7.1 and SRP 3.7.2 versus those used for the PSW building seismic analysis. Therefore, the PSW building is adequately designed to withstand the effects of earthquake loads based on requirements of SRP 3.7.1 and SRP 3.7.2.

The PSW building In-Structure response spectra development is presented in calculation OSC-9506, "Generation of SSE In-Structure Seismic Response Spectra for the PSW Building," Rev. 0. For the PSW building In-Structure response spectra development, linear dynamic time-history analyses of the PSW building have been performed using artificial time history records as seismic input motion.

This calculation follows the requirements of Regulatory Guide 1.122, SRP 3.7.1, SRP 3.7.2 and ASCE 4-98 for the artificial time history record development. The generated time history records in each direction satisfied four (4) characteristic requirements presented in ASCE 4-98, Section 2.3. The developed time-history records satisfied ASCE 4-98 requirements as shown in OSC-9506, Section 6.1.

The SIMQKE software has been used to develop time history record in accordance with ASCE 4-98 criteria.

One set of time history record is developed using SSE site specific design response spectra that includes three statistically independent components of earthquake motion (i.e., three orthogonal time-history acceleration versus time records).

The SIMQKE software is approved for use in the analysis of nuclear safety-related structures. Three statistically independent time history records have been developed for the three defined orthogonal directions X, Y and Z.

The materials damping have been used in dynamic time-history analysis of the PSW Building that contain soil-structure interaction. A steel framing damping value of 2% and a reinforced concrete damping value of 5% for the SSE have been used in dynamic analysis of the PSW Building in accordance with the ONS UFSAR Section 3.7.1.3.The average soil damping value of 72% has been used in time-history dynamic analyses of the PSW Building. Soil damping determination is presented in calculation OSC-9506, Section 6.2.

A 3-D FEA model of the PSW building has been developed that include soil-structure interaction. The developed model has been used for time-history dynamic analyses using STAAD-PRO software. The time-history dynamic analysis method has been used to determine time history response of selected nodes at the PSW Building using two orthogonal time history records that apply to the base of the PSW building. The PSW building has been analyzed using artificial time-history records, one in the horizontal direction and one in the vertical direction that are applied simultaneously according to the UFSAR, Section 3.7.2.5. Therefore, two dynamic analyses of the PSW building have been performed.

The natural frequencies used in the dynamic analyses incorporate the lowest 60 modes at which approximately 97% of the PSW building participating mass are included for all directions (OSC-9506, Table 6.2). Therefore, including higher modes in the dynamic analyses would have had negligible effect on the developed floor response spectra.

The first analysis has been performed using horizontal time history record in X-direction (N-S) plus vertical time history record in Y-direction acting simultaneously. Similarly, the second analysis has been done using horizontal time history record in Z-direction (E-W) plus vertical time history record in Y-direction acting simultaneously.

Results are in the form of time history response of each of the fifteen (15) selected locations. A total of 38692 data points/location/direction) are then input to the RSG V2 software to generate corresponding floor response spectra (FRS). The RSG V2 software has been used to generate SSE horizontal and vertical FRS for fifteen (15) selected locations (points) using time history response of these selected points. The RSG V2 software is approved software for use in the analysis of nuclear safety-related structures.

The developed SSE horizontal and vertical FRS are broadened (+/-) 15% in accordance with ASCE 4-98, Section 3.4.2.3. RSG V2 software has been used for peak broadening. There are four broadened floor spectra for each selected point. They are horizontal X-direction (N-S), horizontal Z-direction (E-W), and two vertical Y-direction spectra. Two vertical Y-direction spectra are result of two seismic analyses for "N-S & Vertical" and "E-W & Vertical" FEA models.

The broadened SSE horizontal floor response spectra in X (N-S) and Z (E-W) directions are enveloped at each selected point to determine the corresponding horizontal SSE floor design spectra (FDS) that can be applied in any horizontal direction.

Similarly, the two broadened SSE vertical floor response spectra are enveloped at each selected point to determine the corresponding SSE vertical floor design spectra. RSG V2 software has been used for enveloping spectra. The enveloping process results in the development of one horizontal and one vertical SSE floor design spectra for each one of the selected points. Therefore a total of thirty (30) FDS are developed for the fifteen (15) selected locations of the PSW building.

In addition, horizontal FRS in N-S direction are enveloped for all selected points in each elevation to develop one horizontal N-S SSE FDS for operating floor, battery room roof, external walls, and PSW building roof. This process is performed for horizontal FRS in E-W direction to develop one horizontal E-W SSE FDS for the same elevations.

Finally, horizontal and vertical FDS are enveloped for all selected points in each elevation to develop one horizontal and one vertical SSE FDS for operating floor, battery room roof, external walls, and PSW building roof.

The horizontal and vertical floor design spectra for OBE can be determined using the developed floor design spectra for SSE in accordance with Specification OSS-027B.00-00-0002, Rev. 8. This specification defines floor design spectrum values of the OBE as one-half (1/2) of the corresponding SSE values in horizontal and vertical directions.

The methodology and approached used in the PSW building In-Structure response spectra development is consistent with RG 1.122, SRP 3.7.1, SRP 3.7.2 and ASCE 4-98 requirements. Therefore, the PSW building generated In-Structure response spectra are acceptable and comply with NRC requirements. See the table below for a reconciliation of the applicable provisions of ASCE 4-98, SRP 3.7.1, SRP 3.7.2, and OSC-9506.

Item No.	Description	ASCE 4-98	SRP 3.7.1 SRP 3.7.2	OSC-9506	Comment
1	Correlation Coefficient limit to check statistically independent	0.3	0.16	0.0137, 0.0248 & 0.0017	satisfy ASCE & SRP requirements
2	total duration of the artificial ground motion time histories	Satisfy Table 2.3-1 recommended durations for different earthquake magnitudes	should be long enough such that adequate representation of the Fourier components at low frequency is included in the time history. The minimum acceptable strong motion duration should be six seconds.	53.74 seconds generated time history records are shown in Figures 6.1.1, 6.1.2 & 6.1.3	satisfy ASCE & SRP requirements
3	calculated spectrum of the artificial time history	No one point of the calculated spectrum (from time history record) shall be more than 10% below the target spectrum	envelop the design response spectrum when no more than five points fall below, and no more than 10 percent below, the design response spectrum	RS plots are shown in Figures 6.1.7, 6.1.8 & 6.1.9	satisfy ASCE & SRP requirements
4	generated artificial ground acceleration histories PSD functions	shall have adequate power at all frequencies in the frequency range of interest	adequately matching a target PSD function compatible with the design response spectra	PSD plots are shown in Figures 6.1.10, 6.1.11 & 6.1.12	satisfy ASCE & SRP requirements
5	acceptable set of frequencies	Table 2.3-2 includes Suggested Frequencies for Calculation of Response Spectra	Table 3.7.1-1 provides an acceptable set of frequencies at which the response spectra may be calculated	RS are calculated for 264 different periods that are between 0.01 to 10 seconds including natural frequencies of the PSW building	satisfy ASCE & SRP requirements

It has been determined that OSC-9506 did not limit the modal composite damping values to 20% as required by the ASCE 4-98 methodology employed in the calculation. To evaluate the impact of the greater than allowed modal composite damping values, an analysis was performed to determine if the existing In-Structure response spectra is bounding. To conduct this analysis, the existing finite element model was modified to remove excessive conservatism present in the model. Specifically, soil-structure interaction springs in the three orthogonal X, Y, and Z, directions were added to the bottom of the structure; and vertical soil damping, completely absent in the existing model, is included for the springs beneath the structure. The horizontal and vertical soil damping values used for the new model are, respectively, 69% and 84% as reported in OSC-9506. Further, this analysis constrains the modal composite damping values of all modes to a maximum of 20% in compliance with ASCE 4-98 and SRP 3.7.2. ONS

calculation OSC-9506 will be revised and the new results compared with the previous results and any impact will be evaluated.

c) STAAD-PRO 2004 was used for the PSW building finite element modeling and analyses (see OSC-9230). The PSW In-Structure Response Spectra was developed after the PSW building analysis and design. At the time the In-Structure Response Spectra was developed the newer version, STAAD-PRO 2007, was available and was utilized.

Both the STAAD-PRO 2004 and STAAD-PRO 2007 FEA software were purchased commercial grade and were subjected to acceptance testing (validation) in accordance with Sargent & Lundy Standard Operating Procedure SOP-0204, the requirements of which are based upon ASME NQA-1-1994, Subpart 2.7.

SOP-0204, governing all software validation and verification (V&V) regardless of its intended use, is based on the requirements of Sargent & Lundy's Nuclear QA Program Topical Report, SL-TR-1A, including its commitment to the pertinent sections of ASME NQA-1-1994. The granting of "O" (Operational) status to any application at Sargent & Lundy, by definition per SOP-0204, means that it has been validated in accordance with the SOP and is therefore suitable for nuclear safety-related applications.

d) ONS is a two directional earthquake motion plant according to UFSAR, Section 3.7.2.5. Therefore, PSW building has been analyzed for the maximum horizontal component (either X or Z) and vertical component (Y) of earthquake that is applied simultaneously. It means that dynamic linear analyses of the PSW building consider two spatial components of earthquake motion simultaneously that is consistent with the ONS UFSAR.

The modal responses used in the PSW building dynamic linear response-spectrum analyses are combined based on complete quadratic combination (CQC) method. The STAAD- PRO seismic models are developed for linear response-spectrum analysis of the PSW building as it is explained in OSC-9230, Sheets 4 and 9. The two spatial components of earthquake motion (E-W & Vertical or N-S & Vertical) are applied to the PSW building simultaneously and the responses are combined based on CQC methodology utilizing STAAD-PRO software.

The CQC is an acceptable method of modal response combination as it is described in NRC Regulatory Guide (RG) 1.92, section C.1.1. Therefore, there is no difference in modal responses combination between NRC RG 1.92 described methods with the method utilized in PSW building linear dynamic analyses. Hence, the PSW building linear dynamic analyses comply with RG 1.92 requirement; therefore, the PSW building is adequately designed to withstand the effects of earthquake loads.

For PSW building floor response spectra development, The STAAD-PRO FEA models developed in OSC-9506 calculation and the dynamic linear time-history analysis is performed to get time-history response of each node. The two statistically independent artificial time-history records (one horizontal and one vertical) are applied to the PSW building finite element models as seismic input motions. It is acceptable methodology to use two statistical independent spatial components of earthquake motion simultaneously to get combined effects for dynamic linear time-history analyses as the ONS is a two directional plant according to UFSAR Section 3.7.2.5.

Therefore, two FEA models are developed for linear time-history analyses including one for seismic input motion in N-S and vertical directions (X &Y) and one for seismic input

motion in E-W and vertical directions (Z &Y). These input files are presented in OSC-9506 calculation, Appendix J and K.

