Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

March 3, 2004

10 CFR 50.59(c)(2)
10 CFR 50.90

TVA-SQN-TS-03-10

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

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2 - TECHNICAL SPECIFICATIONS (TS) CHANGE 03-10 - LICENSE AMENDMENT REQUEST (LAR) FOR THE SEISMIC QUALIFICATION OF THE MAIN CONTROL ROOM (MCR) AIR DELIVERY COMPONENTS AND SUSPENDED CEILING

Pursuant to 10 CFR 50.90, TVA is submitting a request for an Operating License change to License DPR-77 and -79 for SQN Units 1 and 2. The proposed change provides an amendment to SQN's design and licensing basis for the seismic qualification of round flexible ducting and triangular ducting installed as part of the suspended ceiling air delivery system in the MCR. The amendment revises the SQN Updated Final Safety Analysis Report (UFSAR) and Technical Specification Bases (TSB) to describe the qualification of the ductwork. The proposed revisions were reviewed under the requirements of 10 CFR 50.59, "Changes, Tests and Experiments." Based on this review, it was concluded that a license amendment is required in accordance with 10 CFR 50.59(c)(2).

A025
A053

The qualification of this ductwork was previously addressed in TVA's letter to NRC dated August 16, 2002, responding to Allegation No. RII-2002-A-0059. The concerns addressed by the allegation are documented in TVA's Corrective Action Program.

The SQN MCR ductwork was identified as not having qualification to the level described in SQN's current UFSAR, and accordingly, revision to SQN's UFSAR and TSB is proposed in the enclosed amendment request. It may be noted that TVA's Watts Bar Nuclear Plant (WBN) provided a similar license amendment request that was recently approved by NRC letter dated February 12, 2004.

TVA has determined that there are no significant hazards considerations associated with the proposed change and that the TS change qualifies for categorical exclusion from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9). Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter and enclosures to the Tennessee State Department of Public Health.

There are no regulatory commitments in this submittal and TVA has not defined a specific schedule or milestone by which the approval of the amendment is desired. TVA requests that once the amendment is approved, 45 days be allowed for implementation. If you have any questions concerning this change, please contact me at (423) 843-7170 or James D. Smith at (423) 843-6672.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 3 day of March, 2004.

Sincerely,

Pedro Salas
Manager of Licensing and Industry Affairs

Enclosures
cc: See page 3

Enclosures:
1. TVA Evaluation of the Proposed Changes
2. TVA Drawing 47W930-3
3. Relevant Sections of SQN Calculation and ABS Report
4. Changes to Updated Final Safety Analysis Report - (mark-up)
5. Changes to Technical Specifications Bases Pages-(mark-up)
6. Comparison of Alternate QA Requirements with Appendix B QA Requirements

cc (Enclosures):

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

1.0 DESCRIPTION

This letter provides a license amendment request (LAR) that includes revisions to the SQN Updated Final Safety Analysis Report (UFSAR) and the Technical Specification Bases (TSB). The proposed revisions are provided in response to TVA's Corrective Action Program and identification of an issue that determined the main control room (MCR) air delivery components at SQN are not qualified to the level currently described in the SQN UFSAR. A proposed UFSAR revision is enclosed that describes the basis for seismic qualification of round flexible ducting, triangular ducting, and associated air bars installed as part of the suspended ceiling air delivery system in SQN's MCR. The UFSAR and TSB revisions for the qualification of the ductwork were reviewed under the requirements of 10 CFR 50.59, "Changes, Tests and Experiments." Based on this review, it was concluded that a LAR is required in accordance with 10 CFR 50.59(c)(2).

The following sections of the UFSAR are proposed for revision in this LAR:

- Table 3.2.1-2, "Summary of Criteria-Mechanical System Components (Excluding Piping)"
- Table 3.2.2-3, "Non-Nuclear Safety Classifications"
- Figure 9.4.1-1, "Control Room Air Conditioning System (CRACS)"

In addition to the UFSAR revisions, a new section will be added to the UFSAR to specifically address the qualifications of the suspended ceiling and air delivery components.

- Section 3.7.3.16, "Seismic Qualifications of Main Control Room Suspended Ceiling And Air Delivery Components"

The following section of the TSB is also proposed for revision in this LAR:

- 3/4.7.15, "Control Room Air Conditioning System (CRACS)"

2.0 PROPOSED CHANGE

The revisions and additions proposed for SQN's UFSAR are detailed in Enclosure 4. The proposed UFSAR revisions describe the round flexible ducting, the triangular ducting, and the associated air bars installed as part of the suspended ceiling air delivery system in SQN's MCR. The proposed revisions incorporate the design features and facts about the system as outlined below:

1. The ducting is seismically qualified Category I(L) and will remain in place during a Safe Shutdown Earthquake (SSE).

2. The physical configuration of the ducting will be maintained such that air flow will not be impeded.

3. The ducting pressure boundary will not be lost during or subsequent to an SSE.

4. The flexible ducting, triangular ducting, and air bars are constructed of standard commercial-grade materials.

5. The seismic qualification methodology used for the suspended ceiling and air delivery components (i.e., the flexible ducts, triangular ducts, and air bars) is described and added as a new section of SQN's UFSAR (Section 3.7.3.16).

6. The configuration and pressure requirements for the flexible ducting, triangular ducting, and air bars are updated and reflected in UFSAR Figure 9.4.1-1.

The proposed revision to SQN's TSB is detailed in Enclosure 5. The revision affects Bases section 3/4.7.15 entitled "Control Room Air-Conditioning System (CRACS)." A subsection to 3/4.7.15 is entitled "Applicable Safety Analysis," and is revised to include a description of the CRACS supply air ducting and qualification requirements.

The following provides the revised subsection and includes italicized text to indicate the added information:

"The CRACS components are arranged in redundant, safety-related trains. During normal and emergency operation, the CRACS maintains the temperature at or below the continuous duty rating of 104°F for equipment and instrumentation. A single active failure of a component of the CRACS, with a loss of offsite power, does not impair the ability of the system to perform its design function. Redundant detectors and controls are provided for control room temperature control. *A portion of the CRACS supply air ducting serving the MCR consists of round flexible ducting, triangular ducting constructed of duct board, and connecting metallic flow channels called air bars. These components are qualified to Seismic Category I(L) requirements, which will ensure 1) the ducting will remain in place, 2) the physical configuration will be maintained such that flow will not be impeded, and 3) the ducting pressure boundary will not be lost during or subsequent to a SSE.* The remaining portions of CRACS ~~is~~ *are* designed in accordance with Seismic Category I requirements. The CRACS is capable of removing sensible and latent heat loads from the control room, which include consideration of equipment heat loads and personnel occupancy requirements, to ensure equipment Operability."

In summary, the changes described above provide an appropriate level of qualification and controls for SQN's MCR supply air duct and system components.

3.0 BACKGROUND

The heating, ventilation, and air-conditioning (HVAC) system (including ductwork) of SQN's Control Building (CB) is designed to maintain the temperature and humidity of the MCR. This function is provided for personnel comfort and protection, operation of plant controls by plant personnel, and to support the uninterrupted occupancy of the Main Control Room Habitability Zone (MCRHZ). The CB HVAC system is designed to function during normal plant operation, accident conditions, and post-accident recovery conditions.

