U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

DIVISION OF REACTOR INSPECTION AND SAFEGUARDS

SPECIAL INSPECTION BRANCH

Report No.: 50-327/87-74 and 50-328/87-74
Docket No.: 50-327/328
Licensee: Tennessee Valley Authority
Facility Name: Sequoyah Nuclear Plant, Unit 2
Inspection At: TVA - Office of Nuclear Power, Chattanooga, TN
TVA - Division of Nuclear Engineering, Knoxville, TN
Sequoyah Nuclear Plant, Soddy Daisy, TN
Inspection Conducted: November 2-10, November 17-19, 1987
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SEQUOYAH NUCLEAR POWER PLANT

INTEGRATED DESIGN INSPECTION FOLLOWUP

INSPECTION REPORT 50-327/87-74 AND 50-328/87-74

1. Introduction and Background

The NRC conducted an Integrated Design Inspection (IDI) of the Sequoyah Unit 2 power plant between July 8 and September 11, 1987. The inspection report for this effort (50-328/87-48 and 50-328/87-48) was issued on November 6, 1987.

The major programmatic weakness discovered by the IDI team related to the technical adequacy of the structural calculations for safety-related buildings. The team noted fundamental omissions in structural calculations wherein certain design loads and design conditions were not considered. In addition, the IDI team found many cases where calculational assumptions had no factual basis when compared to the actual plant design. The team also found many nonconservative discrepancies between the analyzed configuration of the equipment supports and that shown on the detailed support drawings. Further, the IDI team found problems with the design of reinforced concrete, regarding the placement of reinforcing steel, and the seismic analysis of the steel containment vessel (SCV). As a result of the above concerns regarding the adequacy of the structural calculations, the IDI team could not reach a conclusion regarding the structural adequacy of the plant to withstand design basis events based on the calculations available for review during the inspection. In view of the wide range of concerns regarding the adequacy of structural calculations, combined with the knowledge that the Civil Engineering Branch has not performed a current review of calculations (as have the other three engineering branches) the NRC, during the exit meeting, requested that substantial sample of structural calculations be reviewed. This review was requested to be conducted by personnel external to TVA that were not involved with the original design of Sequoyah.

2. Purpose

This inspection was conducted prior to the receipt of TVA's formal response to the IDI report in order that the team could review additional information, related to the teams concerns regarding the technical adequacy of civil/structural calculations, that was unavailable during the inspection. In addition, TVA stated that a substantial amount of the corrective action related to the IDI findings was already completed, therefore, the NRC felt this early inspection would expedite the closure of the IDI findings.

3. Summary of Findings

One of the principal objectives of the inspection was to assess the information in the civil/structural discipline that was unavailable during the IDI so that NRC could reassess its request that TVA conduct an independent review of structural calculations in order to substantiate their technical adequacy. During the inspection, the team reviewed the responses to the specific findings and reviewed on a sampling basis the TVA assessment of the generic implications of the specific findings in the civil/structural area. TVA was assisted in their review of the IDI team's findings by consultants with substantial supervisory design experience who had not participated in the original design of Sequoyah. Therefore, the TVA structural review did have a degree of independence as requested by the NRC. Based on the team's understanding of the scope and results of generic structural reviews performed in response to the IDI findings as well as a review of TVA's evaluation of the specific IDI findings, the team has a higher degree of confidence in the overall technical adequacy of the Sequoyah structural design. Consequently, the team is of the opinion that TVA does not need to conduct a broad scope generic review to assess the adequacy of the structural design.

However, the team requested that in certain specific areas TVA perform additional generic reviews prior to restart to assess equipment supports, minimum percentage of reinforcement steel in walls, vertical seismic loads, and the 274 retrieved shear calculations. The team also requested that TVA regenerate all missing calculations for both reinforced and unreinforced masonry walls prior to restart.

A major concern of the team during the IDI was that TVA had not performed shear capacity calculations for the design of walls and slabs. Subsequent to the IDI, TVA retrieved approximately 274 shear calculations, thought not to have been performed, and generated an additional 20 shear calculations for areas that were either not analyzed or unretrievable. The sample of calculations reviewed by the team showed the design to be adequate with respect to shear capacity.

In the other disciplines, i.e., mechanical systems, mechanical components, instrumentation and control and electrical power the team evaluated the TVA corrective actions. Although the majority of inspection findings remain open, primarily because the corrective actions were not finalized, the overall opinion of the team was that in general, the corrective actions were responsive to the team's concerns and in most cases should resolve the issues. Appendix A to this report summarizes each item reviewed in this inspection, its status either open or closed, and describes the TVA actions necessary for its closure. Appendix B lists the persons contacted during this inspection.

APPENDIX A

MECHANICAL SYSTEMS

(Open) Deficiency D2.2-1, Design Pressure of ERCW System

This deficiency documented the difference between the FSAR stated system pressure of 160 psig and the 150 psig rated pressure of components and piping.

TVA's justification the lower design pressure relied solely on administrative control. The administrative control consisted of operationally limiting the ERCW pump discharge pressure to 124 psig which, as determined by dynamic flow calculations, limits the maximum pressure to 150 psig at system low points. The IDI team identified inconsistencies/nonconservatisms in this approach in that equipment outages due to maintenance were not considered; maximum plant flood level was not considered, the present system design pressure is 160 psig therefore, components within the ERCW system that are rated at 150 psig are below the system design pressure of 160 psig; and the code-of-record, ANSI B31.1 - 1967, does not permit lowering the design pressure by relying on pressure reducing devices without providing relief valves.

The TVA response identified isolation of equipment and maximum flood level as abnormal conditions and provided a new calculation for abnormal conditions, using pump discharge pressure limited to 124 psig. This calculation established a maximum abnormal pressure of 175 psig at the system low point.

The IDI team agreed that this design pressure concern for piping and components under abnormal conditions would be resolved if TVA could provide assurance that the allowable stresses in piping and components are not exceeded. For piping, (ANSI B31.1), TVA performed a calculation which demonstrated that the entire ERCW system could safely withstand system pressures exceeding at least 245 psig. Since the maximum abnormal pressure was established by TVA to be 175 psig, the IDI team considered the piping to be acceptable. Components built to ASME Section VIII and manufacturer's standards whose maximum abnormal pressure exceeds the design pressure of 150 psig, will be considered acceptable if stress analysis using the maximum abnormal pressure, performed by a TVA Professional Engineer (PE) and checked by an independent third party inspector, demonstrates that allowable stresses are not exceeded. Vendor certification that the components will withstand the higher pressure within allowable stresses is also requested. TVA must also issue ECN L 7125 to lower the system design pressure to 150 psig. Limiting the ERCW pump discharge pressure to the TVA established value of 124 psig (see Deficiency D2.2-2) will provide additional assurance that the design pressure will not be exceeded.

The TVA response to generic review identified similar problems for the raw service water system, the chemical and volume control system, and the component cooling water system where components were verified to be incompatible with the system design pressure. Also, as part of their generic review TVA failed to recognize the need for a relief valve downstream of a pressure reducing valve for the power stores air conditioning unit. Consequently, TVA needs to re-review all components that rely solely on pressure reducing devices to provide overpressure protection. Additionally, TVA needs to identify the new administrative controls that are in place to avoid similar problems in the future. The generic review is not considered to be closed and additional evaluation is considered necessary.

TVA is requested to confirm the following corrective actions are completed:

1. Assure by calculations (TVA PE; consultant PE) with third party verification and through vendor certification documents that components are adequately designed to withstand abnormal pressure of 175 psig (or lower pressure applicable to specific location/elevation of coolers).

2. Issue ECN L 7125 to lower ERCW System Design Pressure from 160 psig to 150 psig, including revision of applicable flow diagrams, calculations, design criteria, etc.

3. Review design pressure for other systems and components.

This item remains open pending the team's inspection of completed corrective actions and review of FSAR changes to assure the team's concerns are properly addressed.

(Closed) Deficiency D2.2-2, <u>Procedure Not Available to Limit ERCW Discharge Pressure</u>

This deficiency was based on the identification of components with a design pressure of 150 psig, installed in a system where the design pressure is 160 psig and a calculation by TVA identified system operating pressure above 150 psig. The TVA calculation showed that the design pressure could be limited to 150 psig if the discharge pressure of the ERCW pumps was limited to 124 psig. However, no such procedure had been approved during the IDI inspection period, although a memorandum had been issued requesting this revision to operating procedures.

The TVA response indicated that the overpressure of the components was only slightly (2.1 psig) above 150 psig for normal operation conditions, and the design complies with ANSI B31.1 rules for abnormal operation. However, TVA committed to issuance of the revised operating procedure to establish the upper bound for normal ERCW pump operation.

In Deficiency D2.2-2, the IDI requested TVA to assure by calculation that components are adequately designed to withstand the abnormal operating pressure of 175 psig, therefore, limiting the ERCW pump discharge pressure to 124 psig provides additional assurance of not exceeding re-rated system design pressure of 150 psig. Procedural controls are not relied on to assure system integrity.

The IDI team reviewed the issued revision of station operating instruction SOI 67.1 (Rev. 33) and determined the limitation of ERCW pump discharge to 124 psig to be acceptable as written. The generic portion of this deficiency is addressed in Deficiency D2.2-1. This deficiency is closed.

(Open) Deficiency D2.2-3, Overpressurization of Auxiliary Air Compressor Coolers

This deficiency identified the design pressures of components in the safety-related auxiliary air compressors (cylinder water jacket cooler and after-cooler) as being substantially lower than the ERCW system design pressure. The piping code of record, ANSI B31.1 - 1967 requires overpressure protection via relief devices where pressure reducing valves are used and system re-rating to the higher pressure has not been accomplished. TVA relied on pressure reducing valves only.

The TVA response identified use of compressor inlet valves to throttle flow and reduce pressure, with valve positions verified periodically by surveillance. They also committed to providing relief valves to prevent overpressurization of the components.

The IDI team reviewed several documents and calculations issued by TVA subsequent to the initial IDI team inspection, applicable to closure of this deficiency, as well as the procedure for throttling flow to the auxiliary air compressor. TVA issued ECN L 7297 to relocate and replace solenoid valves upstream of the compressors to provide a lower flow that was determined by TVA calculation as being necessary to meet relief valve capacity requirements. The solenoid valve, when wide open is an effective flow restriction, thus allowing use of a relief valve with lower rated capacity. The IDI team reviewed the calculation and found it acceptable. Further, the ECN includes the addition of relief valves (one for each compressor) with a set pressure of 75 psig and a capacity in accordance the aforementioned TVA calculation to prevent overpressurization of components.

The calculations were based on the assumption that the design pressure for normal operation is 150 psig (see Deficiency D2.2-1) and that the cylinder jacket cooler design is 75 psig, not 67 psig as initially identified by TVA. For the latter, TVA has obtained vendor information concurring with the higher (75 psig) design pressure. This has been reviewed as a part of the reinspection of this deficiency by the IDI team and found acceptable. The use of 150 psig design pressure, as modified for higher elevation, resulted in a lower dynamic pressure for use in sizing relief valve capacity. The IDI team found the calculations and assumptions on which this lower pressure was based to be acceptable.

The restart issue remains open pending confirmation from TVA that the ECN-L 7297 has been formally issued and physically implemented. TVA is requested to confirm corrective actions are completed. This item remains open pending inspection by the NRC.

(Open) Deficiency D2.2-4, Overpressurization of Station Air Compressor Coolers

This deficiency was based on design pressures of components in the nonsafety-related station air compressors (cylinder water jacket cooler and intercooler) identified as lower than ERCW system pressure. This deficiency is similar to

D2.2-3 in that the code of record, ANSI B31.1 - 1967 requires overpressure protection via relief devices where pressure reducing valves are used and system re-rating to higher pressure has not been accomplished. TVA relied on pressure reducing valves only.

The TVA response included the assumption of a critical crack in the nonseismic station air compressor piping with detection and manual break isolation. From this TVA concluded the performance of safety-related "areas" (ERCW system) would not be affected. TVA also identified that they would throttle flow to reduce pressure and a provision to add relief valves would be made prior to restart.

The IDI team reinspection reviewed several documents and calculations issued by TVA subsequent to the initial IDI team inspection, applicable to closure of this deficiency. ECN L 7294B was issued to install relief valves (one for each compressor) with set pressure of 75 psig and a capacity in accordance with TVA calculation for relief valve capacity sizing to prevent overpressurization of components. The basis for use of "critical crack" in the calculation was questioned by the IDI team, both as a valid assumption to allow a critical crack in non-seismic piping in a non-seismic building (see Deficiency D2.2-5) and for applicability in sizing relief valve capacity during normal operating conditions.

The initial calculation, using the critical crack flow resulted in a lower capacity requirement, allowing the TVA selected relief valve to meet these requirements. Using the system design pressure of 150 psig, corrected for elevation and dynamic conditions and assuming complete severance of the pipe in lieu of the critical crack, TVA revised the calculation and committed to using a larger size relief valve to accommodate the increased capacity.

TVA obtained vendor information concurring with higher (75 psig) design pressure for the cylinder jacket water cooler (formerly 67 psig) and intercooler (formerly 50 psig), such that the relief valve setting of 75 psig is acceptable. The IDI team reviewed this memorandum and found this determination acceptable.

This restart issue, will remain open pending confirmation from TVA that ECN 7294 has been issued and has resulted in the addition of the relief valves with the correct capacity. This item remains open pending inspection by the NRC.

(Open) Deficiency D2.2-5, <u>Evaluation of Failure of ERCW Non-Seismic Piping</u>

This deficiency identified the lack of an evaluation of the consequences of failure of the non-seismically designed piping on the operability of the safety-related portion of the ERCW system. Specifically, TVA did not adequately justify that the safety-related portion of the ERCW system would receive the necessary cooling during the time period it takes the operator to isolate the non-seismic portion following a postulated double-ended guillotine rupture in the ERCW non-seismically designed piping.