The utilized methodology in the PSW building time-history analyses is consistent with NRC RG 1.92 methodology and also it agrees with method described in ASCE 4-98, Section 3.2.7.2 (a); therefore, the PSW building generated floor response spectra is acceptable and comply with NRC requirement.

RAI 142 [EMCB9]

The ONS UFSAR mark-up, included in the licensee's letter dated March 16, 2012, includes American National Standard Institute (ANSI), American Institute of Steel Construction (AISC) N690-1984, and American Concrete Institute (ACI) 349-97, as the design codes for the PSW building structural steel and reinforced concrete elements, respectively.

The current RG 1.142 (revision 2) endorses ACI 349-97 with exceptions. The SRP 3.8.4 references the 1994 edition of ANSI/AISC N690 including Supplement 2 (2004) for the design of safety-related steel structures. Provide discussion and further information relative to the following:

a) Demonstrate compliance with the provisions of the 1994 edition of ANSI/AISC N690 including Supplement 2 (2004) or identify the differences between two editions and provide a reconciliation to demonstrate the acceptability of using ANSI/AISC N6901984.

b) Confirm that ACI 349-97 have been followed in its entirety, where applicable, and all applicable regulatory positions in RG 1.142 have been incorporated in the design and construction of the PSW building.

Duke Energy Response:

a) SRP 3.8.4, Revision 2, was published in March 2007. The PSW project was initiated in 2006 utilizing SRP 3.8.4, DRAFT Revision 2, which endorses the use of ANSI/AISC N690-1984. This version of the N690 code was applied to the design of the new PSW Structures, as supplemented by Appendix F of SRP 3.8.4 DRAFT Revision 2.

b) ACI 349-97 was used for the design of new concrete structures (including the PSW Building, Manholes, and Ductbanks) as supplemented by Regulatory Guide 1.142, Revision 2. Anchorage of items within these structures was designed in accordance with ACI 349-01, Appendix B, as supplemented by Regulatory Guide 1.199, Revision 0. Members subjected to torsion or combined shear/torsion were designed in accordance with ACI 318-99, Section 11.6, as stated in Regulatory Position 15 of Regulatory Guide 1.142, Revision 2.

(Note: Governing load combinations are the same as those presented in ACI 349-97 as supplemented by RG 1.142 as they are in SRP 3.8.4. The load factors presented in SRP 3.8.4 in some instances exceed those within ACI 349-97/RG 1.142 for load cases which do not govern the design of the PSW Building. In either case the enveloping load combination is used (The same applies for ANSI/AISC N690-1984 vs. SRP 3.8.4). The Strength Design Method was used for concrete and Allowable Stress Design was used for steel. Separate load combinations were used for the analysis of steel and concrete.)

RAI 144 [EMCB9]

The ONS UFSAR mark-up, included in the licensee's letter dated March 16, 2012, describes the underground conduit duct banks associated with the PSW building. It specifically states that a second reinforced concrete duct bank/elevated raceway connects the PSW building to the Unit 3 auxiliary building. It also states that these structures are seismically qualified to the maximum hypothetical earthquake and designed to withstand missiles, wind and differential pressure associated with a tornado event.

Provide further information relative to the following:

a) The structural design criteria used for the design of the reinforced concrete duct banks and demonstrate compliance with Section 3.1.2 of the ONS UFSAR;

b) The procedures used for the analysis and design of the reinforced concrete duct banks for seismic and tornado missile load conditions and confirm that these duct banks have been designed for the relative movement at the locations where they enter and exit the respective structures; and

c) The method of protection against tornado wind and tornado missiles for the elevated (above ground) electrical raceway connecting the PSW building to the Unit 3 auxiliary building.

Duke Energy Response:

a) The PSW Ductbanks and related structures are designed for Natural Phenomena as specified in the UFSAR Section 3.1.2. Load combinations and structural design criteria are given in ONS specification OSS-0292.00-00-0001, Specification for Design and Implementation Support of the Protected Service Water System, Revision 2. (Note: The PSW system is not credited for mitigation of station damage from turbine missiles; therefore, turbine missiles are not considered in the design of PSW structures, systems, or components.)

   Load Combinations

   Load Combinations which govern the design of the PSW Ductbank are as specified in NUREG-0800, SRP 3.8.4, DRAFT Revision 2, ACI 349-97 as supplemented by Regulatory Guide 1.142, and ANSI/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4.

   (Note: Governing load combinations are the same as those presented in ACI 349-97 as supplemented by RG 1.142 as they are in SRP 3.8.4. The load factors presented in SRP 3.8.4 in some instances exceed those within ACI 349-97/RG 1.142 for load cases which do not govern the design of the PSW Ductbank. In either case the enveloping load combination is used. (The same applies for ANSI/AISC N690-1984 vs. SRP 3.8.4) The Strength Design Method was used for concrete and Allowable Stress Design was used for steel. Separate load combinations were used for the analysis of steel and concrete.)

Structural Design Criteria

Loads

- Dead loads consist of the weight of the structure plus all equipment and materials permanently fastened to, and supported by, the structure/component.
- Live loads are the loads produced by the use and occupancy of the ductbank. They include the weight of all movable loads, including personnel, tools, miscellaneous equipment and stored material. Areas subjected to roadway loads are designed for two American Association of State Highway and Transportation Officials (AASHTO) HS20 trucks passing simultaneously and Reactor Coolant Pump Motor transport trailer loadings.
- The design wind velocity is 95 mph. The applied wind pressures are computed by the means outlined in ASCE Paper No. 3269 which states that the equivalent static force on the building is equal to the dynamic pressure (q) times the drag coefficient (C_d) multiplied by the elevation area. (Oconee UFSAR Section 3.3.1)
- Seismic design response spectra as specified in Section 3.7.1.1 of the Oconee UFSAR. Critical damping values as specified in Section 3.7.1.3 of the Oconee UFSAR. Components of earthquake motion applied as specified in Section 3.7.2.5 of the Oconee UFSAR.
- Tornado loadings conform to Regulatory Guide 1.76, Revision 1.

Codes and Standards

- Concrete: Subsection C of Regulatory Guide 1.142, Revision 2 (i.e., ACI 349-97 (except for Appendix B) as supplemented by Regulatory Guide 1.142 and supplemented by Regulatory Guide 1.199, November 2003)
- Structural steel and plates: Subsection II.2 of Standard Review Plan (SRP) Section 3.8.4, DRAFT Revision 2 (i.e., ANSI/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4)
- Anchoring components and structural supports in concrete: Subsection C of Regulatory Guide 1.199 (i.e., Appendix B (February 2001) to ACI 349-01 as supplemented by Regulatory Guide 1.199)
- Foundations: Subsection II.3 of SRP Section 3.8.5, Subsection II.4.a of SRP Section 3.8.5, DRAFT Revision 2 (including SRP Section 3.7.2, DRAFT Revision 3 methods for combining three components of earthquake to compute overturning moment), Subsection II.5 of SRP Section 3.8.5, and NUREG/CR-6896, February 2006.
- Structural acceptance criteria: Subsection II.5 of SRP Section 3.8.4, DRAFT Revision 2.

b) Structural analysis and design of the reinforced concrete ductbanks, manholes and associated structural steel utilized a combination of hand calculations and Finite Element Analysis (FEA). Beam on Elastic Foundation analysis used conservative values for soil springs that yielded an upper bound of maximum forces on critical sections. Reinforcement required for critical sections was conservatively continued through the length of the reinforced concrete ductbank. The governing load cases for the design of the ductbank were tornado missile load combinations, except for lateral loads of below grade ductbanks. For lateral loads of below grade ductbanks, the SSE load combination governed and conservative analysis included applying mass inertial forces to the

ductbank without accounting for soil friction to resist lateral loads. This methodology is conservative in comparison to the methodology presented in ASCE 4-98 Section 3.5.2.

Ductbanks were analyzed for direct vertical missile impacts and soil cover was not included in the analysis to resist vertical missile strikes. Horizontal missiles were not included in the analysis for below grade ductbanks, but were included in the above grade ductbank analyses as direct strikes without any side soil cover to resist missile strikes.

New structures were analyzed to resist the shears and moments applied by the ductbanks and connections were analyzed for rigidity to ensure no differential movements would occur between structures. End connection details for the ductbanks at new structures include embedment of bent reinforcement into adjacent structures for a semi-rigid connection. Concrete placement was monolithic between walls of adjacent structures and sufficient tributary length of the ductbank to ensure adequate shear capacity was developed.

To isolate the PSW Ductbank structures from existing structures (i.e. Auxiliary Building, SSF Building/Trenches and existing Keowee trenches) a flexible connection was utilized to allow deflection under the design loads while still precluding water intrusion. An analysis to determine the deflection of the structures under the load combinations listed in part (a) above was compared to the gap provided by the flexible design to ensure accommodation of the expected deflections without applying loads to the conduits/cables housed within these structures.

(Note: fc' = 5,000 psi and fy = 60,000 psi for reinforced concrete design)

c) The above ground electrical raceway is a steel frame and plate structure that connects Manhole 7 (MH7) to the Technical Support Building (TSB) underground vault and spans above ground between the two structures. (Reference drawings O-398-A1-213 and 214) and contains safety related cable supported in cable trays. This structure is designed using the structural design criteria applied to the entire ductbank system, and as described in part (a) above. The raceway is rigidly connected to MH7 and the TSB Vault utilizing sixteen (16) embedded anchors at MH7 and TSB Cable Vault (eight (8) each wall of each structure). MH7, the TSB Cable Vault, the Overhead Cable Raceway, and anchorage between the three structures are all designed for worst case loads which may result from any of the applied loads on the structures. FEA models of each of these structures were developed congruently to ensure that no structure or connection will fail during a design basis event.

RAI 145 [EMCB10]

Provide further information relative to the evaluation of the existing underground commodities (if any) for the additional loads exerted by the PSW building foundation footprint to demonstrate that there will be no adverse effects on the existing underground utilities for all applicable design loading conditions.

Duke Energy Response:

Engineering change package EC 91832, "Underground Commodity Relocation," addressed the existing underground commodities within the PSW Building footprint. These commodities identified on drawing O-398-A1-302, "PSW Building, Underground Utility Composite Plan, Area of PSW Building," Revision B, are: an abandoned air pipe, Radwaste Facility sewer pipe,

existing catch basins and storm sewer (yard drain) pipes. Drawing O-398-A1-301, "PSW Building, Underground Utility Demolition Plan, Area of PSW Building," Revision A indicates the extent of demolition and drawing O-398-A1-303, "PSW Building, Enlarged Underground Utility Plan," Revision A, shows the commodity re-routing.