The system also maintains a positive pressure in the MCRHZ with respect to the outdoors and the adjacent shutdown board room to minimize air in-leakage for all operating modes except during a tornado. Supply air ducting, located above the MCR suspended ceiling, consists of rectangular sheet metal, round flexible ducts, triangular-shaped ducts (constructed of duct board), and linear diffusers called air bars. All of the sheet metal ducting (both supply and return) is qualified to the Seismic Category I criteria and methodology described in UFSAR Section 3.7.3, "Seismic

Subsystem Analysis." Supply air from each rectangular duct flows into the flexible ducts prior to entering the triangular-shaped ducts that are attached directly to the linear diffuser air bars. The air bars are also primary structural members in the suspended ceiling grid work. The triangular-shaped ducts act as plenums for each air bar such that air is evenly distributed to the MCR from the suspended ceiling. Return air from the MCR flows through other air bars in the suspended ceiling and into the area above the suspended ceiling prior to entering the sheet metal return air ducts. The suspended ceiling air bars support the triangular ducting.

Provided below are two simplified drawings of the MCR ductwork and ceiling configuration. This information is provided to clarify the various components and terms used in the discussion of the MCR HVAC and ceiling. Figure 1 depicts the general arrangement of the MCR suspended ceiling and ductwork. Figure 2 was taken from TVA Drawing 47W930-3. This drawing is provided in Enclosure 2 and contains details of the configuration of the HVAC system:

Figure 1
MCR Suspended Ceiling and Ductwork

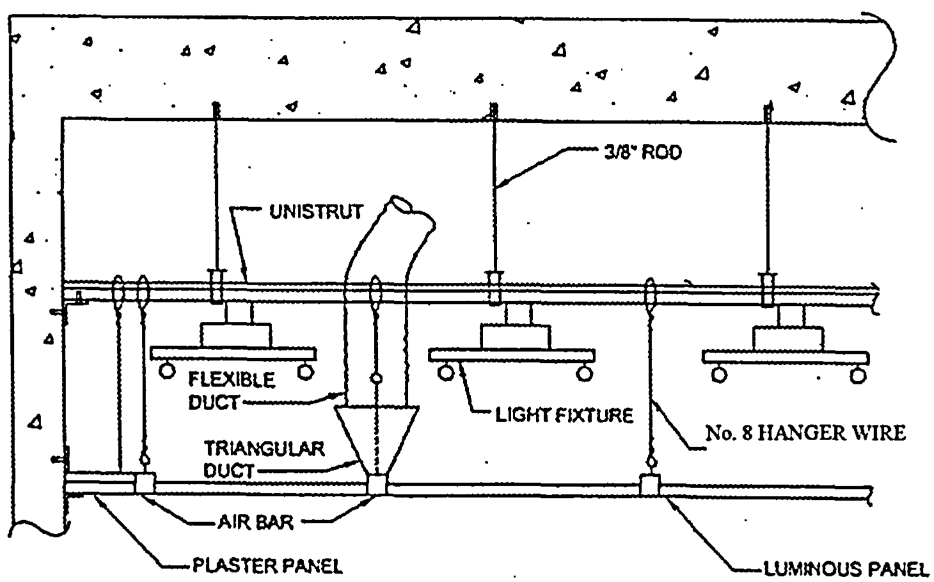
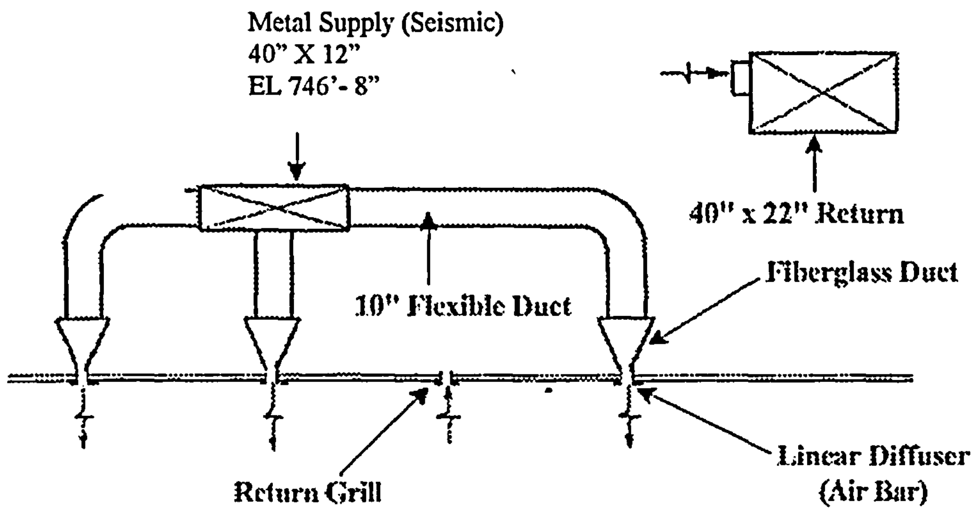


Figure 2
MCR Ductwork Configuration (from TVA Drawing 47W930-3)



TVA reviews established that the procurement documents for the flex and triangular ducts did not specify seismic requirements for the components. This led to the conclusion that the air delivery components were not qualified to Seismic Category I requirements in accordance with Regulatory Guide 1.29, "Seismic Design Classification" and were not procured and installed in accordance with applicable QA requirements. The following provides a description of the 10 CFR 50.59 evaluation and the results:

<u>Criteria: 10 CFR 50.59(c)(2)(ii)</u>
Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a structure, system or component (SSC) important to safety previously evaluated in the UFSAR (as updated).

<u>Evaluation Results:</u>
SQN Design Criteria SQN-DC-V-3.2, "General Design Criteria for the Classification of Heating, Ventilating, and Air Conditioning Systems," requires the safety-related ducting for the CB HVAC system to be classified as American Nuclear Society (ANS) Safety Class 2b. This is consistent with the pertinent requirements of a 10 CFR 50, Appendix B Quality Assurance (QA) Program as required by 10 CFR 50, Appendix A, General Design Criteria (GDC) 1. The Appendix B requirements are translated into the Design Criteria and the USFAR by

specifying the industry application standard for metal ducting, American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME) N509, "Nuclear Power Plant Air Cleaning Units and Components," and by invoking the requirements of the Nuclear QA Plan. Since the flexible and triangular ducting were not designed, procured, and installed in accordance with an Appendix B QA program, alternate acceptable limited QA requirements for this ducting are applied and are considered appropriate for this design application. However, this QA classification change does decrease the qualification/safety classification for the ductwork, and results in the 50.59(c)(2)(ii) being met.

Criteria: 10 CFR 50.59(c)(2)(viii):
Result in a departure from a method of evaluation described in the UFSAR (as updated) used in establishing the design bases or in the safety analyses.