TVA's October 29, 1987 response indicated that a data base type seismic evaluation had been performed on the associated piping and concluded that no conditions have been identified which can lead to a credible failure that would result in a guillotine break of the piping. The IDI team did not accept this response since no quantitative analysis was performed to demonstrate that the subject non-seismic piping which is located in a non-seismic Category I building (i.e., turbine building) would not incur a guillotine break following the design basis seismic event. Also, the IDI team did not accept TVA's analysis which postulated a critical crack in lieu of the double-ended guillotine break, since a justified basis for the assumption was not presented. As a consequence, TVA committed to provide automatic isolation of the non-seismic ERCW piping to the station air compressors. The team requested that these valves be installed and functional prior to restart. TVA is requested to confirm the associated changes have been implemented. Prior to restart, the NRC plans to review the associated setpoint calculation for automatic isolation of these valves as well as the basis for the flowrate utilized.

Generically, TVA had committed in their October 29, 1987 response to the IDI restart items to perform a review of safety and non-safety related system interfaces. TVA has completed that review and the results are documented in a memorandum from J. E. Pilgrim to R. E. Daniels dated October 22, 1987. Therefore, TVA is requested to provide, prior to restart, a confirmatory letter to the NRC documenting that all associated corrective actions have been implemented or provide a Justification for not doing so.

This deficiency remains open pending NRC review of corrective actions.

(Open) Deficiency D2.2-6, Inadequate Procedure for Determination of Safety Class Boundaries for Fluid Systems

This deficiency identified the lack of a TVA procedure for determining suitable boundaries (safety class breaks) between system quality group classifications (TVA Classes) when transitioning from a higher class to a lower class. Several examples of inappropriate boundaries were identified by the IDI team.

The TVA response indicated that the experience of the engineers was relied on along with the limited data available at the time of the original SQN design for class boundaries. They also indicated that current practice in the design of class boundaries had not resulted in any situations which could have a significant impact on the safe operation of the plant as presently designed.

TVA further committed to some drawing clarification related to flow diagrams for the ERCW interfaces with the ice condenser RCW supply and AERCW and CCW pumping station (two examples of those identified by the IDI team). In addition, TVA committed to perform a survey of other AE's to determine methods used for plants of SQN's vintage and those currently used, with a commitment to follow current industry practices for any future design changes. TVA also committed to review other class break boundary interfaces between safety and nonsafety-related systems and examine the application of single failure criteria to these interfaces. Lastly, TVA committed to perform a generic review to identify deficiencies at all TVA nuclear plants if the AE survey identifies inadequacies in TVA practice of designing class breaks.

The IDI team reviewed the TVA response and in particular the specific response to the three examples included in the deficiency with the following determination:

1. Example 1, Class Break at Piping Anchored at Auxiliary-Turbine Building Wall

The class break is acceptable since the system boundary was not adversely affected. However, it is an example of why a specific procedure/criteria is necessary. In addition, use of the wall as the class break in lieu of at the downstream end of the isolation valve added a level of confusion to the determination of the interface between the safety-related and nonsafety-related, non-seismically designed portions of the ERCW system.

2. Example 2, Class Break at ERCW System With Raw Cooling Water (RCW) Supply to Ice Condensers

The location of safety class boundary shifts from the flanged closure beyond the manual valve to the downstream side of the manual valve when the spool piece is connected (not as shown in the response). With the safety class break at the valve, normally TVA, by FSAR commitment, would be required to seismically qualify piping through the first seismic restraint beyond the defined boundary such as a valve. This however was not done in this situation because the spool piece connecting the safety and nonsafety-related piping is only installed during a design basis flood.

However, as a seismic event is not postulated after a design basis flood and a conservative approach by TVA to postulate a critical crack and calculate its effects was performed, the approach is acceptable. Again, as in Example 1, this is another example of why a specific procedure/criteria is necessary. Although this turned out to be an acceptable configuration it is not clear that this was considered in the original plant design.

3. Example 3, Class Break Between ERCW System Piping and AERCW and CCW Pumping Station

The TVA resolution to identify class breaks at these interfaces is acceptable. However, these obsolete systems have been erroneously classified as safety-related since startup of SQN-2. The example, therefore, is applicable to any present or future system safety class downgrades and reinforces the need for a procedure/criteria.

The IDI team agrees with the TVA response with regard to the survey of industry practice and the commitment to follow current industry practice for future design. However, the team requests that TVA develop criteria to address the design provisions necessary to transition between safety classes in accordance with the requirements of 10 CFR 50 Appendix B relating to design control.

To close this non-Restart Issue, TVA should confirm that the survey/review of AE (industry) practices and preparation of a TVA criteria/procedure for proper specification of design provisions for safety class boundaries has been entered in the Corporate Commitment Tracking System (CCTS).

Further, TVA should confirm that the team's request that a generic review of safety class boundaries in all systems be conducted has been entered in the CCTS. This item remains open pending inspection by the NRC.

(Closed) Deficiency D2.2-7, Determination of ERCW Pump House Ambient Temperature for Environmental Qualification (Mild)

This deficiency identified the lack of a justified technical basis for the maximum and minimum ambient temperature limits in the ERCW pump house. The maximum temperature limit was subsequently Justified for the ERCW pump house but the broader issue associated with other mild environment areas was not addressed. Also, the lower temperature limit incorrectly utilized heat gains from items that may not be energized during the specific plant operational condition being evaluated.

TVA's response agreed with the deficiency. TVA revised calculation TI-ECS-53 to address other mild environment areas including definition of outdoor temperature extremes, Justification of the ERCW pump house maximum abnormal temperature of 120°F, and consideration of post-LOCA heat loads and cooling capacities for mild environment areas. For the low temperature limit post-LOCA in the ERCW pump house, TVA revised calculation FSG-WVC-082087 including removal of non-justified heat loads (i.e., non-1E lighting, sump pumps, etc.) but added the heat load from the non-1E space heater. To Justify that the ERCW pump house El. 704 would not be subjected to freezing temperatures, two key calculational assumptions need to be implemented. First, the ventilation fan for the ERCW pump house was assumed to be turned off when the room temperature was below a certain value. TVA accomplished this by revising general operating instruction GOI-6 on October 29, 1987 to turn off the ventilation fan when the room temperature dropped below 65°F. Secondly, since the non-1E heater was assumed to be operating subsequent to a seismic event, TVA needed to demonstrate how operability was ensured for the non-1E heater or demonstrate that the ERCW strainer differential pressure sensing lines freezing would not impair strainer operability. The post-LOCA operability was demonstrated via TVA abnormal operating instruction AOI-9, entitled, "Earthquake," which required that the ERCW structure be placed in continuous backwash within three hours subsequent to the subject seismic event, thus negating the need for post-LOCA space heater operation. However, to ensure that freezing temperatures are avoided in the ERCW pump house lower elevations during normal plant operation, surveillance instruction SI-606 was revised on November 6, 1987 to establish a lower temperature limit for the ERCW pump house temperature indicators which would be monitored once every 8 hours. These TVA corrective actions have adequately resolved this issue.

(Open) Deficiency D2.2-8, ERCW Supply Temperature Limitation

This deficiency identified a statement in the Design Criteria document for the ERCW System (SQN-DC-V-7.4) that implied the plant could be operated at a reduced power level when the ERCW inlet temperature is in excess of the Technical Specification limit of 83°F. The TVA response identified a revision to the design criteria limiting the temperature to Technical Specification limit. To close this non-restart issue, TVA is requested to confirm that the commitment to revise the design criteria has been entered in the Corporate Commitment Tracking System (CCTS). This item remains open pending inspection by the NRC team.

(Open) Deficiency D2.3-1, Inadequate Substantiation of Design Commitments For ERCW Piping (Code Basis)

This deficiency identified that piping systems were improperly identified in the FSAR as being designed to ASME Section III, when they were actually designed to ANSI B31.1 - 1967, with ANSI B31.7 used for component procurement, installation and testing. In addition, the FSAR commits to the use of the equations and service limits of ASME III, Subsection NC-3000 1971 Edition through Winter 1972 Addendum to determine the applicable stress intensity levels. The FSAR, therefore, does not clearly and consistently define the piping codes of record.

The TVA response indicated that the FSAR will be revised to clarify the Codes utilized, i.e., ANSI B31.1, ANSI B31.7, and portions (NC-3000) of ASME III, Winter 1972. However, there was no indication in this response that the Design Criteria which identify ASME III in lieu of ANSI B31.1, ANSI B31.7, etc., will be revised. In addition, Deficiency D3.5-2, "Use of Selected B31.1 Code Rules" identifies concerns with use of ASME III, Subsection NC-3000, Winter 1972 Addenda as "equivalent" to ANSI B31.1 - 1967. The IDI team concurs with the TVA response insofar as properly identifying the code of record and its use of other codes with specific identification to their application.

To close this restart issue, TVA is requested to submit the associated FSAR changes to the NRC for review and confirm that the design criteria has been revised accordingly. This item remains open pending inspection by the NRC.

(Open) Deficiency D2.3-2, Inadequate PE Certification

This deficiency identified a lack of recertification by Professional Engineer (PE) for design specifications reviewed as part of the IDI team inspection of the ERCW system ASME Section III components. The review identified five component specifications where design information in the procurement documents was revised without revision and PE certification of the design specifications.

TVA's response agreed that these examples were deficient and identified corrective action for ERCW pumps, clarification of TVA procedures and evaluation of generic implications as part of the CAQR generic review. Also, TVA provided a memorandum for review and upgrade of certified design specifications. The IDI team reviewed the actions by TVA and the documents included and determined that TVA has responded adequately.

To close this non-Restart Issue, TVA is requested to confirm that the commitment to review and modify all ASME Section III certified design specifications has been entered in the Corporate Commitment Tracking System (CCTS). This item remains open pending inspection by the NRC.

(Open) Deficiency D2.3-3, <u>ERCW Screenwash Pump not Included in ASME XI Program</u>

This deficiency identified the inclusion of the safety class ERCW screenwash pump in the TVA ASME Section XI Pump Inservice Testing (IST) Program. The IDI team determined that these pumps perform a safety-related function during normal plant operation and therefore should be included in the ASME XI Pump IST Program.

The TVA response identified that these pumps will be included in the ASME XI IST Program and, as this program is described in the FSAR, these pumps will be added to the FSAR tabulation of ASME XI components. The IDI team concurs with this response. The IDI team determined that there are no generic concerns with the balance of the ASME XI Pump IST Program.

To close this restart issue, TVA should submit the associated FSAR changes, to the NRC for review. This item remains open.

(Open) Deficiency D2.3-4, <u>ERCW Screenwash Pumps not Produced to ASME III</u>

The ERCW screenwash pumps were identified as ASME Section III, Class 3 in the FSAR, Design Criteria, and from the Certified Design Specification 2653 However, the pumps were actually procured to non-ASME III, manufacturer s requirements (ANSI B58.1), with a quality assurance program to portions of ANSI N45.2, with seismically qualified IE motors, and seismic qualification of the pumps.

TVA's response identified their position that the ERCW screenwash pumps procured to the above meet the requirements of TVA Class C and that corrections to the FSAR and Design Criteria documents will be made to remove erroneous references to ASME III. The IDI team concurs with this response.

To close this deficiency for this non-restart issue, TVA needs to include their commitment to revise the Design Criteria and applicable FSAR Sections in the Corporate Commitment Tracking System (CCTS).

TVA is requested to confirm that the above commitments have been entered in the CCTS. This item remains open pending inspection by the NRC and review of the proposed FSAR changes to assure the team's concerns are appropriately resolved.

(Open) Deficiency D2.4-1, Improper Application of Critical Crack Criteria

This deficiency identified two items: (1) the lack of inclusion in the FSAR of revised criteria allowing break exclusions, based on stress criteria, for postulating critical crack locations in piping seismically analyzed to ANSI B31.1 Code; and (2) clearly limiting the design criteria's applicability to seismically analyzed piping.

TVA's response identified that a revision to the design criteria by design input memorandum (DIM) will include the reference to "seismically" analyzed piping for its application of crack exclusion for item (2) above. However, the response did not address the FSAR changes needed. Subsequent discussion between the IDI team and TVA has resolved this item with the team's review of the associated proposed FSAR revision.

To close this restart issue, TVA should submit the associated FSAR changes to the NRC for review.

(Open) Deficiency D2.4-2, Containment Integrity During Design Basis Flood

This deficiency identified that TVA had not formally submitted to the NRC for review and acceptance, the concept of cutting a hole in the steel containment vessel during a design basis flood. Cutting a hole in the steel containment vessel was considered necessary by TVA to prevent an external buildup of water pressure on the steel containment vessel due to flooding of the annulas space between shield building and containment vessel during a design basis flood. This action has an extremely low probability of occurring since it is predicated on the failure of one or more upstream dams in combination with the dams storing enough water to cause a flood to exceed plant grade. However, TVA has committed that the containment be designed to withstand the effects of natural phenomena such as floods without loss of capability to perform its safety functions.

TVA has indicated that the associated issue will be formally identified to the NRC via a revision to the USAR with a draft revision prepared prior to restart. TVA is requested to confirm that this commitment has been entered in the CCTS. This item remains open pending inspection by the NRC.

(Open) Deficiency D2.5-1, Incorrect Operational Modes Data for ERCW

This deficiency identified the incorrect translation of data from the environmental data drawings to the ERCW operational modes calculation. Specifically, the operational mode calculation identified the ERCW piping to the lower containment ventilation cooler as having an ambient temperature of 160°F for the LOCA condition. However, this 160°F temperature was incorrectly translated from the environmental data drawings, in lieu of a value of 259°F which should have been specified for the maximum ambient temperature during a LOCA in the lower containment for a dead-end compartment. Additionally, since this ERCW piping is only isolated during a Phase B containment isolation it may not come to equilibrium with the containment ambient temperature. This error had no technical consequences since no thermal piping analysis is required for the faulted condition, however, it is an example where an adequate design verification process should have identified and corrected the discrepancy.

To resolve this issue, TVA needs to correct the specific lower containment ventilation cooler data and review the entire ERCW operational modes calculation to ensure that similar mistakes were not made. This non-restart item is considered open until TVA has included the aforementioned corrective actions into the corporate commitment tracking system.