The abandoned air pipe was cut and capped at each end outside the PSW Building footprint to remove it from the extent of construction. The Radwaste Facility sewer pipe was cut and relocated outside the PSW Building footprint to the west and north sides of the PSW Building. The catch basins and storm sewer (yard drain) pipes were demolished within and around the PSW Building footprint and replaced with new catch basins and storm sewer (yard drain) pipes. The new storm sewer (yard drain) system of catch basins and pipes is located to the west and east of the PSW Building, except for one new 15-inch diameter storm sewer (yard drain) pipe. This pipe connects new catch basin CB #1000 on the west side and existing Manhole 2 (MH2), on the east side of the PSW Building. This storm sewer (yard drain) pipe, at its highest point, has an invert elevation 2'-9" below the bottom of the PSW Building foundation and is encased in concrete. There is no interface between the new 15" storm sewer pipe and the PSW Building below grade walls. Refer to drawings O-398-A1-304, "PSW Building, Underground Utility & Catch Basin Sections & Details," Revision A, and O-398-A2-401, "PSW Building, Elevation Sections & Details," Revision E. Therefore, the only commodity under the PSW Building foundation is the one new storm sewer line that is adequately protected by soil cover and concrete encasement from any adverse effects of PSW Building foundation loads.

RAI 147 [EMCB12]

Provide further information relative to the procedures used in calculating the dynamic lateral soil pressure for the design of below grade walls of the PSW building.

Duke Energy Response:

PSW Building external walls (below and above grade) are designed with the same reinforcement size and spacing from foundation level to roof. The horizontal tornado wind and missile impact load combination governs the design of the external walls above and below grade. The generated pressure due to horizontal tornado missile impact (298 kips load applied to 34.5 in^2 area) is much higher, by inspection, than dynamic lateral soil passive pressure. Therefore, the entire wall design governing load combination is bounded by the horizontal tornado wind and missile impact load combination.

In summary, the entire wall is designed based on the horizontal tornado wind and missile impact load combination that is much higher than dynamic lateral soil pressure load combination. Therefore, walls below grade can withstand dynamic lateral soil passive pressure.

RAI 148 [EMCB13]

Provide further information whether there are any existing SSCs, in the vicinity of the PSW building, that could have an adverse interaction with the PSW building.

Duke Energy Response:

There are three major SSCs in the vicinity of the PSW building that could have an adverse interaction with the PSW building. These SSCs are the "RCP Motor Refurbishment Facility," "Radwaste Facility" and the underground "CCW Piping System."

The effects of the "Reactor Coolant Pump (RCP) Motor Refurbishment Facility" and "Radwaste Facility" (RWF) on the PSW building integrity has been evaluated in calculation OSC-9230 "PSW Building Structural Analysis," Revision 0, Section 12.0. It is determined that failure of the "RCP Motor Refurbishment Facility" and "Radwaste Facility" during a seismic event would affect neither structural integrity, nor operability of the PSW Building during and after the seismic event.

The RCP Motor Refurbishment Facility is separated by adequate space, approximately 80', to prevent any adverse seismic interaction.

The RWF is a large, relatively low building (approximately 200 ft length x 140 ft width x 50 ft maximum height, 30 ft height adjacent to PSW Building) that is supported by a minimum 3 ft thick reinforced concrete foundation. Overturning of this structure is not considered a credible scenario during an SSE event.

The maximum load capacity ratio of RWF structural components is 0.8 under OBE seismic load combination. The reserve capacity of the structural components is available to resist the additional loading of an SSE event prior to the onset of localized failure mechanism formation. Complete global failure of the RWF superstructure during an SSE event is not considered a credible scenario. In the unlikely scenario of significant localized failures of RWF structural components adjacent to the PSW building the debris from such failures will not have an adverse impact on the structural integrity or operability of the PSW Building due to its own reserve structural capacity to withstand an SSE event (see OSC-9230, Revision 0, Section 12.0).

The Condenser Circulating Water (CCW) Piping System is located underground parallel to the PSW building east external wall. Concrete fill was placed adjacent to the CCW pipes and beneath the PSW Building foundation from elevation 788'-3," bottom of PSW footing, to approximate elevation 778'-3," the bottom of the existing CCW foundation. This massive concrete fill ensures that both structures are founded on the same subgrade and there is no adverse seismic interaction between the PSW Building and the CCW Piping System (reference drawing O-398-A1-304).

RAI 160 [EMCB15]

In response to RAI-62, the licensee included, in its letter dated January 20, 2012, Institute of Electrical and Electronic Engineers (IEEE) 344-1975 as one of the industry standards that is being used for the PSW system design. Discuss the seismic qualification method(s) used for electrical and mechanical equipment credited for the PSW system. Provide a summary of the seismic qualification results to demonstrate that all equipment credited for the PSW system including their subcomponents (relays, contacts, breakers etc.) are capable to perform their intended design function in the event of a safe shutdown earthquake (SSE) after a number of postulated occurrences of the operating basis earthquake (OBE). The response to this RAI, as a minimum, should include the test response spectra (if applicable), the required response spectra, the method of mounting of equipment to the shake table, and the equipment mounting configuration in service condition. Also, discuss the methodology, the industry codes and standards, the level of earthquake, and the acceptance criteria used for the structural design of the PSW equipment mounting.

Duke Energy Response:

The Duke Energy response to this request for information has three parts: I) Seismic qualification of electrical equipment, II) seismic qualification of mechanical equipment and III) anchorage as discussed below.

I. Seismic Qualification of Electrical Equipment

Seismic qualification of electrical equipment is outlined in Section 3.10 of the Oconee Updated Final Safety Analysis Report (UFSAR). For the PSW project, QA-1 electrical equipment was seismically qualified in accordance with IEEE 344-1975, which meets or exceeds the Oconee UFSAR requirements for qualification by testing or analysis. Qualification is performed for all electrical equipment using shake table testing, analysis or a combination of testing and analysis.

The NRC endorsed IEEE 344-1975, with exceptions, in Regulatory Guide 1.100, Revision 1. The exceptions were:

1) Section 5.3 – Use of the 1.5 static coefficient was found acceptable but a requirement was imposed for justifying its use.
2) Section 6.6.2.1 – This concerns single-frequency test input motion and that the resultant Test Response Spectrum (TRS) at the test frequencies must equal 1.5 times the acceleration of the required response spectrum (RRS). This section also allowed the TRS to not envelope the RRS, if the 1.5 factor was used. Justification is therefore required to use single frequency testing and for the TRS to not envelope the RRS.
3) Section 6.6.2.5 – For sine sweep testing, the TRS was again allowed to fall below the RRS by reference to Section 6.6.2.1. Sine sweep testing was deemed not suitable for equipment qualification unless justification was provided.
4) Section 8 – Documentation. Supplemental documentation is required related to equipment malfunction data.

For QA-1 electrical equipment, procurement documents were generated in accordance with Duke Energy's directive EDM-140 "Procurement Specifications for Equipment." Seismic demand at the equipment mounting location was included in those procurement documents. For new floor- and wall-mounted electrical enclosures, the applicable in-structure response spectra demand was used for the equipment mounting location. For components added to existing safety-related electrical enclosures, such as the electrical components added to the Oconee Main Control Boards, in-cabinet response spectra demand for the electrical component mounting locations was specified.

Procurement documents were used by the selected vendors to perform the qualification. Whether testing, analysis or a combination of testing and analysis was used; the vendors assured the resulting seismic capacity of the equipment enveloped the specified seismic demand. For testing, the 10% margin specified in IEEE 323 was included. Pre- and post-seismic functional testing was performed. All shake table testing consisted of five OBE earthquakes followed by SSE testing taking into account the electrical safety function of the equipment (i.e. contactors were evaluated in energized and de-energized states and for transition between those states and chatter was monitored in excess of 2 msec). In addition, random multi-frequency input was used for the testing as opposed to single-frequency and sine-sweep testing noted in the RG 1.100 exceptions #2 and #3 above. Any anomalies found through testing were documented in the qualification reports and given a disposition. Therefore, RG 1.100, Revision 1 Exceptions #2, #3 and #4 were addressed.

Qualification by analysis was used for some of the equipment following the methods given in IEEE 344-1975. The 1.5 multimode factor was used as appropriate and justified. Therefore, RG 1.100, Revision 1 Exception #1 has been addressed.

As part of the procurement, Duke Energy required an owner review and approval of the qualification plans prior to the qualification to insure the vendor's qualification method would

meet the owner's requirements. Vendor qualifications were documented in vendor qualification reports that were again owner reviewed. Final qualification reports were entered into Oconee Document Control and Records Management to maintain a record of the qualification. Qualification reports met the documentation requirements of IEEE 344-1975 and included seismic capacity versus demand comparisons. Because of the extensive list of electrical equipment, there is a corresponding extensive list of qualification documents.

The procurement documents also required the vendor to determine anchorage requirements. The qualifications documented the adequacy of that anchorage design and each vendor developed drawings to transmit the anchorage design. The drawings were used to anchor the equipment to the structures during implementation of the engineering changes. If problems arose with the vendor-defined anchorage, then site civil was contacted and they worked with the vendor to determine the acceptability of any changes.

Appendix AW of ONS calculation OSC-9506, "Generation of SSE In-Structure Seismic Response Spectra for the PSW Building," Revision 0, includes a figure on P. AW2 identified as PAW1 "Seismic Horizontal and Vertical FDS (5% Damping) and EPS, Elevation 818'." The purpose of that figure is to compare the final horizontal and vertical envelopes of the in-structure response spectra calculated for the center of the roof of the PSW Building against the conservative estimate of worst-case in-structure spectra referred to as "Equipment Procurement Spectra" (EPS). It should be noted that the EPS was determined, and used for procurement purposes for equipment with long lead-times, as the PSW Building response spectra analyses were being performed. When the final enveloped results were created for the operating floor, mezzanine, mid-height of the walls and the roof of the PSW Building, they were compared to the EPS in Appendices AT through AW. As shown in those plots, the EPS did indeed bound all of the PSW Building locations except for the vertical response at the center of the PSW Building roof.

Wherever the EPS was used for the procurement of electrical equipment, the procurement specifications included hold points to validate the seismic input(s). The hold points were removed by either revising the procurement specification to add the corresponding final envelopes from OSC-9506 or in some cases deviations to the procurement specifications were issued with the corresponding final envelopes from OSC-9506. In either case, the equipment that was initially procured using the EPS was qualified using the appropriate seismic in-structure spectra.