Evaluation Results:
SQN Design Criteria SQN-DC-V-3.2 requires the safety-related ducting for the CB HVAC system to be classified as Seismic Category I. The Seismic Category I classification for the system is also discussed in Section 3.2.1 of the UFSAR. This is consistent with the pertinent sections of Regulatory Guide 1.29.

The seismic qualification criteria and methodology for Seismic Category I and I(L) systems and components are described in UFSAR Section 3.7, "Seismic Design." However, neither UFSAR Section 3.7 nor any other UFSAR section specifically described qualification of the MCR air delivery components (flexible ducts, triangular ducts, and air bars).

The key fact in seismic qualification of the air delivery components is demonstration that the aluminum air bars remain structurally stable and provide continuous support for the triangular ducts. This demonstration is contained in a qualification report prepared by ABS Consulting (formerly EQE, Incorporated) for TVA. Relevant sections of the ABS report are provided in Enclosure 3. An ANSYS model was used for this demonstration and the results are described on page 23 of the Enclosure 3 report. Qualification of the attached triangular duct and flexible duct is then justified as described on pages 23 through 26 of the Enclosure 2 report.

The qualification report prepared by ABS Consulting documents a transient dynamic finite element analysis of the air delivery components. The analysis considers nonlinearities and seismic time history inputs per proposed UFSAR Section 3.7.3.16. The dynamic analysis is generally more realistic and reduces conservatism in some aspects relative to linear elastic analysis methods. For example, the linear elastic analysis criteria would require assumption of: 1) low-structural damping; and 2) no gaps, impact loads, internal friction or other non-linear effects. For the suspended ceiling, where the luminous panels represent a large portion of the overall mass (in the order of 70 percent of the total suspended mass) and undergo sliding against friction within the ceiling grid, use of standard linear elastic analysis methodology would result in significantly conservative prediction of the response.

A shake table test of the entire assembly would be impractical due to the size and complexity of the assembly. Accordingly, a non-linear time history analysis was chosen as the best (i.e., most accurate) available alternative.

NRC has not approved the application of the time history analysis methodology for the qualification of the air delivery components; however, application of this methodology has been approved for other SQN systems.

Non-linear finite element T-H analysis for seismic qualification of the suspended ceiling and air delivery components applies the same basic structural analysis methods used for seismic qualification of the seismic category SQN ice condensers and analysis of loss of coolant accident (LOCA) loadings of the reactor internals and reactor coolant loop.

Ice condenser analyses, as described in SQN's UFSAR Section 3.7.2.1.3, were performed and include consideration of gaps, sliding, impact loads, and increased effective damping. In addition, the reactor internals and reactor coolant loop analyses are described in UFSAR Section 3.9.1.5.

The analyses for the suspended ceiling air delivery system may not be identical to these other system analyses; however the methodology, use of industry standards, and use of QA verified software is considered equivalent to the non-linear seismic analyses previously approved for other safety-related seismic Category I equipment assemblies at SQN.

The suspended ceiling and air-delivery component analyses were performed by ABS Consulting using ANSYS software. The analysis runs were made on TVA's QA verified ANSYS installation. ABS reviewed the error reports (issued by

ANSYS, Incorporated as part of the QA program) applicable to this ANSYS installation, and determined that none of the errors have any impact on the element types or features used in the analysis (reference Appendix E of Report 1116518-R-002).

Based on the above discussion, the proposed amendment constitutes a change in the evaluation methodology from that currently described in the UFSAR and results in the above 10 CFR 50.59 criteria being met. Accordingly, TVA is submitting the proposed LAR for staff approval.

4.0 TECHNICAL ANALYSIS

The enclosed LAR provides a proposed revision to the SQN UFSAR and the TSB to describe the seismic qualification analysis for the round flexible ducting, triangular ducting, and associated air bars installed as part of the suspended ceiling air-delivery system in SQN's MCR. The key elements of the proposed revision are outlined as follows:

1. The ducting is seismically qualified Category I(L) and will remain in place during an SSE.

2. The physical configuration will be maintained such that air flow will not be impeded.

3. The ducting pressure boundary will not be lost during or subsequent to an SSE.

4. The flexible ducting, triangular ducting, and air bars are constructed of standard commercial-grade materials.

5. The seismic qualification methodology used for the suspended ceiling and air-delivery components (i.e., the flexible ducts, triangular ducts and air bars) is described in a new section of the UFSAR (Section 3.7.3.16).

6. The configuration and pressure requirements for the flexible ducting, triangular ducting, and air bars is updated and correctly reflected in UFSAR Figure 9.4.1-1.

The suspended ceiling (excluding the air bars) was previously classified Seismic Category I(L) with position retention requirements. The proposed UFSAR revisions classify the air delivery components as Seismic Category I(L) with position retention and air flow delivery requirements. The change in seismic classification from Category I to Category I(L) is reflected in the update of the TSB. Maintenance of the seismically-qualified configuration is controlled through limited QA design output documentation and associated site maintenance instructions.

The following discussion details the changes proposed to the UFSAR and the TSB and the justification for the changes. The justification is principally based on a qualification report prepared by ABS Consulting for TVA. Relevant sections of the ABS report (Report No. 1116518-R-002, "Seismic Qualification of SQN Main Control Room Suspended Ceiling and Air Delivery Components") support the UFSAR and TSB changes and are provided in Enclosure 3. Annotated pages from the SQN UFSAR are provided in Enclosure 4. The affected TSB pages are provided in Enclosure 5. Enclosure 6 provides a comparison of proposed Alternate QA requirements and Appendix B QA requirements with justification for use of Alternate QA requirements for this application.

<u>Proposed Revision to Add UFSAR Section 3.7.3.16:</u>

TVA proposes to add the following information as a new UFSAR section; Section 3.7.3.16, entitled "Seismic Qualification of Main Control Room Suspended Ceiling and Air Delivery Components:"

Flexible ducting, triangular ducting, and air bar linear diffusers deliver air flow from the sheet metal ducts located above the Main Control Room (MCR) suspended ceiling to the air space below the ceiling. These air delivery components have been seismically qualified to ensure position retention and structural integrity such that pressure boundary and air flow delivery are maintained during and after the Safe Shutdown Earthquake (SSE).

Seismic qualification of the suspended ceiling and the air delivery components has been accomplished by rigorous time history analysis using the ANSYS computer code. The analysis models non-linear response due to gaps, friction, ceiling support wires, and geometric effects of the ceiling grid work. The seismic time histories correspond to the control building response to the SSE at the floor elevation above the suspended ceiling. The time histories were then adjusted to account for ±10 percent frequency uncertainty. A factor of safety of at least 1.3 for seismic qualification of the ceiling and air delivery components was demonstrated by increasing the time history motions by 30% and verifying that the seismic demand is less than the capacity of the ceiling grid members (including air bars), support wires, and flexible and triangular ducts.

The ceiling grid member and support wire capacities are based on classical structural analysis formulas. The flexible and triangular duct capacities were based on analysis for potential failure modes, industry precedents, and the analytical determination that the ceiling grid work remains stable. Other suspended ceiling components, including luminous panels, were shown to retain their position during and after the SSE.