(Open) Deficiency D2.5-2, Kerotest Packless Y-Pattern Valves Used For Throttling

This deficiency is based on the use of certain Kerotest valves in a throttling application without consideration of the restriction that the vendor has placed on such usage. The valve manufacturer has stated that Kerotest packless Y-pattern globe valves are not recommended for throttling but did provide guidance that permits throttling in certain regions of percent open versus flowrate. TVA was initially unaware of these vendor recommendations and noncompliance could result in cavitation damage to the valves/piping and failure of valve internals could result in flow restriction to safety-related components. During the IDI inspection, TVA performed a review of all ERCW system valves that were throttled in accordance with surveillance instruction SI-682 and observed that although the four valves were the type with throttling restrictions, all were being operated in the acceptable range. However, TVA needed to establish administrative controls to ensure other similar valves were used in accordance with the vendor's recommendations.

TVA's response of October 29, 1987 agreed with the deficiency and identified the following root causes for the misapplication of these Kerotest valves:

1. Designer was unaware of the unique limitation on throttling.

2. Designer failed to review the specification and depended on the bill of materials which did not identify these valves to be used only for shutoff or drain applications.

3. Vendor supplied these valves before use of 10 CFR Part 21 so no notification was provided.

Subsequently, TVA reviewed the safety-related systems required to mitigate an FSAR Chapter 15 event. As a result of this review 167 Kerotest valves were identified. Three of these valves were being used in an unacceptable throttling application. The three valves were evaluated per TVA's condition adverse to quality report (CAQR) process. The results of this review concluded that one valve located on the discharge of the penetration room cooler 1B1 in the ERCW system needed to be replaced prior to Unit 1 restart. The remaining two Kerotest valves subject to misapplication are located in the discharge piping for the gross failed fuel detectors which have been out of service due to reliability problems. Since TVA is currently performing routine sampling of the reactor coolant system via the chemistry lab and the gross failed fuel detectors (GFFD) are out of service, the IDI team concurs that replacement of these valves is not required prior to restart. However, if TVA intends to utilize the GFFDs, the associated Kerotest valves should be replaced prior to its use on both Unit 1 and Unit 2. Additionally, TVA revised GOI-6 on November 13, 1987 to establish the administrative measures to ensure that all associated Kerotest valves are operated in accordance with the vendor's recommendations. TVA is requested to provide the following information via confirmatory letter: (1) confirm that the valves will be replaced prior to the use of the gross failed fuel detectors and define the method of ensuring compliance; and (2) confirm that the commitment to review the remaining safety-related systems post-restart has been entered in the CCTS.

This item remains open pending inspection by the NRC.

(Open) Deficiency D2.5-3, <u>Environmental Qualification (Mild) ERCW Pump House Components</u>

This deficiency identified non-conservative discrepancies between environmental temperature data on the design specifications and the mild environmental data drawings, for various motor operated components located within the ERCW pump house. Since the initial data reviewed indicated that the ambient environmental conditions exceeded the vendor's environmental qualification for the ERCW pumps, strainers, screen wash pumps and traveling screens, the IDI team was concerned that the associated equipment may not function during all operational conditions.

TVA responded to this concern by performing calculation TI-505, dated September 4, 1987, which established the maximum temperature limit in the ERCW pump house at Elevation 720 feet as 120°F in lieu of the previous limit of 130°F as shown on the environmental data drawings. This upper temperature limit is verified through implementation of surveillance instruction SI-606 which monitors the temperature indicators in the ERCW pump house every 8 hours to assure that the temperature is equal to or less than 120°F. Also, TVA reviewed the vendor data for the motors in question and determined that these motors are all qualified for an effective ambient temperature rating of 122°F which exceeds the environmental ambient requirements. The IDI team verified the motor rating data and concurred with TVA conclusion on 3 motors, but took issue with the strainer motor which must be qualified for 110°F since it is on a lower floor in the ERCW pump house (i.e., El. 704). The IDI team noted that TVA had incorrectly reviewed an obsolete data sheet for the strainer motors and had failed to identify that the original Westinghouse motors with insulation Class H had been replaced with Reliance motors with insulation Class B, which are only qualified to 104°F. The 104°F strainer motor vendor qualification meets environmental drawings requirement for normal operation but fails to meet the 110°F limit associated with LOCA maximum temperature when the strainer is operated in continuous backwash. Since the vendor temperature limits for the strainer motor is 6°F below the LOCA required limit of 110°F, TVA is requested to justify the selection of this motor.

From a generic perspective, TVA sampled 20 motors located in a mild environment, to ensure that the motor nameplate data is compatible with the environmental maximum temperature limit. All of the sampled motors data were reviewed by the IDI team and all were determined to meet the maximum environmental temperature requirements.

This item remains open pending inspection by the NRC.

(Open) Deficiency D2.5-4, Inadequate Substantiation of Procedure For ERCW Screenwash Pump Manual Operation

This deficiency identified the lack of an approved procedure for manual operation of ERCW screenwash pumps to provide an alternative method for automatic control. Since the automatic control using the "bubbler type" differential pressure transmitter could not be incorporated into the design, a temporary change was utilized. This change removed the wiring and logic for the automatic screen wash function from the system, necessitating manual operation to perform the screen wash function. The IDI team was concerned by lack of issuing approved procedures, in a timely manner, when "temporary" changes are utilized in lieu of design changes.

TVA has issued and approved Revision 30 to SOI 67.1 for instructions and surveillance applicable to manual operation of the ERCW screen wash pump. They have also addressed the "generic" concern applicable to issuing future procedures when "temporary" changes are utilized using control via USQD (Unreviewed Safety Question Determination forms). The IDI team has reviewed the TVA response. Closure of the "generic" portion of this deficiency can be accomplished by review of other existing "temporary" (TACF) changes to ensure that the proper procedures are in place prior to restart.

TVA is requested to confirm that corrective actions are completed. This item remains an open inspection by the NRC.

MECHANICAL COMPONENTS

(Open) Deficiency D3.2-1, Nozzle Thermal Displacements of Containment Spray Heat Exchanger 2B

Deficiency D3.2-1 documented TVA's inconsistent evaluation of the nozzle thermal displacements which containment spray heat exchanger 2B imposes on the connecting piping.

CEB's Rigorous Analysis Handbook does not specify threshold magnitudes of nozzle thermal displacements to be coded in rigorous piping analysis. However, CEB indicates that nozzle thermal displacements less than 1/16-inch are not considered significant.

TVA has confirmed that piping calculations performed by EDS (now Impell) evaluated nozzle thermal displacements greater than 1/16-inch in a consistent manner. TVA also noted that Welding Research Council Bulletin 300, dated December 1984, confirms CEB's use of 1/16-inch as the threshold magnitude for consideration of nozzle thermal displacements.

In order to provide an auditable record of the evaluation of nozzle thermal displacements for each piping analysis, TVA will document the disposition of the equipment nozzle thermal displacements for all rigorous piping analysis and reanalysis post-restart. CEB has agreed to revise the Rigorous Analysis Handbook to specify the required procedure pre-restart.

TVA is requested to confirm that the Rigorous Analysis Handbook has been revised and that CEB's commitment to review equipment nozzle thermal displacements for all new and existing rigorous piping analyses has been entered into TVA's Corporate Commitment Tracking System (CCTS) data base program, which tracks the status of NRC commitments. This item remains open pending the inspection of completed corrective actions by the NRC.

(Open) Deficiency D3.2-2, ERCW Cold Thermal Mode

Deficiency D3.2-2 identified a TVA operating modes table which did not specify the 35°F cold thermal mode for the ERCW pipe from header 2B to containment spray heat exchanger 2B. As a consequence, TVA did not rigorously analyze the affected piping segment and associated supports for the cold thermal mode or thermal range.

TVA notes that only piping subsystems analyzed after January 1, 1985 have issued operating modes tables. TVA will review all issued operating modes tables pre-restart, and will review all piping segments subjected to thermal conditions below 70°F pre-restart. TVA will also revise and upgrade Mechanical Design Guide DG-M5.1.1, entitled, "Operational Modes Analysis for Piping Systems" to a design standard pre-restart.

TVA is requested to confirm that all issued operating modes tables and all piping segments subjected to thermal conditions below 70°F have been reviewed. TVA has reviewed and upgraded Mechanical Design Guide DG-M5.1.1 to a design standard. This item remains open pending the inspection of completed corrective actions by the NRC.

(Open) Deficiency D3.2-3, Control of Design Drawings

An area on piping physical drawing 47W450-24 did not agree with the piping isometric drawing or the analysis of record. TVA has indicated that the area of piping in question was shown correctly on full plan drawings 47W450-21 and 25, and therefore, was not a deficiency. However, TVA will add clarifying notes on piping drawing physical 47W450-24 to ensure that future design changes are not affected by confusing details. TVA should provide additional resolution for this issue to demonstrate that proper drawing control has been established. This deficiency will remain open pending the disposition of this additional requirement. Since this is a post-restart item, this deficiency will remain open until TVA confirms by letter that the requisite corrective action has been placed on TVA's CCTS.

(Open) Deficiency D3.2-4, Piping Modeling Error

A length of 4 inch Schedule 40 pipe was rigorously analyzed as a 3 inch Schedule 40 pipe. TVA agrees with the deficiency, but, considers the safety significance of the modeling error to be minor, based on the following observations:

1. The error is an isolated computer coding error affecting less than 2 feet of pipe.

2. The analyst performed only this one piping analysis for the Sequoyah Nuclear Plant.

3. The maximum stress ratio for all Code equations is 0.5.

4. The stresses in the miscoded area were conservatively shown to be acceptable.

The team reviewed TVA's response to the deficiency and finds the issuance of a Condition Adverse to Quality Report (CAQR) an acceptable resolution to the issue. The team also agrees that adequate procedures are in place to prevent recurrence. TVA is requested to confirm that this item has been placed on TVA's CCTS. This item remains open pending inspection by the NRC.

(Open) Deficiency D3.2-5, Design Drawing Inconsistencies

The piping isometric drawing for Problem N2-67-IIR and the accompanying as-constructed physical drawing Section M24 were revised. These revisions were not incorporated on the as-designed piping physical drawing. TVA issued a [AQR to address this deficiency by correcting the as-designed physical drawing.

The team reviewed TVA's response to the generic aspects of this issue, which indicated TVA's commitment to establish, in the long term, a "one drawing concept" for piping physical drawings to prevent recurrence. The team agrees with the proposed TVA resolution. TVA is requested to confirm that this item has been placed on TVA's CCTS. This item remains open pending inspection by the NRC.

(Open) Deficiency D3.2-6, Missing Pipe Clamp

During a field walkdown the IDI team noticed that a Unistrut pipe clamp was not installed on the return line from the Upper Containment Vent Cooler 2B. TVA agreed that this item was a deficiency.

The team reviewed the technical basis for TVA's response, which essentially concluded that the clamp was not needed based upon the criteria stipulated in CEB Report CEB-76-5. Additionally, the team reviewed calculation N2-ERCW IDI-MISC which presented a computer analysis substantiating the flex-hose boundary condition criteria stated in Report CEB-76-5. Despite this, TVA replaced the clamp on August 29, 1987, and stated that the alternate piping analysis Phase 2 program will provide assurance that this type of condition is detected and corrected. The team finds the TVA disposition acceptable and will consider this item closed when TVA confirms that this item has been placed on TVA's CCTS.

(Open) Deficiency D3.2-7, ERCW Piping Spool Pieces

Deficiency D3.2-7 summarized TVA's on-going corrective actions to replace two spool pieces to be installed in the ERCW line from header 2B to the component cooling water surge tank in SQN Units 1 and 2 during the flood mode. The spool pieces were apparently fabricated to the nominal dimensions shown on the piping physical drawings rather than to the as-built dimensions of the installed piping. However, TVA could not verify that the remaining spool pieces to be installed in the ERCW system during flood mode had been similarly evaluated.

TVA has indicated that 22 spool pieces are required to be installed in the ERCW system during flood mode for SQN Units 1 and 2. TVA has indicated that 5 of the 10 spool pieces measured to date do not fit. TVA will complete an evaluation of all spool pieces pre-restart. TVA will modify all spool pieces which do not fit, or evaluate the adjacent piping and supports for the loads induced when the existing spool pieces are installed pre-restart.

TVA is requested to confirm that the evaluation of the 22 ERCW spool pieces is complete, and that TVA will either refabricate and fit-up each spool piece that does not fit, or evaluate the adjacent piping and supports for the loads induced when the existing spool pieces are installed. This item remains open pending inspection by the NRC.

(Open) Deficiency D3.2-8, Valve Operator Fundamental Frequencies

Deficiency D3.2-8 identified a Masoneilan valve operator with a fundamental frequency less than 25 Hz that had not been modeled as a flexible cantilever in the piping analysis as required by FSAR Section 3.9.2.5.2.

TVA is determining the extent of deficiency D3.2-8, which appears to be confined to Masoneilan valves and diaphragm control valves. TVA is also evaluating the effects of the non-rigid Masoneilan valves on attached piping and supports. TVA will complete this evaluation for non-rigid valves necessary for accident mitigation and safe shutdown, pre-restart. TVA will evaluate the effects of the remaining non-rigid valves, post-restart. TVA will compile a list of non-rigid valves for piping analysis use pre-restart, and revise the Rigorous Analysis Handbook to reference the list of non-rigid valves pre-restart.

TVA is requested to confirm that:

1. TVA's generic valve review has been completed.
2. TVA's evaluation of the effects of non-rigid valves, necessary for accident mitigation and safe shutdown, on the attached piping and supports has been completed.
3. TVA has compiled a list of non-rigid valves for piping analysis.
4. TVA has revised the Rigorous Analysis Handbook to reference the non-rigid valve list.
5. TVA's commitment to address the effects of non-rigid valves within the DBVP Phase 2 scope has been entered into TVA's CCTS.

This item remains open pending inspection by the NRC.

(Open) Deficiency D3.3-1, ERCW System Pipe Support Calculation N2-67-2A

Deficiency D3.3-1 identified a common W10x25 support beam for pipe hangers 1ERCWH-71 and -134 which was not evaluated for the combined support loads. Deficiency D3.3-1 also noted that pipe support 1ERCWH-133 was modeled in the piping analysis as an axial restraint, but had insufficient lateral clearance to accommodate the computed lateral movement of the pipe.