Seismic Qualification of Electrical Equipment

Specific Example – Motor Control Centers in the PSW and Auxiliary Buildings

Motor Control Centers (MCC) were included with the scope of PSW electrical equipment and are located in the Auxiliary and PSW Buildings. The requirements for procurement of the MCCs were documented in OSS-0308.00-00-0007, "Procurement Specification for the Design, Fabrication and testing of the QA-1, 600 VAC Motor Control Centers (MCCs) for the Protected Service Water (PSW) System," Revision 2. Nuclear Logistics Incorporated (NLI) was selected as the supplier and their qualification plan was documented in QP-29412392-1, "Qualification Plan for Motor Control Centers," Revision 3. Duke Energy approved that qualification plan and NLI performed the qualification. Seismic qualification of the equipment was documented in NLI Qualification Report QR-29412392-1, "Qualification Report for Motor Control Centers," Revision 4 which was filed as an Oconee vendor manual and placed in Oconee Document Control and Records Management. The vendor manual

number is OM 308.--531.001, "PSW – Seismic Qualification Report for Motor Control Centers XPSW, 1XPSW, 2XPSWA, 2XPSWB and 3XPSW," Revision 4.

The MCCs were qualified by a combination of shake table testing and analysis in accordance with IEEE 344-1975. Shake table testing was used to qualify the enclosures and equipment and analysis was used to qualify additional changes made after the completion of the shake table testing. For example, analysis was used to address vertical barriers added to the enclosures for personnel safety.

The MCCs consist of two different types based on physical location: 1) NEMA 3R MCCs for the Auxiliary Building and 2) NEMA 1 MCCs for the PSW Building. All of the MCCs were Freedom 2100 Series with a 600A main bus and were joined in sets connected on their sides. The largest sets have five sections bolted together and the smallest set has two sections bolted together.

One representative NEMA 1 enclosure was bolted to one representative NEMA 3R enclosure using the standard inter-cabinet bolting used for these enclosures. The bolted enclosure set was welded to a base plate to simulate the installed configuration in the final design drawings. The as-tested layout is shown on NLI Drawing 29412392-LDTS-1, "MCC Test Specimen Outline," Revision 3 that is given in Appendix D of the NLI Qualification Report. The base plate containing the set of two enclosures was fastened to the shake table using four 3/8" diameter bolts. The report states that four bolts used to anchor the set of two enclosures bounds the proposed field installation where four bolts were specified for each individual section (i.e. a set of two sections has a total of eight anchors in the field).

Each enclosure specimen included a representative set of electrical equipment. The equipment was selected by considering all of the equipment in all of the MCC enclosures and the relative mounting locations of that equipment within the enclosure. Traceability between the test specimens and the production units was given in Section 2.2 of the qualification report.

In-structure response spectra for the Auxiliary and PSW Buildings were included in the procurement specification. NLI created a composite envelope of those spectra and used it as the Required Response Spectra (RRS) input for the shake table testing. The Operating Basis Earthquake (OBE) at Oconee is one-half the Safe Shutdown Earthquake (SSE) so the RRS was factored by 0.5 for the OBE and taken as the full value for the SSE.

A comparison of the Test Response Spectrum (TRS), obtained from the control accelerometers, to the RRS for the SSE is shown in Figures 160.1 and 160.2 for the horizontal and vertical excitation directions respectively (Note: Figures 160.1 and 160.2 are provided in the RAI #160 supplemental information section of the Attachment to this letter).

An anomaly documented the fact that the TRS did not fully envelope the RRS below approximately 2 Hz for both excitation directions. Before the OBE and SSE testing, however, the vendor performed low-level sine-sweeps to determine the resonant frequencies of the enclosure set. Because the enclosure set did not have resonant frequencies in that range, the exceedance was deemed acceptable.

The testing consisted of five OBE tests followed by three SSE tests that covered the energized, de-energized and transition states of the electrical equipment. Two of the SSE tests were substituted for two of the OBE tests. The test series was conducted in four different specimen orientations at 0, 90, 180 and 270 degrees to capture the in-phase and out-of-phase response due to the dependent biaxial shake table.

QA-1 electrical equipment was subjected to pre- and post-seismic functional testing and was monitored for contact chatter in excess of two milliseconds during the shake table testing. The list of equipment, functional state, type of monitoring and acceptance criteria was given in Section 4.2.6 of the report for the three SSE tests. Equipment with no moving contacts (i.e. terminal blocks and fuse blocks) was monitored for continuity and non-safety equipment was evaluated for structural integrity (mounting) only. All of the equipment met the acceptance criteria except that the door on the NEMA 3R enclosure popped open during some of the testing. NLI resolved this issue by adding a small padlock to the door and then later qualified a hitch pin proposed by Duke Energy. The requirement to include the hitch pin to maintain seismic qualification was included on the final design drawings.

Anomalies were identified and addressed in an appendix to the test report.

Additional analysis was used to quantify anchorage loads to be used by Duke Energy. The qualification report references a separate NLI anchorage qualification report. The anchorage qualification report is QR-29411642-4, Revision 3 and was filed as an Oconee Vendor Manual OM 302.A-0072.004, "Mounting Base Design and Anchorage Loads for NLI Supplied Equipment," Revision 3.

Specific Example – Batteries and Battery Racks in the PSW Building

See Duke Energy's response to RAI-161 (submitted to the NRC on July 11, 2012) for the details of the qualification of the PSW batteries and racks.

II. Seismic Qualification of Mechanical Equipment

Specification ECV-0601.00-00-0005, Revision1 "Specification for the Seismic Qualification of Equipment" by Duke Energy Carolinas, LLC, Oconee Nuclear Station Units 1, 2 and 3 describes acceptable methods for seismic qualification of electromechanical equipment. The following governing design criteria documents and references are used, among others, as a basis for the seismic qualification:

- UFSAR:

  Section 3.7 "Seismic Design," Section 3.9 "Mechanical Systems and Components," Section 3.10 "Seismic Qualification of Category I Instrumentation and Electrical Equipment."

- Codes and Standards:

  IEEE Standard 344-1975.
  IEEE Standard 323-1974.

- Specifications:

  OSS -254.00-00-4010, "Design Basis Specification for Seismic Design," Revision 4.

- Regulatory Documents:

  USAEC RegGuide 1.60, December, 1973.
  USAEC RegGuide 1.61, October, 1973.
  USNRC RegGuide 1.100, Revision 1.

As QA -1, the PSW mechanical equipment (ME) seismic qualification is governed by the QA program requirements of 10CFR50, Appendix B, and applicable ONS's procurement, design, fabrication, and installation specifications supplemented by industry codes, standards, and US NRC regulatory guides. Procurement specifications cover the design, fabrication, testing, delivery, and quality assurance documentation of the equipment.

Seismic qualification of QA-1 equipment was treated as Class 1E equipment and therefore is governed by detailed requirements stipulated in IEEE Standards 344-1975 and IEEE Standards 323-1974.

IEEE Standards 344-1975 provide procedures which verify that Class 1-E equipment can meet its performance requirements during and following one SSE preceded by five (5) OBE seismic events. Section 4 of IEEE 344 provides acceptable methods used for seismic qualification as follows:

1. Analysis that would predict equipment performance (safety margins against code allowable for various operating and accident loading conditions).
2. Testing under simulated seismic conditions (for operability, and overall structural integrity determination).
3. Qualification by combined test and analysis.

Choice of qualification method is based on the type, size, shape, and complexity of the equipment and the desired reliability of the conclusion.

IEEE Standard 323-1974, Section 4, lists operating experience as a method of limited use as a sole means of seismic qualification but of great use for supplementation of testing. In addition, Section 6.3.1.5 lists margins (suggested factors) to be applied to service conditions (e.g., temperatures +15°F, pressure +10% ≤10 psi, etc.).

For the ONS PSW Project, Mechanical Equipment procurement specifications were issued to Duke Energy approved vendors. These specifications provided detailed seismic qualification requirements for the vendors to use. The following are examples of qualification by analysis and testing.

Examples:

1. Seismic Qualification by Analysis

   Equipment: Booster Pump
   Sulzer Report No.: PVA1000294590010-01, Revision 3.

   Procurement Specification:

   Details seismic testing requirements for any PSW mechanical equipment are provided in pertinent procurement specification. Specification OSS-0208.00-00-0015, "Protected Service Water Booster Pump," Revision 2 provides the following:

   - Section 2.5 of the specification addresses seismic requirements. It refers to ECV-0601.00-00-0005 for seismic conditions. This specification was generated by Duke Energy; the response Spectra is provided in the Attachment for RAI #160.
   - Section 6.0 addresses Quality Assurance requirements including documentation.
   - Section 8.0 addresses supplier's documents.
   - Section 10: Test and Inspection.
   - Section 14.0: Conformance with Specification.

   Seismic Qualification Analysis:

   Qualification Method:

   The seismic qualification analysis of the PSW system Booster Pump was performed using general purpose finite element code ANSYS. A three-dimensional (3-D) Finite Element Model (FEM) detailing mass, stiffness, and bolted connections of various

components of the pump, motor and mounting steel frame was developed. The model included contact elements to simulate bolted connections preload conditions and potential separation between contacted surfaces.

A natural frequency analysis was performed on the FEM and the results indicated that all calculated natural frequencies were above the Zero Period Acceleration (ZPA) frequency of 20 Hz. Accordingly, the pump assembly was, therefore, considered rigid and equivalent static analysis method was used to determine effects of OBE and SSE seismic loading conditions. The method includes the use of applicable ZPA accelerations, a static coefficient of 1.5, and the square-root-sum-of squares (SRSS) method to combine seismic responses in the three orthogonal directions (2 horizontal and 1 vertical).

Loads:

The following loads are considered in the qualification of the pump assembly:

1) Seismic OBE and SSE
2) Internal pressure
3) Nozzle loading
4) Dead weight
5) Thermal
6) Bolt pre-load

Summary of Results:

Following are Load/Capacity, (L/C) ratios (i.e., Calculated/ Allowable):

- Natural frequency: lowest frequency = 82 Hz > 20 Hz (ZPA):

  System is rigid

- Pump/ Pressure Boundary Components:

Casing;	L/C = 0.30 < 1.0	O.K.
Cover;	L/C = 0.35 < 1.0	O.K.
Bearing Housing;	L/C = 0.25 < 1.0	O.K.

- Bolting:

Case to Cover	L/C = 0.50 < 1.0	O.K.
Cover to Bearing Housing	L/C = 0.50 < 1.0	O.K.
Cover to Seal Housing	L/C = 0.50 < 1.0	O.K.
Pump Hold-down	L/C = 0.66 < 1.0	O.K.
Base Plate (stress)	L/C ≤ 0.78 < 1.0	O.K.
Base Plate (deflection)	L/C = 0.35 < 1.0	O.K.
Leakage;		
No leakage into bolt-holes predicted		O.K.

- Anchor Bolt Loads:

  Case 1: Gravity + Nozzle Loads + Motor Short-Circuit
  Calculated maximum Tension and Shear forces are less than allowable values.