Proposed Revision to UFSAR Table 3.2.1-2:

The text below is from Note 10 of Table 3.2.1-2, "Summary of Criteria - Mechanical System Components (Excluding Piping)," and the bolded italicized text reflects the proposed changes.

Note 10: Those components of the Heating, Ventilating, and Air conditioning System (HVAC), which are not covered directly by the TVA piping classifications of subsection 3.2.2, have been designed and constructed to standards and specifications which are equivalent to ANS Safety Class 2b. ***Safety Class 2b (TVA Class Q) Main Control Room air flow delivery components (round flexible ducting, triangular fiberglass ducting, and air bars) and the suspended ceiling which supports them are qualified to Seismic Category I(L) requirements, analyzed to ensure that the components will remain in place, the physical configuration will be maintained such that flow will not be impeded, and the ducting pressure boundary will not be lost. See Section 3.7.3.16. The air flow delivery components are constructed of standard commercial-grade materials. Limited QA requirements ensure they are maintained as qualified.***

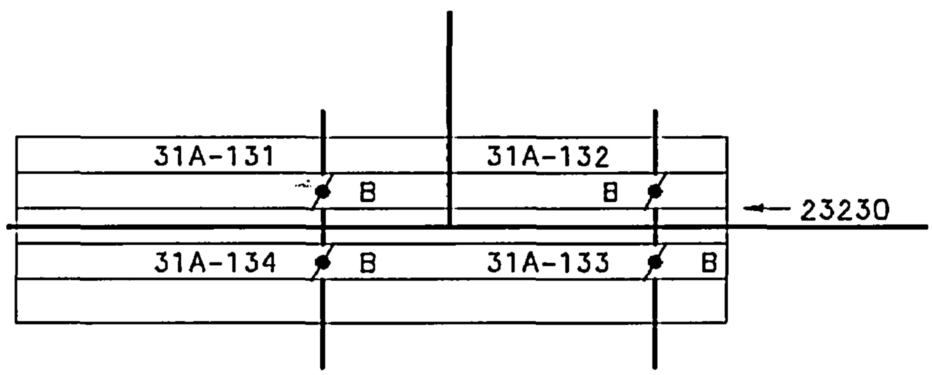
Proposed Revision to UFSAR Table 3.2.2-3:

The text below is from Note 5 of Table 3.2.2-3, "Non-Nuclear Safety Classifications," and the bolded italicized text reflects the proposed changes.

Note 5: Seismic category I if it performs a primary safety-function, ***with the following exception. Safety Class 2b (TVA Class Q) Main Control Room air flow delivery components (round flexible ducting, triangular fiberglass ducting, and air bars) and the suspended ceiling which supports them are qualified to Seismic Category I(L) requirements, analyzed to ensure that the components will remain in place, the physical configuration will be maintained such that flow will not be impeded, and*** *the ducting pressure boundary will not be lost. See Section 3.7.3.16. The air flow delivery components are constructed of standard commercial grade materials. Limited QA requirements ensure they are maintained as qualified.*

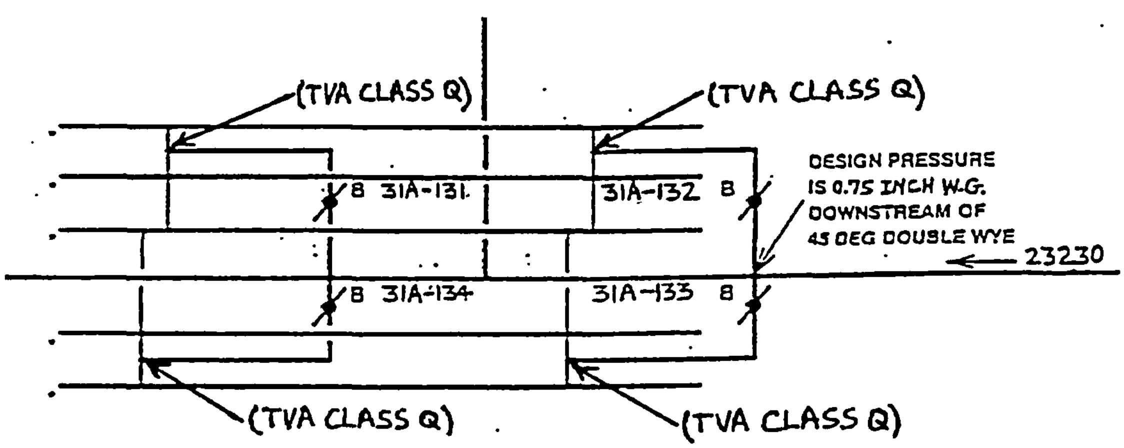
Proposed Revision to UFSAR Figure 9.4.1-1:

UFSAR Figure 9.4.1-1 is based on TVA Drawing 1,2-47W866-4. The current detail of the MCR HVAC system is depicted as follows on Drawing 1,2-47W866-4:



5 LINEAR DIFFUSERS

The proposed amendment replaces the above detail with the following information:



• 5 TRIANGULAR DUCTS WITH LINEAR DIFFUSERS

Proposed Revision to TSB 3/4.7.15:

The license amendment proposes to revise the second paragraph of the "Applicable Safety Analysis" section of TSB 3/4.7.15 to read as follows:

(Any text addition is shown as italicized/bold text. Any deletion is shown as strikethrough.)

The CRACS components are arranged in redundant, safety-related trains. During normal and emergency operation, the CRACS maintains the temperature at or below the continuous duty rating of 104°F for equipment and instrumentation. A single active failure of a component of the CRACS, with a loss of offsite power, does not impair the ability of the system to perform its design function. Redundant detectors and controls are provided for control room temperature control. ***A portion of the CRACS supply air ducting serving the main control room consists of round flexible ducting, triangular ducting constructed of duct board, and connecting metallic flow channels called air bars. These components are qualified to Seismic Category I(L) requirements, which will ensure 1) the ducting will remain in place, 2) the physical configuration will be maintained such that flow will not be impeded, and 3) the ducting pressure boundary will not be lost during or subsequent to a SSE.*** The *remaining portions of* CRACS ~~is~~ are designed in accordance with Seismic Category I requirements. The CRACS is capable of removing sensible and latent heat loads from the control room, which include consideration of equipment heat loads and personnel occupancy requirements, to ensure equipment OPERABILITY.

Justification for the Proposed UFSAR and TSB Revisions:

TVA contracted with ABS Consulting to establish the seismic qualification of the suspended ceiling and the air delivery components utilized in the MCR at SQN. The results of the study performed by ABS are documented in ABS Report No. 1116518-R-002, "Seismic Qualification of SQN Main Control Room Suspended Ceiling and Air Delivery Components." Relevant sections of this report are provided in Enclosure 3.

Prior to selection of the qualification method, TVA Nuclear Engineering performed a functionality evaluation of the SQN suspended ceiling to address the concern for potential distortion of the air bars during an SSE. The evaluation utilized equivalent static calculations. The results of the evaluation concluded that the suspended ceiling grid would remain stable, and that a factor of safety of more than 1.3 existed in the as-found condition.