TVA agrees that the design evaluation of pipe support 1ERCWH-71 did not address the load applied to pipe support 1ERCWH-71 by pipe support 1ERCWH-134. TVA also agrees that the inadequate lateral clearance for pipe support 1ERCWH-133 is an unanalyzed condition. However, TVA indicates that these deficiencies would have been addressed as part of TVA's pipe support calculation regeneration program. TVA will also revise design criteria SQN-DC-V-24.2 to include supports on alternately analyzed piping.

Bechtel is currently regenerating the calculation for pipe supports 1ERCWH-71 and -134, and the calculation for pipe support 1ERCWH-133 pre-restart as part of TVA's pipe support calculation regeneration program.

TVA is requested to provide confirmation that the pipe support calculations have been regenerated and that TVA's commitment to revise design criteria SQN-DC-V-24.2 has been entered into TVA's CCTS. This item remains open pending inspection of the completed corrective actions.

(Open) Deficiency D3.3-2, Pipe Support Discrepancies

Ten pipe support analyses for piping problems N2-67-10R and N2-67-11R were reviewed for compliance to CEB design criteria and FSAR commitments. Three of these pipe support calculations were found to have errors relating to technical assumptions and incorrect dimensional data. These conditions are being tracked by CAQR SQP871498IDI. For one support TVA determined that the calculation documentation was not updated to record the acceptability of subsequent construction configuration changes during the Support Modification Request (SMR) process.

To prevent recurrence of the documentation discrepancies identified for pipe support 47A450-25-344, SMRs are no longer used at Sequoyah. TVA has committed to address the generic aspects of this deficiency as they apply to other pipe supports within the scope of the Rigorous Pipe Support Calculation Regeneration Program and the Alternate Analysis Review Program. The team reviewed TVA's re-evaluations of the identified pipe supports and found the calculations acceptable. TVA has indicated that the team's generic concerns are being addressed as part of TVA's pipe support calculation regeneration and alternate analysis programs. This item remains open pending the team's review of TVA's generic corrective actions.

(Closed) Deficiency D3.3-3, Incorrect Pipe Support Allowable Stresses

Pipe support design loads are obtained from the TPIPE computer program, which combines the individual pipe support loads into the normal, upset and faulted load combinations. Each load combination is then divided by a factor which is associated with the allowable stress for the given service condition. TVA designers used a faulted factor which, when applied, could result in the allowable stress for a faulted condition exceeding the limit of 0.9 Fy as required by the Sequoyah FSAR. TVA agreed that this condition was a design deficiency and also noted that this condition had been previously identified and corrective action had been taken by issuance of CAQR SQP871495IDI.

TVA has indicated that this condition is being addressed and will be corrected during the implementation of the Pipe Support Calculation Regeneration Program for supports on rigorously analyzed piping.

TVA will also address this concern for the pipe supports reviewed under the Phase II portion of TVA's Alternate Analysis Review Program post-restart. TVA will revise design criteria SQN-DC-V-24.2 before the start of the Phase 2 program to include Category I supports.

The team confirmed that TVA has revised design criteria SQN-DC-V-24.2 to restrict the maximum faulted condition allowable stress to 0.9 Fy, as required by the FSAR. This deficiency is therefore closed for the purposes of this inspection. TVA has also indicated that the team's generic concern, that the rigorously and alternately analyzed pipe supports be reviewed for conformance to the 0.9 Fy maximum faulted stress, is being addressed as part of TVA's pipe support calculation regeneration and alternate analysis programs. These programs are being overviewed by the NRC's Office of Special Projects

(Closed) Deficiency D3.3-4, Pullout Loadings for Baseplate and Anchor Bolts

TVA uses "typical" pipe support designs to support and restrain piping systems qualified by their alternate analysis piping program. Review of calculations performed to substantiate the load carrying capacity of these "typical" supports indicated that no consideration was given to the effects of direct tensile loading on anchor bolts and baseplates. The TVA calculation only considered the effects of moment loadings. TVA agreed with the NRC finding that a design deficiency existed. However, TVA noted that this condition would have been corrected for each Category I support by the ongoing pipe support calculation regeneration program. TVA also has established the alternate analysis review program for Category I pipe support documentation. TVA has established the alternate analysis review programs for Category I piping systems and supports to identify and to address any similar deficiencies. In addition, TVA has recalculated the baseplate stresses and anchor bolt loadings considering all forces and moments and has shown that the original design meets FSAR requirements and is therefore acceptable.

The team reviewed TVA's re-evaluations of the identified pipe supports and found the calculations acceptable. This deficiency is therefore closed for the purposes of this inspection. TVA has indicated that team's generic concerns will be addressed as part of TVA's pipe support calculation regeneration and alternate analysis programs. These programs are being overviewed by the NRC's Office of Special Projects.

(Open) Deficiency D3.3-5, Incorrect NCR Corrective Action

Test data for Unistrut pipe clamps, commonly used at Sequoyah on small bore piping, was originally based on one direction of loading. TVA designers, however, used the allowable loads based on the one directional tests for piping loads in multiple loading directions. An NCR written to address the condition incorrectly used an elliptical interaction equation to qualify previously used clamps. TVA agreed with the deficiency and stated that the previous method of interacting the combined effects of loads in three orthogonal directions was incorrect.

The team reviewed TVA's response to this deficiency and found it acceptable. CAQR SQT871487IDI has been written to track the resolution of this issue. Also, a Quality Information Release has been issued to Civil Engineering Branch Lead Engineers requiring the use of the straight-line interaction method for future evaluation of Unistrut pipe clamps. It should be noted that the acceptability of the straight-line interaction method is addressed under IDI Deficiency D3.5-3.

TVA is requested to confirm that Unistrut clamps in rigorously analyzed piping have been reanalyzed using straight-line interaction as part of the Pipe Support Calculation Regeneration Program, that Unistrut clamps in alternately analyzed piping (Phase 1) have been reanalyzed using straight-line interaction as part of the Alternate Analysis Review Program, and that TVA's commitment to reanalyze the Unistrut clamps installed in the alternately analyzed piping to be evaluated during the Phase II portion of TVA's Alternate Analysis Review Program has been placed on TVA's CCTS.

TVA's corrective actions to address this deficiency will be reviewed as a part of the followup inspection.

(Open) Deficiency D3.4-1, Motor Operated Valve Design Pressure

Deficiency D3.4-1 identified a vendor seismic qualification calculation for motor operated valves 47W427-6 and -7 which used an incorrect design pressure of 50 psi instead of the 150 psi system design pressure.

TVA has requalified valves 47W427-6 and -7 using the correct 150 psi design pressure. TVA is evaluating the extent of Deficiency D3.4-1, and is requalifying additional valves using the correct system design pressures. TVA will also amend the FSAR to permit seismic qualification of valves by analysis in addition to test.

TVA is requested to provide confirmation that the following items are completed:

1. A generic review of operating pressures used in valve seismic qualification.

2. TVA has requalified the affected valves.

3. TVA's commits to review incorrect documentation post-restart and this commitment has been entered into TVA's CCTS.

This item remains open pending review of the proposed FSAR amendment to assure that the IDI team's concern will be resolved, and inspection of completed corrective actions.

(Open) Deficiency D3.4-2, <u>Seismic Qualification of Turbine Driven Feedwater Pump 2A</u>

Deficiency D3.4-2 identified an equipment nozzle axial load due to internal pressure in CEB Report 82-1 that was not addressed in the seismic qualification report for turbine-driven auxiliary feedwater pump 2A.

TVA has indicated that the TVA report specified the nozzle load to address the possible installation of an untied bellows, and that the nozzle axial load due to internal pressure was not applicable to the qualification of the turbine-driven auxiliary feedwater pump, which is a closed hydraulic system. TVA will revise CEB Report 82-1 to clarify the applicability of the nozzle axial load pre-restart.

TVA is requested to provide confirmation that CEB Report 82-1 has been revised. This item remains open pending inspection of the completed corrective action.

(Open) Deficiency D3.4-3, <u>CCW Heat Exchanger Calculation</u>

The Component Cooling Water (CCW) heat exchanger was observed during an NRC field walkdown to have three supports. The vendor drawings and seismic qualification report only indicated two supports. TVA's response was that this was a documentation deficiency resulting from inadequate interface review of a design change initiated by TVA piping analysis engineers. TVA reviewed all piping analysis isometrics issued before 8/29/87 to verify attachment to equipment and component supports modeled in the analyses. TVA's isometric review indicated that there were no similar supports which did not undergo the proper review. TVA performed a preliminary analysis of the CCW heat exchanger assembly which indicated that the heat exchanger and supports are or can be qualified for all loadings. A detailed review of the support and anchorage qualification for the CCW and 10 other Category I heat exchangers has been initiated by TVA to ensure no impact on plant safety.

TVA is requested to confirm that:

1 The detailed analysis of the CCW heat exchanger shell and supports has been completed.

2. The analyses for the additional 10 Category I heat exchangers have been completed. These analyses should contain as a minimum a complete review of the effects of the "non-rigid" heat exchangers on equipment support designs and attached piping systems.

3. Corrective actions, if any, are completed.

This item remains open pending the team's inspection of completed corrective actions.

(Closed) Deficiency D3.4-4, CCW and CS Heat Exchanger Nozzle Loading

A vendor provided TVA with the seismic qualification of the Component Cooling Water (CCW) and Containment Spray (CS) heat exchangers. The vendor only considered four components of nozzle load allowables, neglecting the two shear components required by TVA's purchase and design specifications. TVA has determined that the vendor's calculations neglected the effect of nozzle shear loads on the local nozzle/shell interface. TVA has performed additional calculations which indicate that neglecting the shear forces has little effect on the shell stresses and therefore, the analysis provided by the vendor is adequate. This deficiency is therefore closed. TVA has also reanalyzed the CCW and CS heat exchangers to include the effects of these shear loadings on the anchorages and foundations as part of TVA's response to Deficiency D3.4-3.

(Open) Deficiency D3.4-5, Vendor-Supplied Flexible Hose

Deficiency D3.4-5 identified FLEXONICS series flexible metal hoses installed in the ERCW system that TVA did not procure to standard TVA Class C seismic criteria.

TVA has identified the installed hoses, and has inspected the hoses to confirm that none of the hoses exhibit excessive bulging, misalignment, or loose braids. TVA has also seismically qualified the hoses by analysis. TVA will replace the installed hoses post-restart with appropriately qualified flexible metal hoses. TVA will conduct a review post-restart to determine if seismic qualification exemptions were incorrectly invoked in procurement documents for similar components.

TVA is requested to confirm that TVA has established a program before restart that specifies a scope and schedule for the replacement of the installed flexible metal hoses post-restart, and that TVA's commitments to replace the flexible metal hoses post-restart and to evaluate additional procurement documents post-restart have been entered into TVA's CCTS.

This item remains open pending inspection of completed corrective actions.

(Closed) Deficiency D3.4-6, ERCW Upper Containment Vent Cooler Frequency Calculation

A frequency calculation error was found in the Seismic Qualification Report for the Upper Containment Vent Cooler. The Seismic Qualification Report for this cooler also did not exhibit the required Design Review. When corrected, the minimum frequency for the cooling unit was determined to be 23.7 Hz, which is less than the limit of 25 Hz required for consideration as a rigid device. The TVA response consisted of correcting the calculation error and re-evaluating the cooling unit to determine its flexibility or rigidity.

The team reviewed the TVA reponse and found it acceptable. TVA evaluated the low frequency (23.7 Hz) and concluded that the corrected natural frequency would not adversely affect the performance of the cooling unit, since the acceleration levels used in the analysis clearly enveloped the required acceleration levels. The team considers the specific aspect of this deficiency, i.e., calculation error, closed. However, the generic aspects pertaining to design review requirements will be resolved as part of the corrective action for Deficiency D3.6-1.

(Closed) Deficiency D3.4-7, Chiller Unit Seismic Qualification

Deficiency D3.4-7 identified the separate seismic qualification tests of a TVA Class C chiller unit and its control box to margins of safety for the control box less conservative than the three-fourths criterion specified in Section 6.1.3 of Appendix F of the technical specification attached to the procurement document.

TVA has indicated that Footnote 1 to Section 6.1 of Appendix F exempts the vendor from qualifying a device such as the control box to the three-fourths criterion if the vendor qualifies the device to excitation levels which exceed the response levels of the support structure at the device mounting location.

The team confirmed that the seismic qualification levels of the chiller box adequately enveloped the chiller response levels at the chiller box mounting location. Deficiency D3.4-7 is closed.

(Closed) Unresolved Item U3.5-1, Piping Code of Record

The piping code of record for design is stated in the FSAR as ANSI B31.1 - 1967 Edition. Since ANSI B31.1 - 1967 did not define load combinations for the normal, upset and faulted service conditions, TVA used the stress allowable equations from ASME Section III, Subsection NC-3000, Winter 1972 Addendum. In addition, TVA used the stress allowable limits specified in the ASME Code which is inconsistent with FSAR Table 3.9.2-3 which commits to the use of ANSI B31.1 - 1967 stress allowable limits. TVA responded that the allowable stresses for ANSI B31.1 and ASME Section III may be considered equivalent, since they are both developed by the Subcommittee on Properties of Metals of the ASME Boiler and Pressure Vessel Committee. However, minor differences may exist between the allowable stresses listed in ANSI B31.1 and ASME Section III due to the method and timing with which each Code adopts revisions and changes.

TVA has committed to revise the FSAR to change the source of allowable piping stresses from ANSI B31.1 - 1967 to ASME Section III 1974 Edition through the Winter 1976 Addendum.

This item is a licensing issue which must be resolved separately by TVA with NRC's Office of Special Projects. This item is closed for the purposes of this inspection.

(Open) Deficiency D3.5-2, Use of Selected B31.1 Code Rules

On several piping problems, at elbows and tees, TVA incorrectly interpreted ANSI B31.1 - 1967. In these instances, TVA concluded that the additive stresses did not require the use of the stress intensification factor (i). TVA agreed with the NRC that the exclusion of the i-factor was inappropriate. Since this condition only existed in piping problems reanalyzed after OL, TVA reviewed all post-OL reanalysis problems. This review revealed a total of four cases which required requalification. TVA's requalification concluded that all four cases meet the FSAR commitments and require no hardware modifications.