  Case 2: Gravity + SSE Nozzle Loads + SSE
  Calculated maximum Tension and Shear forces are less than allowable values.

- Rotor Evaluation:

  Lateral Displacement: During SSE seismic = 22% of clearance. No touching
  Axial Thrust: During SSE seismic is negligible (< 1% of capacity)
  Coupling Deflection: During SSE seismic is negligible (= 1.7 % of allowable)

- Pipe Work:

  Piping Stress: L/C = 0.29 < 1.0 O.K.
  Nozzle Loads; Acceptable based on piping stresses meeting ONS Specification OS-027B-00-0001, Revision 8 requirements.
  Flange Analysis: L/C = 0.09 < 1.0 O.K.

Based on the above results, the capacity, C, of the evaluated components (as specified by the pertinent allowable values) far exceeds the seismic demand (i.e., the calculated load, L, values). Therefore, ample margins of safety exist against specified operating and seismic load combinations.

<u>Analysis Response Spectra:</u>

Section 3.1 of Sulzer's seismic analysis report lists applicable OBE seismic response spectra (RS) (where the Booster Pump will be mounted) for the Auxiliary Building, Floor El. 771', N-S, E-W, and vertical directions. The applicable RS are provided in procurement specification OSS-0208.00-00-0015, Revision 2 of the PSW Booster Pump.

2. <u>Seismic Qualification by Testing</u>

Equipment: Six inch (6") Velan forged bolted bonnet gate valves OM-245-2576, OM-245-2577 (DMV-1459, DMV-1488); Velan Operability Test Report (Duke Energy File No.): OM 245-2582.001, Revision 1.

Applicable Specifications:

- OSS-0245.00-00-0004, "ASME Section III and Oconee Safety Related Class F, 2.5 inch and larger, carbon and stainless gate, globe and check valves and operators (Duke Energy Class A, B, C and F) Revision 2.
- ECV-0601.00-00-0003, "Specification for Seismic Qualification of Valves for A.S.M.E. Section III and Duke Power safety Class F Applications," Revision 1.
- OSR-0245.00-00-0040, "Technical Requirements for Valve Numbers DMV-1459 and DMV-1488," Revision 1.

Seismic Qualification Test:

<u>Qualification Method:</u>

All active valves having extended structure such as actuators shall be functionally tested to ensure operability. While installed in a suitable test rig, the extended top works (i.e., the actuator and the yoke) of the valve was statically deflected by a load greater than the equivalent seismic load of the SSE. The load was applied at the center of gravity of the operator in the direction of the weakest axis of the yoke. Simultaneously, the design pressure of the valve was applied to the valve while in the closed position while the downstream of the valve was at atmospheric pressure.

To test operability under simulated SSE seismic load, the valve was operated from the closed position to the open position. The valve internal pressure was increased to the

design pressure and the valve closed while still being statically deflected. The opening and closing time was recorded, and checked against the specified operating time limits.

Loads:

- The subject valves are required to meet the acceleration values of 2.5g OBE and 5.0g SSE in each of the three (3) orthogonal directions (specification ECV-0601.00-00-0003, Revision 1).
- The required test side load is F = 10 W
  The test load is determined as follows:
  Resultant acceleration = $[\sqrt{(5.0^2 + 5.0^2 + 5.0^2)}]$ g + 1 g (dead weight) = 9.66 g
  Round up to 10 g
  Where:
  F = the minimum side load to be applied
  W = weight of extended mass

Summary of Results:

- No permanent deformation of the extended structure was recorded.
- The tested valves operated smoothly throughout the full open and close strokes with or without the application of the equivalent SSE static side force and pressure.
- Seat leakage did not exceed the specified limit of 2 ml (cc) per hour per inch of nominal size, in 10 minutes.
- The tested valves pressure boundary shells and packing did not leak.

III. Seismic Qualification of Anchorage

Load combinations and structural design criteria for anchorage of components in the PSW, Auxiliary, and SSF Buildings are given in ONS specification OSS-0292.00-00-0001, Specification for Design and Implementation Support of the Protected Service Water System, for SSE and OBE earthquakes.

Methodology:

All Buildings

- Attachments are QA-1.
- Seismic analysis of the attachment of electrical equipment uses a static coefficient factor of 1.5 for new designs.
- The design of concrete expansion anchors used to attach new and/or existing equipment are in accordance with specifications OSS-0020.00-00-0004, Specification for the Design, Installation and Inspection of Concrete Expansion Anchors, and OSS-0020.00-00-0006, Specification for the Design, Installation, and Inspection of Hilti Concrete Expansion Anchors.

PSW Building and Auxiliary Buildings

- Attachment of equipment is evaluated for worst-case resultant seismic loads by summing forces/moments produced by the vertical seismic acceleration and the controlling horizontal (east/west or north/south) seismic acceleration based on acceleration magnitude and attachment geometry (see Section 3.7.2.5 of the Oconee UFSAR).
- Critical damping values (used for the seismic analysis of the attachment of new and/or existing equipment) are as specified in Section 3.7.1.3 of the Oconee UFSAR.

SSF Building

- The seismic analysis of the attachment of equipment is performed in accordance with Section 6.3.8 of specification OSS-0176.00-00-0002, Design Specification for Standby Shutdown Facility and shall be evaluated for worst-case resultant seismic loads obtained by the square-root-of-the-sum- of-the-square (SRSS) of forces/moments produced by all three components of earthquake motion: vertical acceleration and both horizontal (east/west and north/south) accelerations. (Regulatory Guide 1.92, Revision 1, and Sections 9.6.3.1 and 9.6.4.3 of the Oconee UFSAR).

<u>Structural Acceptance Criteria:</u>

PSW Building

- Subsection II.5 of SRP Section 3.8.4 [DRAFT] Revision 2.

Auxiliary Building

- Section 20.2.3 of OSS-0254.00-00-3007, Design Basis Specification for the Auxiliary Building.

SSF Building

- Section 4.2.1 of OSS-0176.00-00-0002, Design Specification for Standby Shutdown Facility.

<u>Loads and Load Combinations:</u>

PSW Building

- Dead loads consist of the weight of the structure plus all equipment and materials permanently fastened to, and supported by, the structure/component.
- Live loads are the loads produced by the use and occupancy of the building or structure. They include the weight of all movable loads, including personnel, tools, miscellaneous equipment, movable partitions, cranes, hoists, parts of dismantled equipment, and stored material.
- Seismic design response spectra as specified in Section 3.7.1.1 of the Oconee UFSAR. Critical damping values as specified in Section 3.7.1.3 of the Oconee UFSAR. Components of earthquake motion applied as specified in Section 3.7.2.5 of the Oconee UFSAR.
- Load Combinations are as specified in NUREG-800, SRP 3.8.4, DRAFT Revision 2.

Auxiliary Building

- Sections 20.2.1 and 20.2.2 of OSS-0254.00-00-3007, “Design Basis Specification for the Auxiliary Building.”

SSF Building

- Section 6.2.1 of OSS-0176.00-00-0002, “Design Specification for Standby Shutdown Facility.”

Codes and Standards:

PSW Building

- Structural steel and plates: Subsection II.2 of Standard Review Plan (SRP) Section 3.8.4, DRAFT Revision 2 (i.e., ANSI/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4).
- Anchoring components and structural supports in concrete: Subsection C of Regulatory Guide 1.199 (i.e., Appendix B (February 2001) to ACI 349-01 as supplemented by Regulatory Guide 1.199).

Auxiliary Building

- Section 20.2.4 of OSS-0254.00-00-3007, "Design Basis Specification for the Auxiliary Building."

SSF Building

- Section 4.3.1 of OSS-0176.00-00-0002, "Design Specification for Standby Shutdown Facility."

Examples:

PSW Building

- OSC-9818, "PSW Battery and Battery Racks 0 PSW BC CPSW001 and 0 PSW CPSW002 Seismic Mounting Qualification," Revision 0.

Auxiliary Building

- OSC-9357, "Terminal Cabinet 1PSWCA0001 Seismic Mounting Qualification," Revision 0.

SSF Building

- OSC-1371, "Seismic Mounting of Electrical Equipment for the Standby Shutdown Facility," Revision 33.

Note: ONS calculation OSC-9506, "Generation of SSE In-Structure Seismic Response Spectra for the PSW Building," contains the response spectra used for the anchorage of all components within the PSW Building. Appendix AW, Page AW2 contains a plot which demonstrates the equipment procurement spectra is below the vertical design spectra at elevation 818'. As such, no QA-1 equipment is mounted to the ceiling (El. 818'-0") of the PSW Building. All components which are attached to the ceiling (lights, conduit, monorail, etc.) are qualified as QA-4 (Seismic Category II) using the spectra calculated in OSC-9506 and NOT the procurement spectra.

RAI 162 [EMCB17]

Discuss the methodology, the industry codes and standards, the level of earthquake, and the acceptance criteria used for the structural design of the battery rack structure and its anchorages.

Duke Energy Response:

1. Seismic Qualification of Electrical Equipment

   The battery racks were seismically qualified by seismic shake table testing and dynamic similarity in accordance with IEEE 344-1975 as discussed in the Duke Energy response to RAI-161. Because analysis was not used for this equipment qualification, the development methodology or industry codes and standards used by C & D Technologies, Inc (C&D) are not required as part of this qualification. This is acceptable because the structural design of the battery racks was successfully challenged via proof testing in accordance with IEEE 344-1975. The level of earthquake and acceptance criteria are discussed in the Duke Energy Response to RAI-161 (from the RAI response letter dated July 11, 2012)..

2. Anchorage

   Load combinations and structural design criteria for anchorage of the Battery Racks in the PSW Building are given in ONS specification OSS-0292.00-00-0001, "Specification for Design and Implementation Support of the Protected Service Water System, for SSE and OBE earthquakes."

   Methodology:

   Buildings

   - Attachments are QA-1.
   - Seismic analysis of the attachment of electrical equipment uses a static coefficient factor of 1.5 for new designs.
   - The design of concrete expansion anchors used to attach new and/or existing equipment are in accordance with existing Oconee anchor design specifications.
   - Attachment of equipment is evaluated for worst-case resultant seismic loads by summing forces/moments produced by the vertical seismic acceleration and the controlling horizontal (east/west or north/south) seismic acceleration based on acceleration magnitude and attachment geometry (See Section 3.7.2.5 of the Oconee UFSAR).
   - Critical damping values (used for the seismic analysis of the attachment of new and/or existing equipment) are as specified in Section 3.7.1.3 of the Oconee UFSAR.
   - Welds to embedded plates were specified by the vendor and confirmed within calculation OSC-9818, "PSW Battery and Battery Racks 0 PSW BC CPSW001 and 0 PSW CPSW002 Seismic Mounting Qualification," to be conservative.