The methodology (as documented in the ABS report) for seismic qualification of the SQN MCR air delivery components (flexible ducts, triangular ducts, and air bars) and suspended ceiling was chosen based on the existing design configurations at SQN. From field examination of the existing configuration and consideration of seismic experience with suspended ceilings, it was concluded that the methodology must account for potential non-linear effects due to existing gaps, wire support uplift, buckling of air bars, and friction between lighting panels and suspended ceiling grid work. Seismic time history analysis was required in order to properly account for these non-linear effects and to conclusively demonstrate that the air bars, which are also primary structural members in the Seismic Category I(L) suspended ceiling grid work, will not deform in a manner that potentially compromises the functions of the air delivery components. Other possible seismic qualification approaches, such as seismic proof testing or modifications to allow pure pendulum action of the suspended ceiling, were considered and found to be impractical or impossible.

The selected method of seismic qualification has been widely used in the nuclear industry for analysis of components such as reactor pressure vessel internals and ice condenser components. An example of this type of analysis for ice condenser components is discussed in UFSAR Section 3.7.2.1.3, "Seismic Analysis of Ice Condenser." The methodology is considered more exact than simplified linear elastic response spectra or equivalent static analysis methods that are typically applied for production analysis and design activities. It closely simulates seismic proof testing per IEEE 344-1975, Section 6.3, which is standard practice for seismic qualification of new design safety-related electrical and mechanical equipment at SQN, but is not practical for the suspended ceiling and air delivery components. It also complies with the requirements for dynamic analysis in IEEE 344-1975, Section 5.2. Only the SSE case is directly analyzed but adequacy for the operating basis earthquake (OBE) case is also demonstrated.

The qualification analysis was performed by ABS Consulting using the ANSYS computer code capability for time history analysis and carefully selected linear and non-linear elements to simulate the suspended ceiling with attached triangular ducts. The air bars, other ceiling grid members, and luminous panels were directly included as members in analytical strip models of the suspended ceiling. These models are for typical strips of the suspended ceiling in the North-South (N-S) and East-West (E-W) directions. The analytical models used for seismic qualification accurately depict the design configuration that has been documented on upgraded design output drawings.

Prior to the analysis, repairs to restore the intended design configuration were identified and implemented in accordance with the SQN Corrective Action Program based on field examination of the suspended ceiling and air delivery components. Also, so that the boundary conditions of the model corresponded to the as-installed condition in the field, SQN installed minor modifications (a spacer and added connection screws at the ends of each air bar).

The features of the SQN suspended ceiling and air delivery components model include, in addition to modeling aspects customarily included in the "conventional" linear structural models, nonlinear element types to represent gaps and sliding, with friction "across" the gaps, and geometric nonlinearity effects. The nonlinear gaps/sliding element types and the associated modeling assumptions are described on pages A-3 through A-5 of Enclosure 3 and are "standard" implementations of gap/sliding modeling in general purpose nonlinear finite element software. The properties, gap widths, and friction coefficient values assigned to these elements are based on information provided on design/vendor drawings for the SQN installation and on observations in the field. For example, the general configuration was observed to be consistent with the design output drawings and the gap around the outer periphery of the suspended ceiling was observed to vary from zero to approximately 1/8 inch. There are no additional assumptions/limitations to the ones described on pages A-3 through A-5 of Enclosure 3. Modeling was performed in a manner consistent with the ANSYS user's manuals. The proper function of the selected elements is covered by the ANSYS program QA. The treatment of geometric nonlinearity effects is consistent with the standard formulations developed for nonlinear finite element applications.

ANSYS is a general-purpose finite element type software, with modeling and solver capabilities that are more extensive than those implemented in several other finite element codes often used for civil/structural analysis. ANSYS Incorporated supports a 10 CFR 50, Appendix B compliant QA verification program (including verification problems and error notices).

The SQN control room suspended ceiling analyses were performed using TVA's ANSYS installation that was verified to the 10 CFR 50, Appendix B compliant QA verification package. The non-linear time history analyses were run by ABS Consulting on a TVA computer server, using TVA's QA verified ANSYS Version 5.7 software. In addition, ABS reviewed the ANSYS Version 5.7 software error reports and determined that no errors could have any impact on the analysis. Their review of the error reports is documented in Report 1116518-R-002 Appendix E (see Enclosure 3). ANSYS has been widely used in nuclear, aero-space, maritime, oil and gas, and electronics industries to solve linear and nonlinear structural stress and dynamics problems (as well as problems involving heat transfer, fluid flow and electro-magnetism). Such wide use of the software over the last several decades, often subject to stringent QA requirements, provides a level of additional assurance of the quality and verification of the software.

A level of assurance of the validity of the ANSYS results for the nonlinear time history analyses of the ceiling structure is provided by the various verification calculations in the ANSYS Verification Manual that include one or more of the particular features present in the SQN model. These include the following:

- Nonlinear time history analysis
- Nonlinear spring elements
- Coulomb friction
- Gap/Impact condition
- Geometric nonlinearity and/or buckling condition

Of the total 249 verification calculations included in the ANSYS Version 5.7, "Verification Manual," nine sample calculations, with at least one of these features employed in each, are identified in the following table:

Verification Calculation	NonLinear T-H Analysis	NonLinear Spring	Coulomb Friction	Gap/ Impact	Geom. NL and/or Buckling
VM9 Large Lateral Deflection of Unequal Stiffness Springs	X	X			
VM21 Tie Rod with Lateral Loading					X
VM31 Cable Supporting Hanging Loads					X
VM73 Free Vibration with Coulomb Damping	X		X		
VM79 Transient Response of a Bilinear Spring Assembly	X	X		X	
VM83 Impact of a Block on a Spring Scale	X			X	
VM85 Transient Displacement in a Suddenly Stopped Moving Bar	X			X	
VM136 Large Deflection of a Buckled Bar					X
VM156 Natural Frequency of a Nonlinear Spring-Mass System	X	X			

This analysis was well within the capability of the ANSYS program and the knowledge of the analysts.

Member and material properties used in the analysis were based on review of existing documentation (suspended ceiling contract, calculations, and drawings) and field examination of the installed ceiling and components. Non-linear elements in the model were selected by ABS Consulting based on this information and on engineering judgment focused on obtaining realistic dynamic response. TVA Nuclear Engineering reviewed and approved the ABS Consulting model and qualification report.

Seismic SSE time histories for the analysis were generated by ABS Consulting based on the applicable floor response spectra (unbroadened) at Elevation 748.5'. The nominal time history accelerations were multiplied by 1.3 to assure an adequate margin against structural failure. They were then applied to the N-S and E-W strip models. N-S + vertical time histories were applied to the N-S model, and E-W + vertical inputs were applied to the E-W model. These analyses were repeated with the seismic time histories lengthened and shortened in time +/- 10 percent to account for building and ceiling frequency uncertainty, in accordance with UFSAR Section 3.7.2.3.7, "Effects of Variations on Floor Response Spectra."