In order to prevent a recurrence of the identified deficiencies, TVA should revise the Rigorous Analysis Handbook pre-restart to provide additional guidance to the piping analyst to ensure that TVA's use of stress intensification factors in piping stress analysis is in accordance with code requirements.

TVA should include in their response to this item, the revision to the Rigorous Analysis Handbook. This revision should include (1) a formal discussion of the acceptability of using just the elbow i-factor and not some other higher factor for an elbow with a branch connection when evaluating stresses due to sustained loadings (i.e., weight and seismic); (2) a more complete discussion of the "i" values used as a basis for the stress calculations for concentric reducers; and (3) a statement that the "i" values used for the evaluation of thermal stresses on elbows with branch lines were determined by using the lesser of "i" x "i", or "i" + "i".

This item remains open pending inspection of completed corrective actions.

(Open) Deficiency D3.5-3, Unistrut Clamp Load Testing

TVA has developed load ratings for Unistrut clamps using the design rules of ASME Section III, Subsection NF, 1974 Edition, Winter 1976 Addendum. The use of ASME Section III instead of the B31.1 - 1967 code of record is under current licensing review by the NRC's Office of Special Projects. The NRC IDI team raised several questions relating to the application of these load rating rules. Among them are TVA's failure to take the 10 percent reduction when only one sample is tested, the applicability of A307 bolts in a friction connection, TVA's failure to consider temperature effects, and the applicability of the data obtained from the test installation. TVA is performing additional testing to avoid the 10 percent reduction. Additional tests will be performed to establish a yield strength for the A307 bolting typically used in the Unistrut assemblies. In addition, TVA will establish load ratings as a function of temperature. TVA has indicated that interim use of the clamps without considering temperature effects as acceptable. Actual support verification of the temperature effects will therefore be accomplished post-restart. TVA also provided additional information concerning the actual test configuration and discussed configuration effects on the resulting load ratings.

TVA has been requested to document the yield and ultimate strengths of A307 bolts incorporating information from sources such as TVA testing and published literature for 1/4" and 3/8" diameter bolts, to develop a bolt load vs. torque test using the actual clamp configuration for the 1/4" bolt similar to the test done for the 3/8" bolt, and to place the commitment to review all Category I supports for temperature effects on TVA's CCTS.

This item remains open pending inspection of completed corrective actions.

(Open) Deficiency D3.6-1, Design Review for ERCW Equipment

Some vendor seismic component qualification reports did not meet the Quality Assurance provisions of the procurement documents in that no evidence of the required design review could be found. TVA responded that at the time of acceptance of the seismic qualification reports, TVA performed a Design Review (as permitted by Paragraph 2.0 of Appendix A to the procurement documents) in those instances where the equipment vendor did not provide a Design Review. The IDI team is concerned that TVA's response does not provide adequate assurance that the TVA design review of the vendor seismic qualification reports met the procurement document requirement and intention of an independent design review.

The IDI team review of the documentation provided by the TVA response indicates that the TVA design review is in the form of an internal TVA memorandum which "reviews and accepts" the seismic qualification report. It is not apparent that this review was meant to be the missing design review or whether it is simply part of the acceptance cycle. In addition, TVA has reviewed three additional equipment seismic qualification reports which apparently focus on potential calculation errors. From this review TVA concluded that, since the calculation errors discovered were not significant, no deficiency was identified.

The team concluded that TVA's response was unacceptable, since the lack of committed Design Reviews was not satisfactorily addressed.

As a result, the IDI team requested TVA to establish and implement a comprehensive program to review a specified number of seismic qualification reports for compliance with their respective procurement document requirements prior to restart of Unit 2. In order to provide an acceptable breadth of review, TVA should choose as their sample a minimum of forty (40) seismic qualification reports evenly distributed (if possible) encompassing the following scope of safety-related equipment; air handling units, heat exchangers, pumps, valves, tanks and dampers. Also, where applicable, within each equipment type the sample should cover various equipment manufacturers.

This item will remain open pending inspection of TVA's completed corrective action.

CIVIL/STRUCTURAL

(Closed) Deficiency D4.2-1, Stability of ERCW Access Cells

The seismic analysis report Report No. CEB-74-14 Rev. 2, 1/3/79, for the ERCW Access Cells assumed that the 6 cells would act as a single "J-shaped" unit. The supporting calculation postulated shrinkage of the interior concrete and gaps between the interior concrete and the exterior sheet piles. The calculation also postulated vertical movement between the adjacent cells. The inability to transfer the vertical shear between adjacent cells makes the original assumption of a "J-shaped" unit invalid. The supporting calculation also indicated that a single cell has a factor of safety of less than one for the overturning moment, i.e., during a seismic event the access cell could tip up on one corner. Failure or excessive movements of the access cells would cause the failure of the ERCW piping which is essential for safe shutdown.

TVA has committed to perform a non-linear time history response analysis of the ERCW access cells. The team requested that the non-linear analysis and the supporting documentation including the design criteria, analysis of the ERCW piping, the stress analysis of the concrete cells and rock foundation and the computer programs used in the analysis be submitted to the NRC for review and approval prior to restart.

This item is closed for the purposes of this inspection. It will be resolved separately as a licensing issue by the NRC's Office of Special Projects.

(Open) Deficiency D4.2-2, Seismic Analysis of Shield Building and Steel Containment

The review of the original seismic analyses showed that they were not signed by the preparer or the checker. The technical position cited by TVA was that CEB reports which summarized the seismic analysis results were signed by checker and approved.

In response to this deficiency, TVA revised the seismic analysis of the shield building (B41 870917 008). The review of these calculations by the team showed that the calculations still contained information that was incorrect or unsupported. The team requested that TVA make a thorough review of the calculations and clarify the necessary information and results and also eliminate information and results which have no significance to the final results or correct information as appropriate.

In addition, TVA report CEB-80-22-C titled "Dynamic Earthquake Analysis and Static Wind-Tornado Analysis of the Shield Building", also reflected incorrect and unsupported information from the shield building seismic calculations. The team believes that this report should also be similarly revised.

The following discrepancies, inconsistencies, and errors were noted by the team:

1. Mode shapes shown in figure 5 report CEB-80-22-C were not supported by calculation B41 870917 008.

2. Calculation B41 870917 008 (pages 9 thru 11) uses the same formula as the original calculations (pages 19 thru 22) for mass moment of inertia. This property is used as input t DYNANAL computer program. The formula used was in error since no mass or weight was considered.

3. Table I of report CEB-80-22-C does not list all the data that was used as input to DYNANAL.

4. Item 4 and Table III of report CEB-80-22-C are based upon unchecked conclusions with no calculations available.

5. There is an inconsistency in report CEB-80-22-C. Item B states that the use of shell theory is necessary for the dome, however, vertical response spectra are based on a stick model.

6. Figure 2 in report CEB-80-22-C is based on page 177 of calculations B41 870917 008, which is unchecked and stamped "INFO ONLY".

7. Figure 3 in report CEB-80-22-C is based upon page 178 thru 181 of calculation B41 870917 008, which is stamped "INFORMATION ONLY NO CHECKING REQUIRED."

8. In Table IV of report CEB-80-22-C, values are listed for the vertical natural periods as 0.067 and 0.022 seconds. On page 235 of calculation B41 870917 008, a handwritten value of 0.067 seconds is shown. The value of 0.022 seconds was not found in the calculation (Note that it is recognized that a period of 0.022 seconds is in the rigid range).

9. Horizontal periods for modes 1 and 2 listed in Table 11 of report CEB-80-22-C correspond to modes 2 and 4 shown on page 217 of calculations B41 870917 008. Output containing data for modes 1 and 3 are marked with a handwritten note: "This torsional mode not used."

The documentation should be revised so that all necessary design data is supported and documented and that unnecessary calculations, tables, etc., be removed from the body of these documents. The team also noted that there were some discrepancies in the calculations of mass, however, they were not considered to have a significant effect upon the results. This item remains open pending confirmation by TVA that the corrective actions are completed and inspection by the NRC.

(Open) Deficiency D4.2-3, Seismic Analysis of Steel Containment Vessel

The original calculations for the seismic analysis of the steel containment vessel contained newly generated vertical amplified floor response spectra issued in June 1987, which showed increased responses in the high frequency range between 20 and 25 Hz.

Prior to 1979, the vertical amplified floor response spectra was established as simply being 2/3 of the horizontal amplified response spectra at the elevation under consideration. During 1979-1980, TVA calculated vertical amplified response spectra for the steel containment vessel (SCV) in order to reduce conservatism. During 1986, TVA noted that at some elevations the vertical amplified response spectra had unexplainable variations from those at adjacent elevations. As a result of these discrepancies, TVA issued problem identification report PIR SQNCEB8652 and a corrective action was initiated.

Using earthquake "A", one of the four artificial time histories of ground motion, several comparison analyses by TVA were initiated. Both a beam model and an axisymmetric finite element model were prepared. The ANSYS computer program was used for both the beam and finite element models for the seismic analysis and calculation of response spectra. An integration time step of 0.001 seconds was assigned for the ANSYS analysis using both the beam and axisymmetric finite element models. The beam model was also analyzed using the STARDYNE computer program which generated floor time history information. This information later was used as input to the RESPONSE computer program for the calculation of amplified response spectra. For STARDYNE, no time step was assigned because the time step is determined internally. However, TVA assigned both a t = 0.01 and 0.005 seconds for calculations of amplified response spectra using the RESPONSE computer program. The peaks of the response spectra at the fundamental vertical frequency of the SCV were different depending on whether the time step of integration was 0.01 or 0.005 seconds.

TVA supplied comparisons to the team which indicated that the response spectra developed entirely using STARDYNE compare very well with the combinations of STARDYNE and RESPONSE where the time step of integration in RESPONSE was 0.005 seconds. If the time step of integration was selected as 0.01 seconds, the peak of the amplified response spectra (ARS) was reduced by 30 percent. While these comparisons indicate the validity of RESPONSE, they also indicate that an appropriate small time step of integration must be established for structures with a high dominant frequency. While the amplified response spectra developed from STARDYNE and RESPONSE using the time step of integration of 0.005 seconds exceeded the amplified response spectra generated by ANSYS using 0.001 seconds' the peaks obtained from the RESPONSE using a time step of 0.01 seconds did not exceed the ANSYS spectra.

Since the time step of integration originally used for generating the ARS with RESPONSE was 0.01 seconds, the amplified response spectra may not be conservative for the analysis of piping systems with dominant frequencies near 24 Hz. The use of a time step of integration of 0.005 seconds in the RESPONSE computer program is considered acceptable to the team for the development of all vertical response spectra for the SCV which has a vertical dominant frequency of approximately 24 Hz.

In order to assure that the piping systems and equipment supported by SCV will withstand the postulated earthquake loads, TVA committed to use the vertical amplified response spectra regenerated by STARDYNE and RESPONSE Codes with a time integration step of 0.005 seconds and reanalyze two worst-case piping systems. TVA is requested to confirm that the reanalysis of the two "worst-case" piping systems is completed. This deficiency remains open pending inspection of completed corrective actions.

(Closed) Deficiency D4.2-4, Seismic Model of Auxiliary Control Building

The review of the original calculations showed that the seismic model of the auxiliary building does not include columns and there were indications that some walls may have been omitted.

TVA calculation (B41 870917 004) indicated that the walls which were omitted in the preliminary calculation were in fact included in both Revision 0 and 1. The team agrees that it was appropriate to exclude the columns, block wall partitions, and short non-continuous walls in both the calculation of the shear area and bending moment of inertia.

As a direct response by TVA, calculations on pages 5 through 8 of TVA calculations (B41 870917 004) were prepared, which showed that the addition of all columns added very little to the bending stiffness of the auxiliary control building. Furthermore, the auxiliary control building is considered to be a shear building, i.e., a low height to length ratio with long continuous reinforced concrete walls extending the full height of the building. For such buildings, the bending stiffness is much greater than the shear stiffness, so that bending stiffness has little effect on seismic response. Therefore, minor differences in bending stiffness have even a lessened impact on seismic response. In addition, columns and discontinuous walls of relatively short length add little to shear stiffness due to local bending between floors, and therefore should not be included in the calculations of shear area.

The TVA calculation (B41 870917 004) supports the conclusions that long and continuous walls have been appropriately considered in the calculation of the shear and bending stiffness of the auxiliary control building.

The auxiliary building is the type of structure such that it is appropriate not to consider columns in determining shear and bending stiffness. The team believes that no walls which would have a significant effect on the stiffness of the seismic model were neglected. Therefore, the team considers this deficiency to be closed and that no further work by TVA is required.

(Closed) Deficiency D4.3-1, Auxiliary Building Base Slab Design

The base slab of the auxiliary building is anchored to the rock to minimize the bending stresses in the slab due to hydrostatic uplift pressure. The team's review of the original calculations for the base slab showed that the net uplift pressure used for the design of the anchor rods and the base slab reinforcement was incorrect. A uniform pressure equivalent to the weight of the whole building was deducted from the hydrostatic pressure, however, only the weight of the base and fill slab should have been deducted.

In order to resolve this deficiency, TVA performed additional calculations (B25 871110 451) using the correct uplift pressure. These calculations addressed both the length of anchor rods and also the capacity of the base slab to resist the revised pressure. The review of the calculations showed that a composite section made from rock, subpour and the base slab was used to overcome the uplift pressure. The stresses calculated for rock, concrete and the reinforcing bars in the base slab were all within the FSAR commitments. TVA used working stress design methods to perform this reanalysis. This is in agreement with the FSAR commitments for the auxiliary building base slab design. These additional calculations also showed that the anchor rods are not required for the auxiliary building stability against floatation and overturning.

TVA also reviewed the calculations for the Reactor and Control buildings, which are the only other Category I buildings with anchor rods. Their review showed that the dead weight of the buildings and slabs was properly considered for the design of the anchor rods.