Structural Acceptance Criteria:

- Subsection II.5 of SRP Section 3.8.4, DRAFT Revision 2.

Loads and Load Combinations:

- Dead loads consist of the weight of the structure plus all equipment and materials permanently fastened to, and supported by, the structure/component.
- Seismic design response spectra as specified in OSC-9506, "Generation of SSE In-Structure Seismic Response Spectra for the PSW Building."
- Load Combinations are as specified in NUREG-800, SRP 3.8.4, [DRAFT] Revision 2.

Codes and Standards:

- Structural steel and plates: Subsection II.2 of Standard Review Plan (SRP) Section 3.8.4, DRAFT Revision 2 (i.e., ANSI/AISC N690-1984 as supplemented by Appendix F of SRP Section 3.8.4).
- Anchoring components and structural supports in concrete: Subsection C of Regulatory Guide 1.199 (i.e., Appendix B (February 2001) to ACI 349-01 as supplemented by Regulatory Guide 1.199).

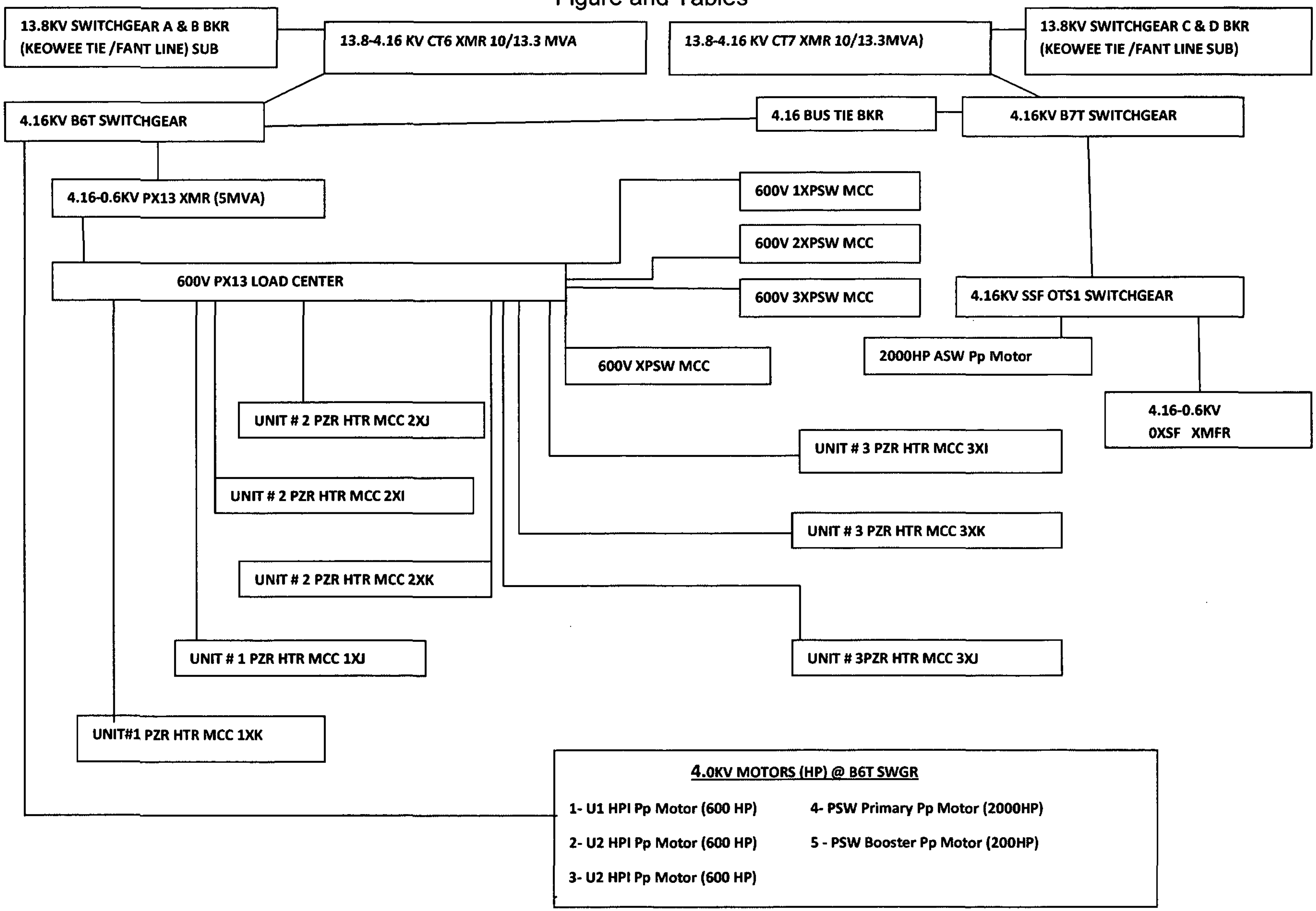
Attachment

RAI Item Supplemental Information

1. RAI #125 - 13.9kV, 4.16 kV, 600V Bus Figure and Tables (9 pages)
2. RAI #128 - DC Equipment Ratings and Voltage Drop Summary Table (1 page)
3. RAI #160 - Seismic Result Figures (2 pages)

RAI #125 (page 1 of 9):

Figure and Tables



RAI #125 (page 2 of 9):

ITEM	13.8KV SWITCHGEAR B6T-A &B BUS Rated @ 1200A LOAD DESCRIPTION/AMPACITY	LOAD (Amp)	Switchgear Breaker
1	Main Incoming Breaker B6T-A (Keowee Supply) OR B6T-B (Fant Line Substation Supply)	330A	1200A
	CT6 XMR Supply (PSW System Load & SFF House Loads) (@13.3MVA Max XMR FA Rating = 558A)	330A	N/A

ITEM	13.8KV SWITCHGEAR B7T-C &D BUS Rated @ 1200A LOAD DESCRIPTION/AMPACITY	LOAD (Amp)	Switchgear Breaker
1	Main Incoming Breaker B7T-C (Keowee Supply) OR B7T-D (Fant Line Substation Supply)	150A	1200A
	CT7 XMR Supply (SSF System Load & PSW House Loads) (@13.3MVA Max XMR FA Rating = 558A)	150A	N/A

NOTES:
1. 1HP= 1A @ 600V
2. 1KVA= 1A @ 600V
3. 1KW = 1A @ 600V
4.4KV Motors are considered with 1.15 SF for maximum loading.
5.208/120V loads connected to 15KVa, 45KVA XFMR are considered fully loaded to XFMR sizing.
6. Battery Charger 1Full Load bounds considering PSW Battery Charger 2 in Standby .

RAI #125 (page 3 of 9):

ITEM (Cub #)	**4.16KV SWITCHGEAR B6T** (Bus Tie-Breaker closed) **(BUS Rated @2000A)** **LOAD DESCRIPTION/AMPACITY**	LOAD (Amp)	Switchgear Breaker
1 (1)	Main Incomer Beaker	1089A	2000A
2 (2)	XFMR PSWTFPX13 Supply	479A	1200A
3 (3)	Alternate Supply to HPI INJC Pp Motor 1A/1B 600HP (1.15SF)	87A	1200A
4 (4)	Alternate Supply to HPI INJC Pp Motor 2A/2B 600HP (1.15SF)	87A	1200A
5 (5)	Alternate Supply to HPI INJC Pp Motor 3A/3B 600HP (1.15SF)	87A	1200A
6 (6)	PSW Main Pp Motor 2000HP(1.15SF)	288A	1200A
7 (7)	PSW Booster Pp Motor 200HP (1.15SF)	31A	1200A
8 (8)	SPARE		1200A
B7T (Load)	SSF Building House Loads (30A @ 4.30KV)	30A	1200A

ITEM (Cub #)	**4.16KV SWITCHGEAR B7T** (Bus Tie-Breaker Closed) **(BUS Rated @2000A)** **LOAD DESCRIPTION/AMPACITY**	LOAD (Amp)	Switchgear Breaker
1 (1)	Switchgear B6T & B7T BUS-Tie Breaker	*	2000A
2 (2)	Main Incoming Beaker	495A	2000A
3 (4)	SSF Loads OTS1 SWGR. (ASW Pp Motor & Lumped Max Load of 1500KVA @ 4.16KV)	449A	1200A
4 (3, 5)	SPARES		1200A
B6T (Load)	PSW Building House-Loads (314KVA @ 600V) (MCC XPSW Maximum Load less Submersible Pp motor Load)	46A	1200A

* The Tie-Breaker will have either 1059A or 449A or 46A or 30A considering the Tie-Breaker closed and either CT6 or CT7 providing power under PSW or SSF (Plant) event.

RAI #125 (page 4 of 9):

ITEM (Cub #)	<u>600V LOAD CENTER PX13</u> BUS Rated 5000A LOAD DESCRIPTION	LOAD (Amp)	Breaker SIZE (w/LSIG Units)
1 (5B)	Load Center Main Incoming Supply Breaker	3318A	5000AF 5000A Sensor 'A' * *Derated to 88% (4400A) per Qualification Report Section 5.
2 (1B)	Supply to PZR HTR MCC 3XJ	378A	800AF 600A Sensor 'C'
3 (1D)	Supply to PZR HTR MCC 3XI	210A	800AF 600A Sensor 'A'
4 (2A)	Supply to PZR HTR MCC 3XK	168A	800AF 400A Sensor 'A'
5 (2B)	Supply to PZR HTR MCC 1XJ	322A	800AF 800A Sensor 'A'
6 (2C)	Supply to PZR HTR MCC 2XJ	280A	800AF 600A Sensor 'A'
7 (2D)	Supply to PZR HTR MCC 2XK	168A	800AF 400A Sensor 'A'
8 (3B)	Supply to PZR HTR MCC 1XK	126A	800AF 400A Sensor 'A'
9 (3C)	Supply to MCC 2XPSWA	362A	1600AF 800A Sensor 'A'
10 (3D)	Supply to MCC 3XPSW	348A	1600AF 800A Sensor 'A'
11 (4B)	Supply to PZR HTR MCC 2XI	196A	800AF 600A Sensor 'A'
12 (4C)	Supply to MCC XPSW	414A	1600AF 1200A Sensor 'A'
13 (4D)	Supply to MCC 1XPSW	346A	1600AF 800A Sensor 'A'
14 (1A)	SPARE BREAKER	0A	800AF w/800A Sensor 'A'
15 (1C)	SPARE BREAKER	0A	800AF w/800A Sensor 'A'
	TOTAL LOAD (A)	3318A	

RAI #125 (page 5 of 9):