Maximum dynamic responses of critical suspended ceiling members (air bars, T-bars, and support wires) were determined by enveloping the seismic time history analysis results for the N-S and E-W strip models. Air bars are the primary grid members that run in the N-S direction; T-bars are secondary grid members that run in the E-W direction; and support wires support the grid work vertically on nominal 4-foot by 4-foot centers. The dynamic responses for these members were combined with dead weight loads to determine limiting cases for evaluation of stresses. The potential for buckling was directly simulated in the ANSYS time history runs. As indicated above, the seismic time histories were increased to ensure a minimum safety factor of 1.3.

The resulting displacements, forces, moments, and stresses in the critical support members indicate that the ceiling assembly remains stable and structurally intact. The calculated stresses and loads from this dynamic analysis are less than half of member yield and static buckling loads. The air bars provide a stable continuous support for the triangular ducts and do not distort in a manner that could cause damage to the triangular ducts or flexible ducts. The luminous panels and other ceiling components remain in place and do not fall. The margin conveyed by these results justifies analysis for the SSE seismic event only and qualifies the suspended ceiling, including the air bars and luminous panels, to perform its design function. The ABS report compares the results of the ANSYS time history analysis to the results of the TVA Nuclear Engineering functionality evaluation calculations and concludes that the functional evaluation results are reasonable and conservative.

The triangular ducts are made of commercial-grade fiberboard material that is lightweight and strong relative to its weight and operating pressure requirement. Each side of the triangular duct is 16-inches wide and the fiberboard is 1-inch thick. These ducts were supplied by the suspended ceiling vendor and were custom made to match the air bars that support them. They are attached to the air bars by sheet metal channel adapters that capture the bottom edges of the fiberboard and are attached to the air bars with self-tapping screws. The sheet metal channel adapters provide vertical and horizontal support for the fiberboard duct in the N-S, E-W, and vertical directions. Vertical downward and horizontal N-S and E-W support for the triangular ducts is also provided by 1/4-inch diameter threaded steel eyebolts that attach to ceiling support wires above. The eyebolts are spaced on nominal 4-foot centers along the air bars. They are attached to the air bars by mounting clips. The eyebolts pass through holes in the top of the triangular fiberboard ducts. Tinnerman clips and special washers on the eyebolts provide downward restraint for the top of the triangular ducts. The triangular fiberboard ducting is made in 4- to 8- foot long sections that are taped together with special reinforced tape recommended by the duct vendor. The joints between the triangular fiberboard duct sections are ship-lapped joints that are sealed by the reinforced tape.

In this design configuration, the triangular ducts are supported by redundant load paths and are protected from significant distortion due to the seismic loading. The most significant seismic loading is due to the inertial response of the lightweight fiberboard duct material itself. Seismic acceleration force per square inch of duct wall is significantly less than the corresponding design pressure load force per square inch. The reinforced tape at butt joints sees insignificant seismic loading relative to its tensile and shear load capacity. Seismic qualification of the triangular ducts is documented in the ABS report and is based on analysis of all potential failure modes of the ducts.

The flexible ducting is lightweight, spiral-wire wound, commercial-grade ducting which is firmly attached to the sheet metal ducting outlets and the triangular duct inlets by commercial-grade steel clamps. Seismic tests and industry precedents indicate that the only credible seismic failure mode for this type of flexible ducting is due to large relative movements of the end attachment points. The seismic analysis results for the suspended ceiling and the existing qualification for the sheet metal ducting ensure that the relative seismic movements for the flexible ducts end attachments are much less than the flexible duct relative movement capacity, as documented in the ABS report.

The suspended ceiling grid-work, support wires, and luminous panels are explicitly modeled and their response determined from the ANSYS T-H analysis. Effective masses of the triangular and flexible ducts are also attached to the air bars which are main structural members of the grid-work. The ANSYS output is the basis for asserting that the grid-work remains stable and the luminous panels remain in place. Most importantly, deformations in the air bars and the T-bars are negligible as they were demonstrated not to buckle, and at the ceiling perimeter displacements are limited to 1/8 inch, the approximate gap width along the perimeter. For very light items such as both the triangular and flexible round duct, both theory and seismic experience data support that deformation demand tends to be the important determinant of seismic performance, inertial loading being typically insignificant. This is supported by seismic experience for various types of HVAC ducting as documented in EPRI Report No. 1007896, "Seismic Evaluation Guidelines for HVAC Duct and Damper Systems," April 2003.

The earthquake experience database includes information on HVAC duct performance at 38 sites, in 15 earthquakes varying in magnitude from 5.5 to 8.1 with peak ground accelerations ranging from 0.25 gravity to 0.85 gravity, at the investigated sites. Collectively, these sites contained thousands of HVAC duct spans. In general, duct systems exhibited good seismic behavior, with few instances of damage or failure. Where damage or failure occurred, it could be attributed to a particular inadequate design or construction aspect or to seismic spatial interaction. The design aspects demonstrated by the experience data as causing vulnerability to seismic damage are as follows:

a. Inadequate connection detail either between two adjacent duct sections or at a point where a grille/diffuser connects to duct,(e.g., a lap joint either with small number of rivets or relying on friction only).

b. Inadequate range of free displacement in the bellows connecting duct to equipment in an installation where either or both are on flexible supports and therefore subject to significant differential displacement. (In some cases, equipment such as air handling units or fans have been mounted on inadequately designed vibration isolators with the result that the equipment dislodged and the bellows tore.)

c. Inadequate supports.

d. The end of a long flexibly-supported duct run not attached to the last support.

With the absence of any of these features in the triangular duct and the flexible round ducting in the SQN Control Room ceiling installation, the earthquake experience data clearly supports the capability of this ducting to withstand the SQN SSE without loss of structural integrity.

The flexible ducts in this application are similar to flexible hoses and ducts which have been seismically tested in numerous applications and as part of equipment assemblies. Seismic testing and earthquake performance experience indicate that flexible hoses and ducts which are properly designed for their pressure and flow delivery loads do not fail due to seismic inertial loads. Failure may occur due to excessive relative end movements. In the current application, the flexible ducts have been properly designed for their flow delivery function; and the relative end movements have been shown to be small and well within the end movements capabilities of the ducts. Also, the flexible ducts have been visually examined to verify that they are properly installed and not degraded. Additional justification for qualification of the flexible ducts is provided on pages 28 and 29 of Report No. 116518-R-002 (see Enclosure 3).

The triangular duct is continuously supported by the air bars and is also supported by support rods on 4-foot centers. Thus, it has redundant support load paths and is primarily loaded by self-weight seismic inertial loads. Those loads are small due to the light weight of the ducting material and well within the structural capacity of the triangular duct material. Additional justification for qualification of the triangular ducts is provided on page 25 of the ABS report (see Enclosure 3).

In summary, the analysis documented in the ABS report concludes current design configuration of the suspended ceiling and air delivery components will perform the required safety functions during and after a design basis SSE event. Significant margins of safety were demonstrated relative to the minimum level of structural damage that would compromise either the HVAC air delivery or position retention functions. The report provides adequate basis to support the classification of the air delivery components as Seismic Category I(L) with position retention and air flow delivery requirements. The analysis also establishes that the commercial-grade materials used in the fabrication of the air delivery system are acceptable. Maintenance of the system is based on the design output limited QA requirements and associated implementing procedures. Together, the qualification analysis and the proper maintenance of the air delivery components and suspended ceiling provide sufficient justification for the license amendment request.