The team concludes that TVA has adequately addressed this deficiency and has shown that the auxiliary building base slab anchors have enough capacity to resist the uplift pressures. The team considers this deficiency closed, and therefore no additional work is required to be performed by TVA.

(Closed) Unresolved Item U4.3-2, Development Length of Base Slab Anchor Rods

The base slab of the auxiliary building is anchored to the foundation rock by grouted #11 reinforcing bars. These reinforcing bars are straight in the rock, however, in the slab they have a 90 degree hook with a straight extension. The review of the original design calculations and drawings showed that the detail of the embedment of the #11 reinforcing bars in the base slab did not adhere to the requirements of the ACI 318-63 code. The full strength of the #11 reinforcing bars could not be attained by the detail provided by TVA.

TVA's response to NRC dated October 29, 1987 stated that their interpretation of the ACI 318-63 code would allow the use of the embedment detail as provided for the auxiliary building base slab. The NRC team still feels that the intention of the ACI 318-63 code to limit the allowable stresses that can be developed by a hook was violated by the TVA design. However, the embedment requirements for reinforcing steel have been reduced by the ACI 318-83 due to recent tests performed on hooks. TVA has performed additional calculations using Section 12.5 of the ACI 318-83 code. These calculations, B25 871021 451, show that for the maximum required area of reinforcing steel (1.51 sq. in.), there is enough embedment in the base slab to develop the strength required in the reinforcing steel.

TVA also reviewed the design of the reactor and control buildings which are the only other two Category I buildings with anchor rods. The control building has a similar design, however, the reactor building anchors do not have any hooks. The team reviewed the additional calculations, B25 871109 450, performed by TVA for the control building base slab using the same provisions of the ACI 318-83 code. These calculations show that for the maximum required steel area of 1.25 square inch, enough embedment was provided in the original TVA design.

The team concludes that TVA has adequately shown that the anchor rods for the auxiliary and control buildings have adequate embedment in the base slabs to resist the uplift pressures. The team considers this unresolved item closed, and therefore no additional work by TVA is required.

(Closed) Unresolved Item U4.3-3, Negative Moment Reinforcement in Base Slabs and Walls

The review of the original calculations for the auxiliary building showed that the base slab and certain walls which are placed against rock has reinforcing only on the inside face. TVA did not consider the effects of the negative moments that would develop at the anchor rods of the base slab, as well as the top and bottom of walls. Since there was no negative reinforcement provided at these fixed or continuous supports, the concrete could crack increasing the positive moments and in the case of the anchor rods, could diminish the bondage to concrete.

In response to this NRC concern, TVA has performed additional calculations (B25 871021 453) for the auxiliary building base slab assuming that the slab would crack at the anchor rods due to the lack of negative reinforcement. These calculations show that the base slab is structurally adequate to resist the uplift pressures, even if it is assumed to crack along the anchor rods. TVA also calculated that a crack width of 0.0016 inches would develop at the anchors, which is about 16 percent of the ACI 318-63 crack width limitation for exterior exposure. Such a crack would not jeopardize the strength of the #11 reinforcing bars to resist tension loads.

TVA also performed a similar calculation (B25 871109 450) on the control building base slab, as a part of their generic review. The team's review of this calculation also showed that the control building base slab has adequate strength to resist the uplift pressures.

TVA reviewed the auxiliary and control building walls that were placed against rock and identified all walls which had reinforcing only on the inside face. This review is documented in TVA calculation B25 871021 450. TVA evaluated all these walls assuming one-way simple spans and showed that they have adequate capacity to resist all horizontal loads even if the walls were to crack at the top and bottom supports.

The team concludes that the additional calculations performed by TVA show that the base slabs and walls poured against rock in the auxiliary and control building have adequate capacity to resist the vertical and horizontal loads.

Although not considered in the original design, the cracking of concrete along the fixed or continuous supports, would not jeopardize the structural integrity of the auxiliary and the control buildings. Therefore, the team considers this unresolved item closed and no further action is required from TVA.

(Open) Deficiency D4.3-4, Load Combination For Concrete Slab

The review of the original design calculations for the auxiliary building slab at elevation 669.0' showed that the construction load combination was used as the most critical case. However, the team noted that if the live loads as shown on TVA drawing 41N704-1 was used, then the most critical load combination to design the slab would have been the normal operating condition. The team was concerned that the worst load combination was not used in the original design calculations.

In response to this deficiency, TVA has performed a review of drawing 41N704-1 to determine whether the live loads that are shown on this drawing were actually used in the original design calculations of the Category I buildings. This review by TVA has shown that there are discrepancies between the live loads shown on this drawing and live loads used in the design calculations. TVA has issued a problem identification report PIR SQNCEB8780 to track this problem. TVA has also performed additional calculations (B25 870918 450) to determine the adequacy of the floor slabs for the live loads shown on the drawing, whenever such live loads were different in the original design calculations. These reevaluations by TVA have shown that the slabs are structurally adequate, however, TVA used Ultimate Strength Design (USD) methods to qualify certain slabs. This is contrary to the FSAR commitment that the original design of various Category I buildings use the Working Strength Design (WSD) for concrete. Therefore, the approach taken by TVA to qualify certain slabs by the use of USD is not acceptable to the NRC team. This failure to meet this FSAR commitment should be resolved prior to restart.

The team was advised that TVA will evaluate the generic implications of this deficiency in conjunction with the live load reconciliation and reinforcing bar cut programs that are being performed as a part of the employee concerns program. These evaluations, as stated by TVA, will include the reactor building and other Category I buildings. However, the team notes that these evaluations can be performed post-restart.

TVA is requested to confirm that the post-restart evaluation has been placed on the CCTS. This item remains open pending inspection and resolution of the FSAR deviation.

(Open) Deficiency D4.3-5, Shear Calculations for Slabs and Walls

The review of the original design calculations for the auxiliary building roof slab and the walls on column line A1 and A15 showed that evaluations for shear forces were not performed. Failure to check shear forces in critical sections is in violation of the ACI 318-63 code requirements as stated in sections 1201 and 1207. The NRC team was concerned that shear stresses could have been exceeded at critical sections of certain structural elements.

In response to this deficiency, TVA has performed a review of shear calculations for 13 Category I buildings required for safe shutdown, except the ERCW pumping station. A total of 294 structural elements including walls, floors, roof and base slabs, beams and columns were selected. These elements were reviewed to determine whether shear stresses were checked in the design calculations. The review of these calculations associated with the selected samples showed that the shear calculations existed for 274 cases, as documented in TVA calculation B25 870917 450. TVA performed additional calculations to show that the remaining 20 cases had shear stresses which were within the FSAR commitments. The NRC team performed a cursory review of these additional calculations and agrees with the TVA approach. The team also reviewed the shear calculations performed for the auxiliary building roof slab at elevation 778.0 and the A1 and A15 line walls and found them to be acceptable.

The generic review performed by TVA on the 274 elements did not check whether the shear calculations were performed in accordance with the ACI-318 Code requirements. Therefore, the team believes that TVA should select some additional samples from the 274 elements to determine the adequacy of the original shear calculations. The team recommends that at least 30 sample elements including walls and slabs be selected from these 274 elements and evaluated. Since the 20 regenerated shear calculations showed no shear overstress, the team requested 10 calculations be reviewed prior to restart and the remaining 20 to be reviewed post-restart, if the review results of the first 10 samples are found to be acceptable. The post-restart portion of the generic review should be entered on the CCTS and be completed before the end of the next refueling outage.

TVA is requested to confirm that the pre-restart generic review is completed and that the post-restart review has been entered on the CCTS. This item remains open pending inspection.

(Open) Deficiency D4.3-6, Minimum Reinforcement for Walls

The review of the original design calculations for some auxiliary building walls showed that the minimum horizontal reinforcement provided was less than the ACI 318-63 Code requirements. TVA provided a horizontal steel area ratio of 0.0020 whereas the ACI 318-63 Code section 2202 (f) requires this amount to be 0.0025. The same TVA calculations also showed that the effective depth "d" instead of the thickness "t" was used to calculate the minimum steel area. The NRC team was concerned that minimum steel areas, less than what is required by the ACI 318-63 Code, could have been provided for the Category I buildings.

In response to this deficiency, TVA performed a review of the calculations for structural slabs and walls in the auxiliary building, reactor building, ERCW pumping station and control building, as documented in TVA calculation B25 870916 453. This review identified approximately 78 cases where the effective depth "d" was used to calculate the minimum reinforcement. TVA has performed additional calculations to determine the actual amount of steel required in accordance with ACI 318-63 Code. Review of the corresponding as-built drawings has shown that for all cases the provided reinforcement was within the Code requirements. The NRC team believes that no further work is required from TVA for this aspect of the deficiency.

In the auxiliary building, the design of the A1 and A15 line walls for minimum horizontal steel used the TVA Temperature and Shrinkage Standard. The use of this standard for these two walls resulted in a minimum percentage of horizontal steel of 0.20 percent in the upper portions of the walls, and 0.55 percent in the lower portions. The additional calculations (B25 870911 450) performed by TVA on the A1 and A15 walls showed that an average of 0.27 percent and 0.34 percent horizontal steel were provided, respectively. These amounts of steel would meet the ACI 318-63 Code requirements. However, the team believes that additional samples of walls should be evaluated in a similar fashion. This evaluation can be performed post-restart. The post-restart generic review should be entered on the CCTS and be completed before the end of the next refueling outage.

TVA should confirm that the post-restart evaluation has been entered on the CCTS. This item remains open pending inspection.

(Open) Deficiency D4.3-7, Vertical Seismic Load on Auxiliary Building Roof Truss

The auxiliary building roof at elevation 791.75' is supported on structural steel framing made up of girders spanning between trusses. The review of the original calculations showed that the trusses were assumed to be rigid in the vertical direction and unamplified vertical accelerations were used in design. The team was concerned that the roof system was not rigid in the vertical direction leading to an unconservative design.

In response to this deficiency TVA issued CAQR SQP871386 and agreed that the auxiliary building roof would not be rigid. Additional calculations (B41 B71023 001) performed by TVA show that the roof was originally designed for a total uniform load of 275 psf. However, TVA reduced the live load from 50 psf to 30 psf, as per FSAR commitments. Also, a careful review of the roof drawings showed that there was no insulation on the roof and the steel decking dead load used in the original design was too high. Revising all these loads and including a higher seismic load due to roof flexibility, TVA calculated that the actual total load on the roof would be 254.5 psf. This is less than the original design load of 275 psf, leading to the conclusion that the roof is structurally adequate to carry the higher seismic load due to the roof flexibility considerations. The NRC team agrees with this TVA conclusion on the auxiliary building roof.

As a part of generic implications of this deficiency, TVA reviewed other Category I structural steel framing to determine whether flexibility was considered in the original design calculation (B25 871106 452). This review identified that the condensate demineralizer waste evaporator building roof and various floors of the control building would have similar problems, since the original designs did not consider vertical flexibility. TVA performed additional calculations (B25 871106 451) to determine whether these identified structural elements are adequate to withstand the higher seismic loads obtained when flexibility is considered. The review of this calculation by the NRC team showed that TVA used 2/3 of the horizontal response spectra instead of the vertical spectra for the condensate demineralizer waste evaporator building roof. The team believes that this approach might not be conservative since 2/3 of the peak horizontal response spectra was not used. In order to satisfy. the team's concern regarding the condensate demineralizer waste evaporator building roof and other seismic Category I structures, systems and components, TVA should either review the FSAR to ascertain their commitment regarding vertical input to seismic analyses of subsystems or demonstrate that the use of 2/3 of horizontal response spectra for the vertical input is more conservative than the use of actual vertical response spectra. This issue needs to be resolved prior to restart.

TVA is requested to confirm the completion of the work regarding to the use of 2/3 of horizontal response spectra as vertical input. This item remains open pending inspection of TVA corrective actions.

(Open) Deficiency D4.3-8, Overturning of Tanks Located on the Auxiliary Building Roof

The auxiliary building roof at elevation 791.75' supports four nonsafety-related tanks weighing approximately 90 kips to 135 kips. The original design calculations for the structural steel members supporting the tanks did not consider the overturning moments due to horizontal seismic loads. The team was concerned that the allowable stresses for these members could be exceeded if such loads were considered.

In order to resolve this deficiency, TVA performed a coupled seismic analysis of the auxiliary building roof and the tanks (B41 871026 002). This was a linear elastic analysis where the support loads obtained resulted from seismically induced loads, as well as the dead weight of the tanks. These support loads were later used to check the anchorages of the tank to the roof

(B41 871103 021). The review of this calculation performed for the demineralizer and the cask washdown tanks showed that the anchor bolts for the tanks would yield under the SSE loading. The same calculation showed that the bolts have sufficient ductility so that failure of the anchorage would not occur. The NRC team believes that TVA should extend their analysis to evaluate the consequences of failure of the tanks since there is yielding in the anchor bolts.

TVA also performed an evaluation of the structural steel members supporting the tanks using the loads obtained in calculation B41 871026 002. The NRC team reviewed a portion of TVA calculation B41 871103 008 related to the raw service water tank and concurs that the stresses in the supporting elements were all within the FSAR committed allowable stresses. TVA further evaluated the reinforced concrete corbels that support the 80' long trusses for the increased loads due to the overturning moments. TVA used USD methods for this reevaluation. The team believes that the use of USD methods deviates from FSAR commitments, and that such reevaluation should use the WSD methods as committed in the FSAR.

The team concludes that the reevaluation performed by TVA is acceptable to the NRC team with the following exceptions:

1. TVA needs to evaluate the consequences of the failure of the tanks.

2. TVA should use WSD for the reevaluation of corbels supporting the roof trusses or justify the USD analysis in view of the FSAR commitments.

TVA is requested to confirm that the evaluation of the consequences of tank failure is complete. This item remains open pending resolution of the FSAR deviation and inspection of corrective actions.

(Open) Deficiency D4.3-9, <u>Masonry Block Wall Evaluation for Bulletin 80-11</u>

TVA calculations for the reinforced and unreinforced masonry wall evaluation in response to NRC Bulletin 80-11 could not be located. Although TVA had already identified that these calculations were missing, they did not schedule the regeneration of these calculations until post-restart. The team does not agree with this TVA position because the structural adequacy of the masonry walls could not be assessed without these calculations.