ITEM (Cub #)	600V MCC 1XPSW BUS Rated @600A LOAD DESCRIPTION	LOAD (Ampacity)	Breaker SIZE
1 (1A)	MCC Main Incoming Supply (MCC MAIN BUS RATED 600A)	345.5A	600A TM
2 (1D)	4HP STM GEN 1A & 1B Flow ISO MOV 1PSW6	4.0A	Size1 Starter W/ 20A TM
3 (2B)	0.17HP PSW STM 1A THROTTLE MOV 1PSW23	0.2A	Size1 Starter W/ 15A TM
4 (2D)	0.17HP PSW STM 1B THROTTLE MOV 1PSW25	0.2A	Size1 Starter W/ 15A TM
5 (3A)	2.6HP RCP Seal Flow Outlet CNTL MOV 1HP139	2.6A	Size1 Starter W/ 20A TM
6 (3C)	0.17HP RCP Seal Flow CNTL MOV 1HP140	0.2A	Size1 Starter W/ 15A TM
7 (3D)	2HP 1A HPI BWST Suction MOV 1HP24	2.0A	Size1 Starter W/ 15A TM
8 (4A)	3.3HP HP INJC to Reactor Inlet MOV 1HP26	3.3A	Size1 Starter W/ 20A TM
9 (4B)	PSW ALT Feed to Existing Battery Charger 1CA	159.0A	200A TM
10 (4C)	PSW ALT Feed to Existing Battery Charger 1CB	159.0A	200A TM
11 (4D)	Power PNL 1KPSW 15KVA XMFR	15.0A	30A TM
12 (3B, 5B, 5C, 5D & 5E)	SPARE TM BREAKERS		20A, 30A, 200A, 20A & 30A TM
13 (2A, 2C, & 5A)	SPARE STARTERS		Size1 Starter W/ 20A TM
	TOTAL LOAD (A)	345.5A	

RAI #125 (page 6 of 9):

ITEM (Cub #)	**600V MCC 2XPSWA/B** BUS Rated 600A LOAD DESCRIPTION/AMPACITY (A)	LOAD (Ampacity)	Breaker SIZE
1 (1A)	MCC Main Incoming Supply (MCC MAIN BUS RATED 600A)	361.2A	600A TM
2 (1D)	4HP PSW STM GEN 2A & 2B Flow ISO MOV 2PSW6	4.0A	Size1 Starter W/ 20A TM
3 (2A)	0.17HP PSW STM 2B THROTTLE MOV 2PSW25	0.2A	Size1 Starter W/ 15A TM
4 (2B)	0.17HP PSW STM 2A THROTTLE MOV 2PSW23	0.2A	Size1 Starter W/ 15A TM
5 (2D)	PSW Feed to Auto Transfer Switch for Control Battery Charger 2CA	159.0A	200A TM
6 (3D)	POWER PANEL 2PSWPL2KPSW 15KVA XFMR	15.0A	30A TM
7 (3E)	PSW PUMP ROOM EXH Fan 15HP	15.0A	50A TM
8 (3F)	PSW Feed to Auto Transfer Switch for Control Battery Charger 2CB	159.0A	200A TM
9 (4C)	0.66HP PSW RECIC MOV 0PSW 14	0.7A	Size1 Starter W/ 15A TM
10 (4D)	2.6HP RCP Seal Flow Injc Isolation CNTL MOV 2HP 139	2.6A	Size1 Starter W/ 20A TM
11 (5A)	3.3HP HP INJC to Reactor Inlet MOV 2HP26	3.3A	Size1 Starter W/ 20A TM
12 (5B)	0.17HP RCP Seal Flow CNTL MOV 2HP 140	0.2A	Size 1 Starter W/ 15A TM
13 (5C)	2HP 2A HPI BWST Suction MOV 2HP 24	2.0A	Size 1 Starter W/ 15A TM
14 (3C)	SPARE TM BREAKERS	0A	20A TM
15 (2C, 4B, 5D)	SPARE STARTERS	0A	Size1 Starter W/ 15, 20 & 20A TM
	TOTAL LOAD (A)	361.2A	

RAI #125 (page 7 of 9):

ITEM (Cub #)	600V MCC 3XPSW BUS Rated 600A LOAD DESCRIPTION	LOAD (Ampacity)	Breaker SIZE
1 (1A)	MCC Main Incoming Supply (MCC MAIN BUS RATED 600A)	347.5A	600A TM
2 (1D)	PSW PUMP ROOM EXH Fan 15 HP (Alternate Feed)	0.0A Standby	50A TM
3 (2A)	4 HP PSW STM GEN 3A & 3B Flow ISO MOV 3PSW6	4.0A	Size1 Starter W/ 20A TM
4 (2C)	0.17 HP PSW STM 3A THROTTLE MOV 3PSW23	0.2A	Size1 Starter W/ 15A TM
5 (3A)	0.17HP PSW STM 3B THROTTLE MOV 3PSW25	0.2A	Size1 Starter W/ 15A TM
6 (3B)	2.6HP RCP Seal Flow INJC Isolation CNTL MOV 3HP 139	2.6A	Size1 Starter W/ 20A TM
7 (3C)	0.17HP RCP Seal Flow CNTL MOV 3HP 140	0.2A	Size1 Starter W/ 15A TM
8 (3D)	2HP 3A HPI BWST Suction MOV 3HP 24	2.0A	Size1 Starter W/ 15A TM
9 (4A)	3.3HP HP INJC to Reactor Inlet MOV 3HP26	3.3A	Size1 Starter W/ 20A TM
10 (4B)	PSW Feed to Auto Transfer Switch for Control Battery Charger 3CA	159.0A	200A TM
11 (4C)	PSW Feed to Auto Transfer Switch for Control Battery Charger 3CB	159.0A	200A TM
12 (5A)	0.66HP PSW RECIC MOV 0PSW 14 (Alternate Feed)	0.0A	Size1 Starter W/ 15A TM
13 (5E)	Power Panel 3KPSW 15KVA XMR	15.0A	30A TM
14 (5D)	2-1HP Emergency Cooling Priming Pp Motors	2.0A	20A TM
15 (4D, 5B, 5C)	SPARE TM BREAKERS	0A	30A, 30A & 200A TM
16 (2B,2D)	SPARE STARTERS	0A	Size1 Starter W/ 20A TM
	TOTAL LOAD (A)	347.5A	

RAI #125 (page 8 of 9):

ITEM (Cub #)	600V MCC XPSW BUS Rated 600A LOAD DESCRIPTION	LOAD Ampacity	Breaker SIZE w/CL (Current Limiter)
1 (1C)	MCC Main Incoming Supply MAIN BUS RATED 600A	414A	600A TM
2 (2A)	PSW BLDG 208/120V Distribution PNL LP1 (45KVA XFMR)	45A	60A TM W/CL
3 (2C)	HVAC (Safety Related) Loads Heating &Ventilation Panel (PSWPLEC01) (2-3HP(TR/EF), 2-10HP(BR/EF), 2-6KW(BR/HTR), 2-30KW(TR/HTR), 2KVA - CNTL/XMR)	100A	150A TM W/CL
4 (3A)	HVAC (Safety Related) Loads Heating &Ventilation Panel (PSWPLEC02) 2-3HP(TR/EF), 2-10HP(BR/EF), 2-6KW(BR/HTR), 2-30KW(TR/HTR), 2KVA (CNTL/XMR)	0.0 Standby	150A TM W/CL
5 (3B)	HVAC (Non-Safety Related) Loads ISO XMR PSW TF203A/205A (600/480V) powering (2-Circuits Each Fused with 10A Fuse) 2-3HP AC Comp , 2-1/8HP Cooling Fans & 2-CNTL XMRs (480V/24V) Isolation XMR)	6.5A	20A TM W/CL
6 (3C)	HVAC (Non-Safety Related) Loads ISO XMR PSW TF204A/206A (600/480V) powering (2-Circuits Each Fused with 10A Fuse) 2-3HP AC Comp , 2-1/8HP Cooling Fans & 2-CNTL XMRs (480V/24V) Isolation XMR)	6.5A	20A TM W/CL
7 (3D)	PSW Battery Charger 1	82.0A	125A TM W/CL
8 (4A)	PSW Battery Charger 2	0.0A Standby	125A TM W/CL
9 (4D)	100HP Submersible Pp Motor (Size 4 Starter)	100A	150A TM W/CL
10 (5A)	HVAC (Non-Safety Related) Loads (XMR Room Condenser PSWAH201&201A) 2-Circuits for Compressors & Condensers Fused with 45A & 10A Fuse respectively. 2-15HP Compressors, 2-1HP Cooling Fans, 1-5HP 1-Condenser & 1-CNTL XMR	37A	90A TM W/CL
11 (5B)	HVAC (Non-Safety Related) Loads (XMR Room Condenser PSWAH202&202A) 2-Circuits for Compressors & Condensers Fused with 45A & 10A Fuse respectively. 2-15HP Compressors, 2-1HP Cooling Fans, 1-5HP 1-Condenser & 1-CNTL XMR	37A	90A TM W/CL
12 (2B, 4B, 4C, 5C,5D)	(SPARE TM BREAKERS)	0A	50A,125A, 125A, 70A 125A ALL TM BKR W/CL
	TOTAL LOAD (A)	414A	

RAI #125 (page 9 of 9):

ITEM (Cub #)	UNIT 1 600V MCC 1XK & 1XJ (600A BUS) (PRESSURIZER HEATERS LOADS) (LOAD DESCRIPTION)	LOAD Ampacity(A)
1	MCC 1XK 126 KW Total Pressurizer Heaters Load	126A
2	MCC 1XJ 322 KW Pressurizer Load	322A

ITEM (Cub #)	UNIT 2 600V MCC 2XK, 2XJ & 2XI (600A BUS) (PRESSURIZER HEATERS LOADS) LOAD DESCRIPTION/AMPACITY (A)	LOAD Ampacity
1	MCC 2XK 168 KW Total Pressurizer Heaters Load	168A
2	MCC 2XJ 280KW Pressurizer Load	280A
3	MCC 2XI 196 KW Total Pressurizer Heaters Load	196A

ITEM (Cub #)	UNIT 3 600V MCC 3XK, 3XI & 3XJ (600A BUS) (PRESSURIZER HEATERS LOADS) LOAD DESCRIPTION/AMPACITY (A)	LOAD Ampacity
1	MCC 3XK 168 KW Total Pressurizer Heaters Load	168A
2	MCC 3XJ 378 KW Pressurizer Load	378A
3	MCC 3XI 210 KW Pressurizer Load	210A

RAI #128 (page 1 of 1)