5.0 REGULATORY SAFETY ANALYSIS

TVA proposes a revision to the Sequoyah (SQN) Updated Final Safety Analysis Report (UFSAR) and the SQN Technical Specification Bases (TSB) to update the basis for the quality assurance (QA) requirements and seismic qualification of the round flexible ducting and triangular ducting installed as part of the ceiling air delivery system in the main control room (MCR). The seismic qualification methodology for the air delivery components and the suspended ceiling is being revised from the methodology currently described in the UFSAR for safety-related equipment. TVA is applying a time history analysis to the system components which concludes that the air delivery components and suspended ceiling are seismically qualified and will continue to perform their safety function during normal and accident conditions

The UFSAR and TSB update for the qualification of the ductwork was reviewed under the requirements of 10 CFR 50.59, "Changes, Tests and Experiments" and based on this review, it was concluded that a license amendment must be requested in accordance with 10 CFR 50.59(c)(2). The proposed revisions update the UFSAR to indicate the following for the air delivery system in the MCR:

1. The ducting is seismically qualified Category I(L) and will remain in place during a Safe Shutdown Earthquake (SSE).

2. The physical configuration will be maintained such that air flow will not be impeded.

3. The ducting pressure boundary will not be lost during or subsequent to an SSE.

4. The flexible ducting, triangular ducting, and air bars are constructed of standard commercial grade materials.

5. The seismic qualification methodology used for the suspended ceiling and air delivery components (i.e., the flexible ducts, triangular ducts and air bars) is described in a new UFSAR section.

6. The configuration and pressure requirements for the flexible ducting, triangular ducting, and air bars are updated and correctly reflected in an UFSAR figure.

5.1 No Significant Hazards Consideration

TVA has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of Amendment," as discussed below:

1. Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No.

   The design function of the MCR ducting system is to support pressurization and cooling of the control room during normal and accident conditions. The design function of the MCR suspended ceiling is to remain in place during and subsequent to an accident, support the triangular and flexible ducts, and not damage safety-related equipment. The MCR ducting, including the classification and methodology changes, is a passive feature and does not act as an accident initiator, i.e., failure of the ducting would not initiate a design basis accident. The MCR suspended ceiling has been qualified such that it will remain in place and perform its safety function during and after an accident. Consequently, the changes associated with the MCR ducting and suspended ceiling do not affect the frequency of occurrence for accidents previously evaluated in the UFSAR.

   For the principal design basis accidents, loss of coolant accident (LOCA), internal flood, steam generator tube rupture (SGTR), main steam line break (MSLB), etc., the integrity of the MCR HVAC system, including the suspended ceiling, will not be compromised. These accidents do not have a structural effect on the MCR. This means that for radiological or toxic chemical accidents, the ability to both pressurize and maintain MCR temperatures within the design limits is unaffected by the limited quality and seismic requirements for the flexible and triangular ducting.

An accident that involves a fire that affects the MCR or the habitability of the MCR was not a consideration for the qualification of the air distribution components. A fire of this nature will result in plant operation from the Auxiliary Control Room (ACR) which is supported by a separate heating, ventilation and air conditioning (HVAC) system.

The physical effects of an earthquake (including the design basis SSE) is the only event in which the design basis for the MCR HVAC is potentially challenged. An evaluation by an industry seismic expert shows that the ducting and suspended ceiling will remain in place, will retain their structural integrity such that flow will not be impeded, and the ducting pressure boundary will not be lost. Thus, reducing the QA and seismic qualification requirements for the MCR ducting and changing the method of seismic qualification will not result in loss of safety function for any design basis accident or event. Thus, the accident dose as previously evaluated in the UFSAR is not affected by the proposed license amendment.

Based on the above discussion, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No.

   The MCR ducting addressed by the proposed amendment is not an accident initiator; i.e., failure of the ducting will not initiate a design basis accident. In addition, the subject ducting and suspended ceiling have been evaluated and a determination has been made that they will continue to perform their safety functions during normal and accident conditions. Consequently, this activity does not create a possibility of a new or different type of accident than any previously evaluated.

3. Does the proposed change involve a significant reduction in a margin of safety?

   Response: No.

   The changes addressed in TVA's proposed amendment are associated with changes in QA requirements and seismic qualification methodology for safety related air delivery components and for the suspended ceiling. The change does not affect specific HVAC equipment safety limits, design limits, set points, or other critical parameters. In addition, the new seismic analysis methodology and limited QA requirements ensure that these components will continue to perform their safety functions during normal and accident conditions. The previously implied margin of safety against structural or functional failure of the air delivery components or suspended ceiling during and after a design basis SSE has not been reduced. Therefore, the proposed change does not involve a significant reduction in a margin of safety.

   Based on the above, TVA concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c); and, accordingly, a finding of "no significant hazards consideration" is justified.

5.2 Applicable Regulatory Requirements/Criteria

TVA's enclosed LAR for Sequoyah Nuclear Plant (SQN) revises quality assurance (QA) requirements and seismic qualification of the air delivery system for the main control room (MCR). The proposed amendment revises the SQN Updated Final Safety Analysis Report (UFSAR) and the Technical Specification Bases. The original licensing basis for this system is documented in a SQN Safety Evaluation Report (SER) dated March 1979, NUREG-0011 and is described in the following sections of the SER;

3.2.1, "Seismic Classification"

3.2.2, "System Quality Group Classification"
6.4, "Habitability Systems"
9.4.1, "Control Building"

The discussion provided in the SER identifies the following regulatory documents that were considered in the initial NRC assessment for SQN.

Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water, Steam, and Radioactive-Waste-Containing Components of Nuclear Power Plants"

Regulatory Guide 1.29, "Seismic Design Classification"

Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release"

General Design Criteria 19.

TVA contracted with ABS Consulting to establish the seismic qualification of the suspended ceiling and the air delivery components utilized in the MCR at SQN. The results of the analysis performed by ABS are documented in ABS Report No. 1116518-R-002, "Seismic Qualification of SQN Main Control Room Suspended Ceiling and Air Delivery Components."

TVA and ABS Consulting established that the most appropriate method of seismic qualification for the affected components was a time history analysis. This type of analysis has been widely used in the nuclear industry for analysis of special components such as reactor pressure vessel internals, spent fuel racks, and containment ice condenser components. The methodology is more exact than simplified linear elastic response spectra or equivalent static analysis methods that are typically applied for production analysis and design activities. It is used sparingly for seismic qualification because it is more time consuming and expensive than the standard production analysis methods.

The qualification analysis was performed by ABS Consulting using the ANSYS computer code. This code has the capability for time history analysis and carefully selected linear and non-linear elements to simulate the suspended ceiling with attached triangular ducts. The air bars, other ceiling grid members, and luminous panels were directly included as members in analytical strip models of the suspended ceiling.