TVA submitted to the NRC team various documentation relating to masonry walls during the reinspection performed to close the IDI items. The team reviewed this documentation which were grouped into three categories:

1. Documents relating to the NRC Information Request on masonry walls.

2. Documents relating to NRC Bulletin 80-11.

3. Miscellaneous calculations performed by TVA related to masonry walls.

The review of these documents showed that the masonry wall evaluations have been reviewed by NRC and found to be acceptable based on NRC interim criteria. This is stated in SER Supplement No. 5. However, there is a license condition that TVA should evaluate all seismic Category I masonry walls to final staff criteria prior to startup following the first refueling. The team could not locate any documents showing that such an evaluation was made by TVA and submitted to NRC. The team also did not see any documentation showing that the calculations for IE Bulletin 80-11 were reviewed by NRC.

Therefore, the team believes that the masonry block wall calculations should be generated prior to restart. TVA is requested to confirm the regeneration of the masonry block wall calculations is completed. This deficiency will be kept open pending the completion of this regeneration effort by TVA and inspection of TVA corrective actions.

(Open) Deficiency D.4.4-1, Design of ERCW Pumphouse Structure to Resist Tornado Missiles

The original tornado missile protection calculations for the ERCW pumphouse roof considered only the bending mode of failure. The ductility ratios that were calculated for the steel beam missile protection system exceeded industry standards.

The original calculations did not include the following elements.

- Critical angle of impact. Only 45 degree angle was considered.
- Critical missile impact locations. Only the missile impact at the center of the beam was considered.
- Critical spectrum of missiles for both missile penetration and missile load.
- Analysis and design of the connections.
- Ductility ratios in accordance with industry standards. Local buckling, lateral and web crippling.

The revised calculations addressed three angles of missile impact, namely 45 degrees parallel to axis of beam, vertical and 45 degrees perpendicular to axis of the beam. The vertical missile appears to be the most critical.

The new calculations also address the critical missile impacting the root at several locations including the end of the beam which are critical for the analysis and design of the connections.

The revised calculations addressed all of the missiles listed in Table 3.5.5-4 of the FSAR for both missile penetration and missile load. The 3" diameter pipe and the 6" diameter pipe were the critical missiles for missile penetration and the 12" diameter pipe was critical for missile load.

Also the revised calculations address the analysis and design of connections, local buckling, lateral buckling and web crippling.

The maximum ductility ratio used in the revised calculations was 20. This ductility ratio is consistent with Topical Report, BC-TOP-9 Rev. #1, Design of Structures, For Missile Impact, Prepared by Bechtel Power Corporation, July 1973.

In general, the revised calculations are found to be acceptable with two exceptions.

The calculations predict that the beams will have large deflections and rotations when impacted by the 12" diameter steel pipe. The vertical deflection of the center of gravity of one of the beams is approximately 19 inches and the rotation is approximately 45 degrees. The beams and the beam connections should be analyzed to demonstrate that the system can take these large deflections and rotations.

Also, the calculations do not adequately demonstrate that the beam connections can resist the 700 kip load predicted by the 12" diameter pipe missile.

TVA is requested to confirm that the above corrective actions are completed. This item remains open pending inspection by the NRC.

(Open) Deficiency D4.4-2, Analysis of Pile Supports for the ERCW Pipeline

The original ERCW access dike calculation did not consider the vertical earthquake in the stability analysis of the dike. Also earthquake induced deformation of the dike and the relative displacement at the access dike - access cell interface were not computed.

The revised calculations computed the earthquake induced deformations of access dikes. The vertical deformation was computed to be 8 inches and the relative displacement at the access cell-access dike interface were computed to be zero since the last cell is completely embedded in the access dike.

The revised calculations investigated an assumed failure plane through the ERCW pipe support concrete slab and found this failure plane was not controlling.

In general the revised calculations were found to be acceptable with one exception. The stability analysis did not include the vertical earthquake. This is an FSAR commitment and should be addressed.

Also the last cell of the access cells and the access dike are assumed to act together. This assumption should be consistent with the assumptions used in the analysis of the stability of the access cells.

TVA is requested to confirm completion of the above corrective actions. This item remains open pending inspection by the NRC.

(Open) Deficiency D4.6-1, Discrepancies Between Design Calculations and Construction Drawings

The review of design calculations and drawings of various safety related mechanical component foundations showed that there were discrepancies between the calculations and drawings. The team was concerned that the embedded plates and anchors could be unconservatively designed, leading to the failure of mechanical equipment supports.

In response to this deficiency, TVA has prepared a plan which describes the actions that will be taken to resolve the specific and generic concerns relating to equipment supports. With regards to the specific IDI finding, TVA will reanalyze the component cooling water heat exchanger and the containment spray heat exchanger. The supports of these two heat exchangers will then be analyzed using the as-built information and the support loads obtained from the previous analyses. The NRC team could not review this reevaluation, since the work was not complete at the time of the inspection. The third specific IDI finding was related to the component cooling water surge tank anchorage. TVA performed additional calculations (B25 871104 455) which demonstrate that the as-built condition of this tank's support is adequate to resist all seismic loads without exceeding the allowable stresses.

For generic evaluations, TVA has classified the equipment at Sequoyah into three categories, namely; heat exchangers, tanks, other equipment. TVA will review 11 seismic Category I heat exchangers and their supports against as-built information that will be obtained from walkdowns. TVA also reviewed tank anchorages for 12 Category I tanks and found them to be adequate. The NRC team reviewed samples of these calculations (B25 871104 455). This review by NRC is covered under IDI Deficiency D4.6-2. At the request of the team, TVA will also select 60 other component supports (including pumps, electrical equipment, etc.) and compare the information in calculations and on drawings with as-built data to determine whether discrepancies exist. Additional calculations will be performed to reconcile any discrepancies existing between drawings, calculations and as-built data.

The NRC team reviewed the TVA program described above to resolve the generic aspects of the equipment support deficiency. The team requested that the program should be revised to include walkdowns for the 60 equipment supports. This was agreed to by TVA. TVA was requested to document the program and the results of the equipment support evaluation. This item remains open pending inspection by the NRC.

(Closed) Deficiency D4.6-2, Anchor Bolt Design for Tank

The review of the original design calculations for the component cooling water surge tank anchorage showed that the anchor bolts were sized without considering the shear forces at the bottom of the tank. The team was concerned that the anchor bolts could be undersized leading to a failure of the tank support.

To resolve this deficiency, TVA selected 12 types of Category I tanks for evaluation. All of these tanks are required for safe shutdown of Unit 2. These 12 tank samples included the IDI specific finding relating to the component cooling water surge tank. TVA generated the support loads for all of these tanks in calculation B41 871013 D07. Using these regenerated loads, each tank anchorage was evaluated to determine its structural adequacy.

The NRC team reviewed the regenerated support calculations for the component cooling water surge tank (B25 871104 455), the boron injection tank (B25 B71104 454), the UHI surge tank (B25 871104 452) and the UHI water accumulator tank (B25 871104 452). These calculations showed that the stresses in the anchorage elements were within the allowables.

The team concludes that the TVA evaluation performed on the anchor bolts for Category I tanks is acceptable to the NRC and considers this deficiency to be closed. No further work is required from TVA for the resolution of this deficiency.

(Open) Deficiency D4.6-3, Seismic Analysis of Steel Tanks

The review of the original seismic calculations for certain steel tanks showed that shear stiffness was neglected in the frequency calculations. The omission of shear stiffness in the seismic analysis of tanks could result in an overestimation of the frequency such that the tank would incorrectly be assumed to be rigid.

The team reviewed calculations for 11 representative seismic Category I tanks which were regenerated or compiled by TVA in response to this deficiency. The 7-day diesel generator fuel oil tank, diesel generator day tank, diesel generator starting air tank, control air receiver and the UHI surge tank were determined to be rigid, therefore this deficiency is not applicable to these tanks. The waste gas tank, boron injection tank, safety injection tanks and the UHI water and gas accumulator tanks were determined to be flexible. The team reviewed newly regenerated natural frequency calculations for these tanks and found them acceptable. However, the team needs to further review the seismic analysis of these tanks for new seismic loads resulting from the consideration of tank flexibility.

The team also reviewed the seismic analysis of the Sequoyah refueling water storage tank (RWST). The RWST is unique in that it is the only seismic Category I tank that is supported by soil. The current TVA analysis relies on the seismic analysis of the Watts Bar RWST. Although these tanks are similar, the Watts Bar and Sequoyah sites have different ground response spectra. Therefore, the team requested that TVA provide additional information to justify the results of the newly generated analysis for the Sequoyah RWST. This item remains open pending confirmation of the completion of corrective action and NRC inspection.

(Closed) Deficiency D4.7-1, Rawl Expansion Anchors

The design of many pipe supports called for the use of Rawl expansion anchors to fasten the pipe support base plates to the concrete structure. The allowable loads used for these anchors were based on manufacturer's data submitted for the Phillips Red Head expansion anchors. The manufacturer's data for the Rawl expansion anchors would have given lower allowable loads for some of the larger sized Rawl expansion anchors than were obtained by using data for Phillips Red Head anchors. In addition, the design criteria allows for increasing the allowable bolt loads to take advantage of the increase in concrete strength due to aging without test data to support this increase. Recent tests performed by TVA indicated that the increase in the allowable loads should be less than that allowed in Design Criteria DS-C1.7.1. These tests also indicated that the strength of the Rawl anchors and Phillips Red Head anchors are essentially equivalent.

TVA has committed to base the increase in allowable bolt loads due to concrete strength gain with age on actual test data in the current regeneration of the pipe support calculations and all future expansion bolt evaluations. TVA also agreed that the minimum factors of safety to be used in evaluation of expansion anchors will be as follows:

- Prior to the next refueling outage for SQN Unit 2 the minimum factor of safety will be 2.0.

° After the next refueling outage for SQN Unit 2 the minimum factor of safety will be 5.0.

This item is closed for the purpose of this inspection. This will be reviewed further by NRC's Office of Special Projects.

INSTRUMENTATION & CONTROL

(Open) Deficiency D5.2-1, Inconsistency of ERCW Safety Classification in FSAR

This item identified inconsistencies in the FSAR regarding safety classification of certain ERCW components presented in FSAR Tables 3.2.1-2 and 3.11.1-1. The team, however, did not find any misclassification of safety-related instrumentation and control systems, functions, or components in the ERCW instrumentation. The team requested that TVA review the generic implications of this deficiency.

The team has not yet received a formal response from TVA for this deficiency. This item remains open pending the team's review of TVA's proposed FSAR revision to correct this deficiency, and inspection of TVA's generic resolution of this deficiency regarding the potential extent of misclassification in the FSAR.

(Open) Deficiency D5.2-2, Inadequate Tag Identification of Control Switches in Control Room Panels

This item resulted from a walkdown in which the team found several examples in the rear of the ERCW main control room panel where the unit prefix identification had been omitted from the identification tag on the rear of the control switch module. This practice can result in duplicate tag numbers at the rear of the panel, and is a nonconformance to TVA Equipment Specification 678855 Revision 0 and name tag fabrication requirements contained in TVA Mechanical Instrument Tabulation 47B601-67 series, Revision 20. Apart from the specification nonconformance, the team was concerned that the absence of the unit prefix could increase the potential for a maintenance error that could affect ERCW operation for both units.

TVA should correct the nonconforming tag numbers to include the unit prefix as required by the specifications or demonstrate that there could be no significant consequences of maintenance errors as a result of the missing unit prefix. Any such analysis must use human factors principles accepted by NRC for the SQN control room design review. This item will remain open pending inspection of the completed corrective actions.

(Open) Deficiency D5.2-3, Ineffective ERCW Alarms

This item reflects the team's concern, based on the observed performance of the ERCW control room alarms during a walkdown, that excessive invalid or nuisance alarms exist in the ERCW system. The team believes that if this sample were representative of other plant systems, the annunciator system could be ineffective as an operator aid, particularly during multiple alarm plant transients. Consequently, any credit taken for operator action in response to an alarm may not always be valid.

TVA has stated in their response that no credit is taken for the annunciator in safety-related actions. The team does not agree with TVA's interpretation that IEEE-279 is not a valid basis for the finding; however, the team does find TVA's actions in resolving this finding responsive to our concern and acceptable, as discussed herein. Regarding interpretation, the team believes that since the ERCW system is a vital engineered safeguards support system that performs a protective function and embodies protection system signals (such as safety injection and loss of offsite power), that the IEEE-279 requirement for unambiguous alarms is applicable to certain ERCW and other alarms, albeit the alarm hardware and other design aspects need not be safety-related. We believe this item meets the restart criteria since operator response to a plant transient or safety system/protective action malfunction could be adversely affected by incoherent alarms.

In response to our concern, TVA has stated that the following action is being taken:

1. Obsolete alarms from the original ERCW pumping station will be removed prior to restart.

2. Alarms which can be cleared by performing maintenance will be cleared prior to restart.

3. The low ERCW flow nuisance alarms will be removed prior to restart; TVA has determined that because of the variety of normal system flow conditions that can exist in the ERCW, it is not practical nor necessary to detect system malfunctions with low flow alarms since better alarms/indications such as low header pressure exist. The team agrees with this assessment.

4. As a part of TVA's previous detailed control room design review (DCRDR) submittal commitment to detailed evaluation/corrective action regarding the annunciator system, any remaining deficient control room alarms in either the ERCW or other systems will be addressed. Implementation of any corrective actions will be done in accordance with the schedule requirements of the NRC Safety Evaluation Report for the Sequoyah DCRDR dated August 27, 1987.

The team agrees with TVA that action items 1, 2, and 3 above will eliminate a sufficiently substantial number of the problem alarms identified during the inspection. We also believe that proper implementation of TVA's existing DCRDR commitments to the NRC should adequately address in a timely fashion any remaining concerns for the ERCW alarms or for other control room alarms. The team notes that the TVA submittal states that portions of the annunciator review are best done at power; the team agrees.

The team finds TVA's response as understood above to be acceptable. TVA is requested to confirm implementation of above actions 1, 2, and 3 prior to restart, and confirm that action 4 has been entered in the SQN CCTS. This item will remain open pending inspection of the completed corrective actions.