DC Equipment Ratings and Voltage Drop Summary

Equipment Description	DC Load Component	Device Manufacturer	Manufacturer Model #	Minimum Rated Equipment Voltage, VDC	Maximum Rated Equipment Voltage, VDC	Minimum Calculated Panel Voltage , VDC	Minimum Required Panel Voltage to Ensure Sufficient Voltage at Equipment Terminals, VDC	Maximum DC System Voltage (Battery Float Voltage), VDC (note 1)	COMPONENT REFERENCES
13.8kV Circuit Breakers	Breaker Close Coil	Square D	52/CC	100.00	140.00	119.01	Bounded by the minimum required panel voltage for the Switchgear Charging Motor (SCM) on PSWPL1DC of 104.65 VDC	133.83	OM-302A.0080.001, OSC-9190, OSC-9844
	Breaker Trip Coil	Square D	52/TC	70.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	Breaker Charging Motor	Square D	52M	100.00	140.00	119.01	104.65	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
4.16kV Circuit Breakers	Breaker Close Coil	Square D	52/CC	100.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	Breaker Trip Coil	Square D	52/TC	70.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	Breaker Charging Motor	Square D	52M	100.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
13.8kV-4.16kV Relaying	50/51, 51, 51N Relays	ABB	51, 51I, 51L, 51D, 51M	70.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	27 & 27/59 Relays	ABB	27/59, 27N	100.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	52bX Relays	Eaton	D26	89.80	132.00 (note 6)	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844, OM 302.A--0097.002, Eaton TIP D26 dated 10/1/87
	27/59X, 86X Relay	Eaton	D26	89.80	132.00 (note 5)	119.20	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844, OM 302.A--0097.002, Eaton TIP D26 dated 10/1/87
	50G Relay	ABB	GR5	100.00	137.50	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	86 Lockout Relay	Electroswitch	Series 24 LOR	38.00	140.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	94 Relay	ABB	AR	100.00	137.50 (note 2)	119.20	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	87 Relay	ABB	HU-1	(note 3)	(note 3)	119.20	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
	TDA & TDV Relays	Crompton Inst	253-TAR, 253-TVR	100.00	250.00	119.01	Bounded by SCM	133.83	OM 302.A--0080.001, OSC-9190, OSC-9844
600VAC Circuit Breakers	Breaker Close Coil	Square D	MX	90.00	140.00	119.01	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
	Breaker Trip Coil	Square D	XF	70.00	140.00	119.01	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
	Breaker Charging Motor	Square D	MCH	90.00	140.00	119.01	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
600VAC Misc. Loads	27N UV Relay	ABB	27N	100.00	140.00	119.20	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
	52X Relay	Eaton	D26	<102.00	132.00 (note 6)	119.20	Bounded by SCM	133.83	OM-303.0222.001, OSC-9190, OSC-9844, Eaton TIP D26 dated 10/1/87
	Micrologic Controller External Power Supply	Phoenix Contact	QUINT-PS	90.00	350.00	119.20	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
	Bus Monitor (CM4000T)	Power Logic	Series 4000	100.00	300.00	119.20	Bounded by SCM	133.83	OM 303.--0222.001, OSC-9190, OSC-9844
5kV Transfer Switch 1HPISXTRN001/2	DC-DC Converter	Schaefer	C 2554-U009	80.00	160.00	117.83	80.09	133.83	OSC-9335
5kV Transfer Switch 2HPISXTRN001/2	DC-DC Converter	Schaefer	C 2554-U009	80.00	160.00	118.53	80.11	133.83	OSC-9336
5kV Transfer Switch 3HPISXTRN001/2	DC-DC Converter	Schaefer	C 2554-U009	80.00	160.00	118.86	80.11	133.83	OSC-9337
1PSWSXTRN001/2	Auto Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	117.83	100.06	133.83	OSC-9190, OCS-9536
2PSWSXTRN001/2	Auto Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	118.53	100.12	133.83	OSC-9190, OCS-9536
3PSWSXTRN001/2	Auto Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	118.86	100.12	133.83	OSC-9190, OCS-9536
0PSWSXTRN006	Manual Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	118.53	100.02	133.83	OSC-9190
0PSWSXTRN007	Manual Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	118.53	100.02	133.83	OSC-9190
0PSWSXTRN008	Manual Transfer Switch Interposing Relays	Struthers Dunn	219 Series	100.00	137.50	118.53	100.02	133.83	OSC-9509
PSWLXDC01 Bus Loads	64 Relay	Bender	IRDH365-323	76.00	286.00	119.44	Bounded by NGV	133.83	OM 306--0123.001, OM-306.0107.001, Bendor Price List
	RK-170 Relay	Bender	RK-170	20.00	297.00	119.44	Bounded by NGV	133.83	OM 306.--0123.001
	27 Relay	GE	12NGV17A2F	100.00	140.00	119.44	100.01 (note 4)	133.83	OM 306.--0123.001

Notes:

1. Per OSC-10055, battery float voltage is 132.5 VDC +/-1%. Therefore, maximum voltage at the equipment at any time is conservatively assumed to be equal to the maximum battery float voltage which is 1.01 x 132.5 = 133.83VDC
2. For Maximum Rated Voltage, 10% above nominal voltage is assumed if value is not available from vendor documents. This assumption complies with the 13.8/4.16kV switchgear specification OSS-0302.0A-00-0001 Revision 2
3. DC supply voltage is only used to operate a "target" and does not affect relay operability.
4. Assumed 5ft of #12 AWG internal wire to determine minimum voltage required at bus for relay operation.
5. 27/59X and 86X relays are normally de-energized. These relays are only energized during fault conditions. Short term overvoltages have no impact on coil operation. These relays are therefore acceptable for the application in which they are used.
6. 52bX and 52X relays are continuously energized and are exposed to a voltage above the manufacturer's rated voltage. The issue will be resolved prior to placing the equipment in service (PIP O-12-08004 written to track the issue).

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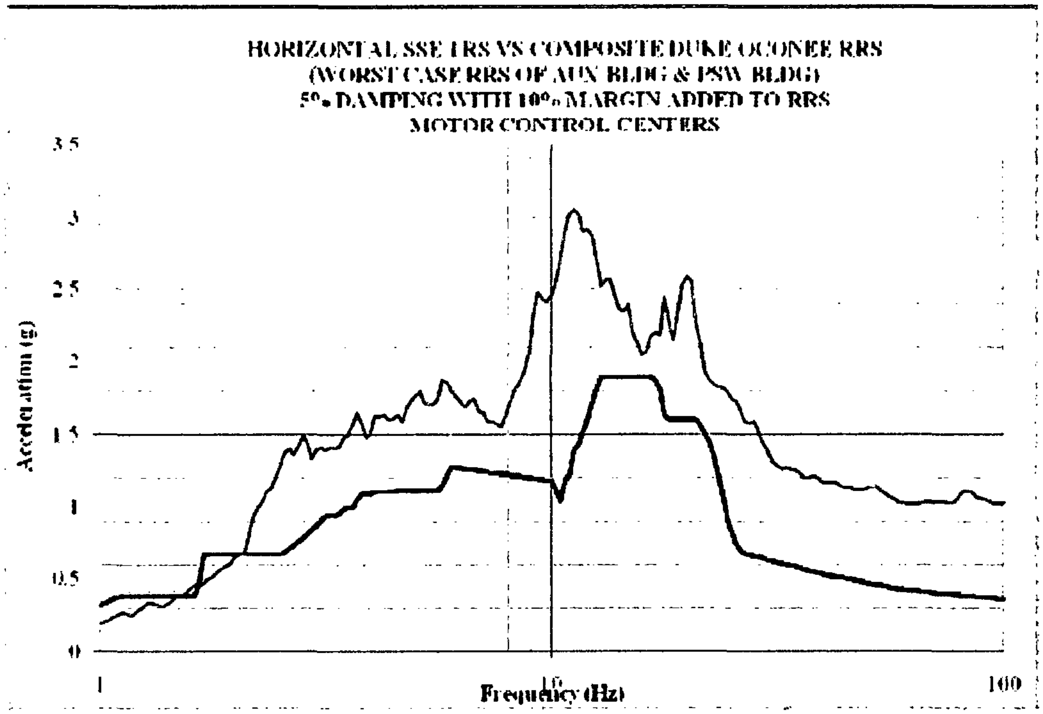
Figure 160.1



Note: The horizontal TRS is the worst case of the front-to-back and side-to-side test runs.

Legend:
Required Response Spectra (RRS)
Test Response Spectra (TRS)

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Figure 160.2

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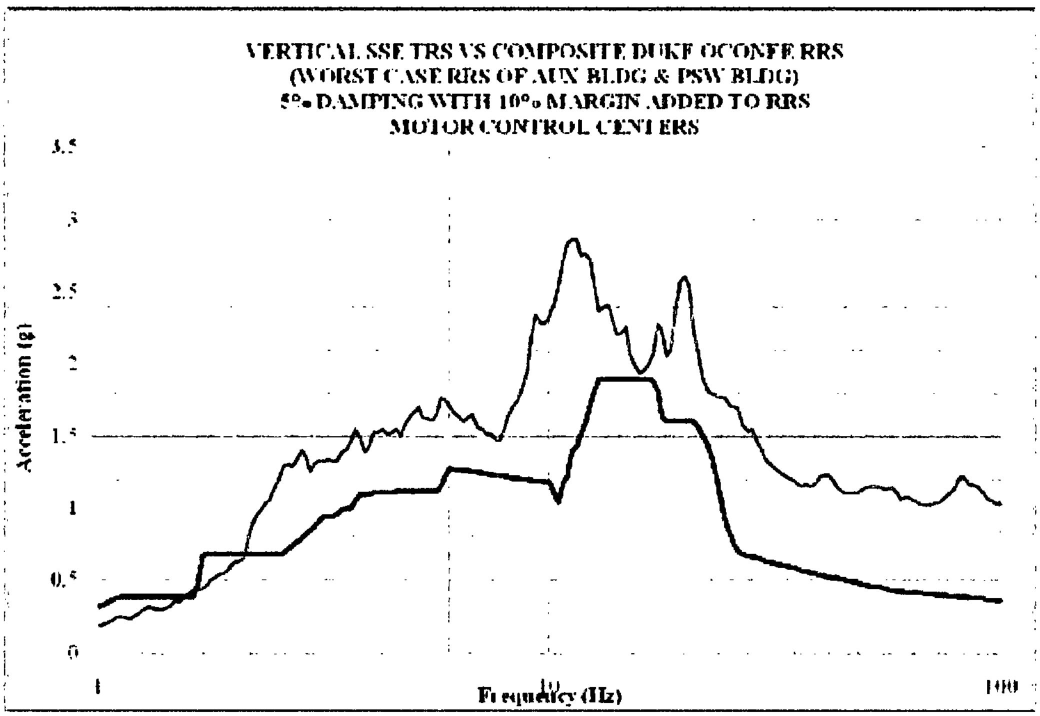
Nuclear Logistics. Inc.	Page A-5



Legend:

Required Response Spectra (RRS)

Test Response Spectra (TRS)