These models are for typical strips of the suspended ceiling in the North-South (N-S) and East-West (E-W) directions. The nominal time history accelerations were multiplied by 1.3 to assure an adequate margin against structural failure. Then they were applied to the North-South (N-S) and East-West (E-W) strip models. N-S + vertical time histories were applied to the N-S model and E-W + vertical inputs were applied to the E-W model. These analyses were repeated with the seismic time histories lengthened and shortened in time +/- 10 percent to account for building and ceiling frequency uncertainty, in accordance with UFSAR Section 3.7.2.3.7, "Effects of Variations on Floor Response Spectra."

The results of the analysis are documented in ABS Consulting Report No. 1116518-R-002 and ensure that the design configuration of the suspended ceiling and air delivery components will perform the required safety functions during and after the design basis safe shutdown earthquake (SSE) event. Large margins were demonstrated relative to the minimum level of structural damage that would compromise either the heating, ventilation, and air conditioning (HVAC) air delivery or position retention functions. The report and limited quality assurance (QA) maintenance requirements for the air delivery components and suspended ceiling provide adequate basis to support the classification of the air delivery components as Seismic Category I(L) with position retention and air flow delivery requirements and adequate justification for the requested license amendment.

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types of or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed change meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7.0 REFERENCES

1. TVA letter to NRC dated August 16, 2002, "Tennessee Valley Authority (TVA) - Seismic Design of Control Room Ventilation System - Allegation No. RII-2002-A-0059."

2. TVA letter to NRC dated March 12, 2003, "Browns Ferry (BFN), Sequoyah (SQN), and Watts Bar (WBN) Nuclear Plants - Insurance Status."

3. NUREG-0011, Safety Evaluation Report dated March 1979.

4. NUREG-1232, Safety Evaluation Report dated May 1988.

5. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water, Steam, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

6. Regulatory Guide 1.29, "Seismic Design Classification."

7. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release."

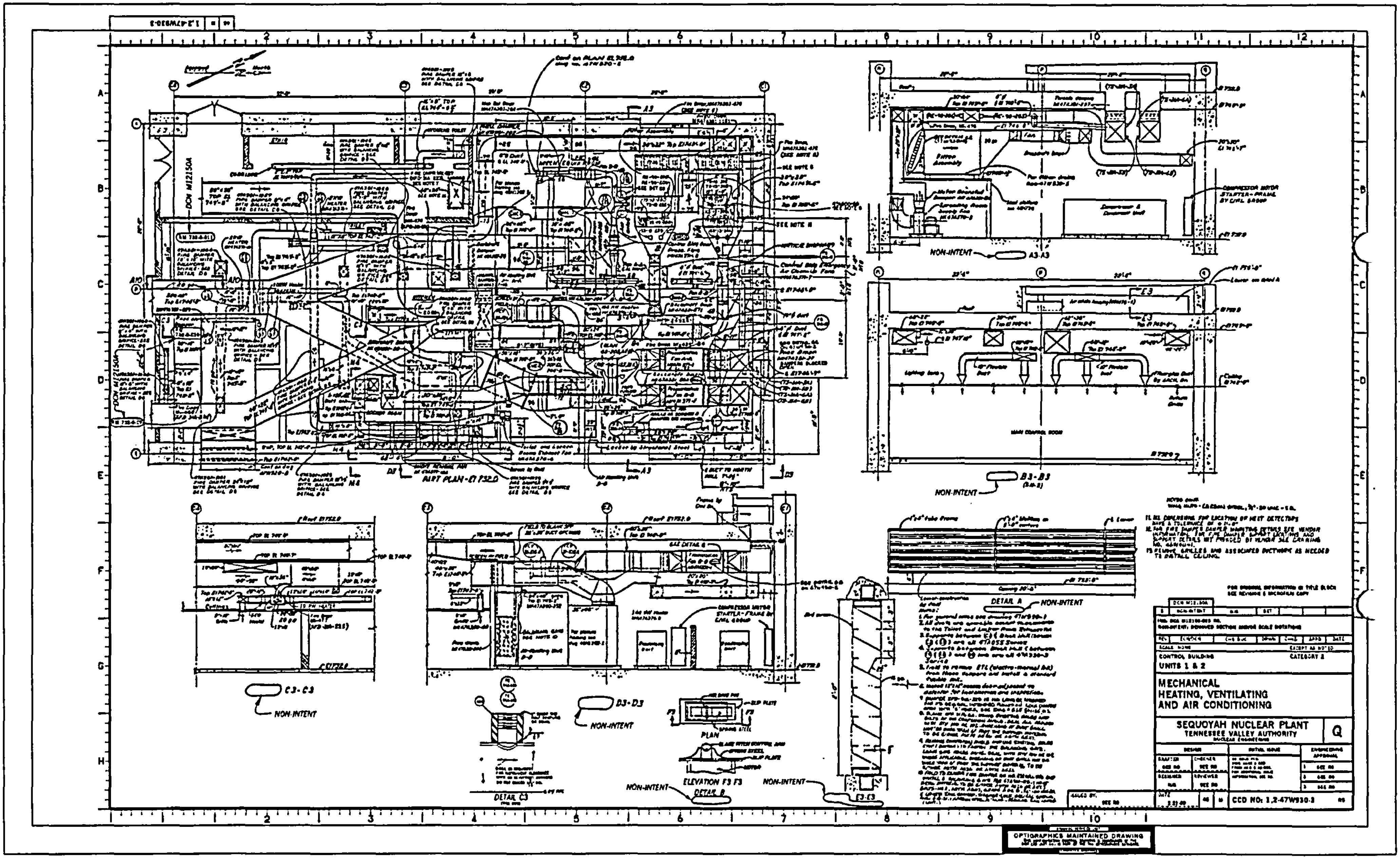
8. General Design Criteria 19.

9. ABS Consulting Report No. 1116518-R-002, "Seismic Qualification of SQN Main Control Room Suspended Ceiling and Air Delivery Components."

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

TVA Drawing 47W930-3


AIRT PLAN - El 732.0
NON-INTENT
A3-A3
B3-B3
C3-C3
D3-D3
DETAIL A
DETAIL B
DETAIL C3
ELEVATION F3 F3
PLAN
F3-F3
MAIN CONTROL ROOM
SEE NOTE 8
COMPRESSOR MOTOR STARTER-FRAME BY CIVIL GROUP
DCN M12150A
FOR ORIGINAL INFORMATION IN TITLE BLOCK SEE REVISION & MICROFILM COPY
SCALE NONE
EXCEPT AS NOTED
CONTROL BUILDING
CATEGORY I
UNITS 1 & 2
MECHANICAL
HEATING, VENTILATING
AND AIR CONDITIONING
SEQUOYAH NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
NUCLEAR ENGINEERING
Q
DESIGN
INITIAL ISSUE
ENGINEERING APPROVAL
DRAFTER
CHECKER
DESIGNER
REVIEWER
DATE
CCD NO: 1,2-47W930-3
OPTIOGRAPHICS MAINTAINED DRAWING