(Open) Deficiency D5.2-4, Inadequate Electrical Isolation of Non-Class IE Traveling Screen Speed Switch

This item identified four isolation fuses having inadequate coordination with the upstream control power fuses for the traveling screen control circuits; consequently, a seismic event could render all traveling screens inoperable by shorting the non-1E devices and causing both the isolation fuses and the control power fuses to clear.

As with deficiency D5.2-3, TVA does not agree that IEEE-279 is a part of the basis for this finding. While the team dces not agree with this aspect of TVA's interpretation of IEEE-279, the team finds TVA's responses in resolving this finding responsive and acceptable, as discussed herein. Regarding interpretation, the team notes that the traveling screens perform a protective function in assuring operability of the ultimate heat sink for engineered safeguards of both units. Additionally, in the original design basis, the screens were to be automatically actuated; the team understands that the present manual mode of operation under administrative controls is a temporary one. The team believes that automatic operation of the traveling screens is a protective function for which the isolation and single failure requirements of IEEE-279 apply. The team also notes that TVA's corrective action complies with those aspects of IEEE-279 under their licensing basis as well as with TVA's design criteria.

In response to our concern, TVA has developed an ECN to replace the fuses and resolve the coordination problem. Implementation will be completed prior to restart; the team finds this acceptable for the specific concern, of this deficiency.

Regarding the team's generic concerns about fuse coordination, TVA has performed prior studies of the ac and dc power systems for common mode failure of non-Class 1E circuits connnected to the power system (10 CFR 50, Appendix R analysis and coordination studies); a cascade fuse analysis study of fuse combinations in the Class 1E 120V ac and 125V dc distribution (Ref. TVA Calculations SQN-CPS-013, SQN-E1-004); and a study done to assure isolation of the Crydom relays used for status monitoring system inputs from switchgear, motor control centers, and instrumentation panels. TVA had established the identity of the fuses in the studies through a walkdown program. Although these recent studies were comprehensive, they did not include all 1E/non-1E 120V ac series fuse combinations within individual motor control centers (i.e., situations as identified in this finding). TVA will investigate the latter situations to assure fuse coordination as a post-restart study tentatively scheduled for completion in March 1988. TVA believes that the only other cases where isolation is dependent on fuse coordination are the Crydom relay circuits previously analyzed, but this will be confirmed by the proposed additional analysis.

TVA has determined that the root cause of the deficiency was failure in the preparation of ECN L5637 to provide complete documentation of a fuse coordination study. Existing plant and DNE procedures SQEP-34, AI16, and DS-E8.1.2 require analysis of fuse substitutions listed in the approved design standard. These standards and procedures apparently were not in effect during preparation of the ECN. TVA has revised Design Standard DS-E8.1.2, Revision 3, to further emphasize the importance of coordination analysis and require that interim emergency substitution of unanalyzed replacement fuses be regarded as rendering the installed circuit inoperable for technical specification purposes; the interim period for such substitutions could not exceed the lesser of 72 hours or the allowable technical specification operability limit for the system of interest. Also, TVA has instituted a calculation checklist under TVA EEB procedure methods as part of the change control process; this will further identify the need for fuse coordination analysis when ECNs are being prepared. TVA believes that this finding is an isolated case, since they state it has not been common practice to retrofit isolation of non-1E devices except for the Crydom relay circuits previously analyzed; based on information reviewed, the team tends to agree and expects the proposed TVA analysis to confirm this limited practice.

The team finds TVA's corrective actions acceptable for both our specific and generic concerns. TVA is requested to confirm the fuses have been replaced prior to restart, and confirm that timely completion of their motor control center control circuit fuse study (including any corrective actions) has been entered in the SQN CCTS. This item will remain open pending submittal of TVA's confirmatory letter and inspection of the completed corrective actions.

(Open) Deficiency D5.2-5, <u>Inadequate Separation of Redundant Main Control Board Wiring</u>

During the July 28, 1987 walkdown of the ERCW control room panel, the team identified deficiencies in the installation of braided metallic sheathed cable, where the braided sheaths of redundant trains of control cable were touching or could migrate with time to touch; this was in violation of FSAR requirements. In response to this finding, TVA performed a QC inspection of all main control room panels to specifically identify all wiring requiring corrective action to achieve conformance with the FSAR separation criteria. TVA will correct these deficiencies by installing approved spacers to separate and secure the cables. TVA stated that these modifications would be done under the design control program so that no new unanalyzed failure modes would be introduced through the use of different materials or techniques. The necessary modifications will be completed prior to restart. The team finds this approach acceptable.

In accordance with the FSAR, TVA takes credit for metal braid in lieu of 6-inch or solid barrier separation only for circuits in main control room panels which contain redundant safety-related wiring, and which were supplied by Westinghouse. On this basis, the team finds TVA's generic response acceptable.

This item is open pending TVA's confirmation that implementation of the above action prior to restart is completed and inspection of the completed corrective action.

(Closed) Unresolved Item U5.2-6, <u>Adequacy of Electrical Separation of Isolation Device Inputs and Outputs</u>

The team had identified many cases where TVA had bundled together the input and output wiring of isolation devices located within switchgear, motor control centers, and other enclosures; the team was concerned that this internal wiring practice could defeat the purpose of the isolation device and allow propagation of credible faults from the non-Class 1E wiring to the Class 1E wiring. During initial discussions with the team regarding this matter, TVA indicated that credit was taken for the Westinghouse Protection System Noise Test, Revision 2, October 1975 and WCAP-8892A of June 1977 in establishing the acceptability of this wiring practice. The team was then concerned that these tests might not be fully applicable to this situation, since the primary objective of the tests was to qualify isolation amplifiers located in electronic rack assemblies, and the wiring configuration as well as other details might not be representative.

TVA does not agree that IEEE-279 would be part of the potential basis for this item. However, since the postulated failure of these isolation devices or their wiring could affect the actuation device circuit and defeat the protective function, the team considers the isolation requirements of IEEE-279 to be applicable.

TVA investigated this matter further and determined that the appropriate test report was WCAP-7508-L, since they believed the test bounded most of the required conditions for the circuits in question. TVA indicated that the wiring configuration under test was equivalent to the installed wiring since the input and output wiring was bundled together in both cases. WCAP-7508-L demonstrated that input/output isolation was maintained not only for the isolation amplifiers but also for the wiring under test. TVA performed a 100 percent review of the ERCW cables to identify the types of cables routed to motor control centers and switchgear as non-Class 1E circuits. They determined that the insulation of these cables was rated at 600V, except for shielded/twisted pair cables rated at 300V. The WCAP-7508-L tests used 600V rated cable, therefore, all of the TVA cable identified except shielded/twisted pair (TVA type WVA) is enveloped by the tests which were previously accepted by NRC in qualifying the Foxboro isolation amplifiers.

For the type WVA cable not covered by the tests, TVA determined that there were two circuit types where this cable could be used in connecting to switchgear or motor control centers using the wiring practice in question (1) wiring from an ammeter shunt to a control room ammeter and (2) wiring to the control room annunciator. For the first case, TVA stated that the supports for all cabling and related structures are at least Category 1L; therefore, structural integrity is assured so that no credible external exposure from outside the raceway in excess of 300V can be postulated. Within the raceway, TVA design criteria assures that the maximum levels of exposure are 120V ac or 125V dc. In addition, TVA design criteria prohibits routing non-1E cable leaving an enclosure of one train from being routed with an opposite train. For the ammeter circuits, TVA concludes that no credible failure of the non-1E circuit could propagate to the 1E circuit.

For the second case using WVA cable (annunciator inputs), TVA also applied the preceding logic. In addition, TVA retrieved calculation No. SQN-CSS-013 Section 5.1, dated July 30, 1987 and demonstrated that the WVA cable could withstand the maximum credible annunciator fault determined by the calculation. This portion of the calculation was reviewed and accepted by the team.

Based on the preceding documented supplemental evaluation by TVA, the team finds TVA's response acceptable, and considers this item closed. The team notes that the NRC staff has concerns relating to other sections of Calculation SQN-CSS-013. Resolution of any remaining areas of concern regarding calculation of SQN-CSS-013 not referenced herein will be addressed as part of future NRC inspections.

(Closed) Unresolved Item U5.2-7, Use of Common Penetrations for Redundant Instrument Lines

This item concerned the use of common penetrations for redundant instrument lines and the potential for loss of redundant instruments as a result of an accident, internally generated missile, or other hazard. TVA's response stated that sufficient design controls are in place to assure that common penetrations are used only when necessary and that appropriate barriers or other protection are installed when pipe break hazards are present. TVA also stated that no redundant Class IE field instruments are located on common panels. The team confirmed this for the ERCW instruments with a followup drawing inspection. TVA practice is to evaluate the installed configuration of instrument lines in areas where the potential for unacceptable interactions with postulated pipe breaks are present. The evaluation would identify the need for barriers or for additional separation if a common hazard were found. The team reviewed examples that illustrated how this process is implemented.

Presently and in the future, since the sleeves for wall, floor, or containment penetrations are shown on the 47W600 series drawings, designers can identify if a proposed route might cause the use of a common penetration for redundant sensing lines. Also, design output drawing 47W600-I33 requires that lines be verified by DNQA to meet the separation requirements of the drawing and the TVA design criteria. In addition, the pipe break analysis team is included in the ECN review process and will ensure that any changes to instrument lines that create new line routes will be evaluated for impact of postulated pipe breaks. The team finds TVA's response acceptable and considers this item closed.

(Open) Deficiency D5.2-10, <u>Adequacy of ERCW Instrumentation Provided for Detection of a Break in Non-Seismic ERCW Piping</u>

This item concerns the effectiveness of the alarms and indicating lights currently provided for detection of breaks in non-seismic ERCW piping during a seismic event. TVA had not demonstrated that manual isolation of a double-ended break could be done in sufficient time in response to the available alarms/indicating lights.

TVA has committed to install automatic isolation to isolate the non-seismically designed piping from seismically designed ERCW piping in the event of a pipe break in the non-seismically designed piping. This item remains open pending TVA's confirmation that the automatic isolation is functional and an inspection of the completed corrective action. The team has asked TVA to also address in their response the acceptability of accuracy and repeatability errors in the required flow measurement.

(Open) Deficiency D5.3-1, <u>Inadequate Shutdown Capability Outside Control Room: Traveling Screen/Screenwash Circuits</u>

This item concerned a situation the team identified where short circuits induced by a design basis control room fire could prevent operation of the ERCW traveling screens and screenwash pumps. If debris were present, this could disable the ERCW system for both units.

TVA will independently fuse the main control room circuits exposed to the design basis fire. These fuses will be coordinated with the control power fuses to prevent loss of control power at the pumping station. These changes will be implemented prior to restart.

TVA determined that the root cause of this deficiency was failure to include the traveling screen and its auxiliary equipment in the SQN 10 CFR 50, Appendix R functional requirements, and not a failure to recognize vulnerability of local control circuits to fire induced failures in portions of the circuits that provide status indication in the control room.

Since the SQN licensing basis allows credit for properly coordinated fuses for isolation purposes, the team finds TVA's corrective action acceptable. Based on the information reviewed, the team agrees with TVA's determination of root cause. This item remains open pending TVA's confirmation of completed corrective action prior to restart and inspection by the NRC.

(Open) Deficiency D5.4-1, Adequacy of Freeze Protection for Instrument Lines in the ERCW Pumping Station

This item concerns inadequate freeze protection for safety-related instrument lines in the ERCW pumping station. The team was concerned that since non-1E heaters are used, their failure could go undetected during a seismic event. In addition, the team found no procedures that would assure freezing would be detected in a timely fashion under normal or seismic conditions.

In response to the team's concerns, TVA will revise AOI-9 to add specific procedures such that the ERCW pumping station will be manned within three hours of any seismic event; this would allow local control and supervision of the screenwash pumps and strainer backwash without relying on the vulnerable instrument lines. TVA will also revise SI-606 to add lower limits (40°F) on environmental temperatures for the ERCW pumping station and the diesel generator areas. These temperatures are monitored every 8 hours during normal and abnormal conditions; the control room will be notified immediately if the 40°F limit is reached. TVA stated that Class 1E power is available if temporary space heaters are required due to failure of the installed heaters.

To further pursue any generic concerns, the team sampled three additional areas where Class 1E instruments could be located and cold temperatures could be encountered; the refueling water storage tank, the condensate storage tank, and the atmospheric steam dump valve areas (East and West valve vaults). TVA stated that instrumentation for the tanks is heat traced and demonstrated that the valve vault rooms have low temperature surveillance limits.

The team finds TVA's response and proposed action acceptable on both a specific and generic basis. This item remains open pending TVA's confirmation that the procedures have been revised prior to restart and inspection of the completed corrective action by the NRC.

(Open) Deficiency D5.4-2, Seismic Qualification of Westinghouse Switches

This item documented seismic qualification of a Westinghouse supplied vertical control room panel and two Westinghouse switch models to margins of safety less conservative than the three-fourths criterion stipulated in FSAR 3.10.2.

TVA has confirmed that Westinghouse provided generically qualified systems through a program of topical reports which have received NRC approval, but which did not specifically reflect the three-fourths margin of safety specified in FSAR 3.10.2.

The team reviewed the separate qualification reports for the panel and switches and confirmed that the panel response levels at the switch mounting locations are adequately enveloped by the switch excitation levels.

TVA will amend the FSAR to remove the three-fourths criterion from FSAR 3.10.2. This item remains open pending review of the proposed FSAR change to assure that the team's concern is resolved.

(Open) Unresolved Item U5.4-3, Adequacy of Seismic Qualification for Field Located Relays, Timers, and Terminal Blocks

This item concerned the potential for invalidating seismic qualification of field located devices on switchgear, motor control centers, and other panels. In response to the team's concern, TVA performed a 100 percent review of the Class 1E power systems equipment where the control devices of interest had been annotated for field location on the drawings. This review included all Class 1E switchgear, motor control centers, and shutdown logic relay panels.

The review identified the following types of components that had been field located: fuseblocks, terminal blocks, arc suppression networks (for the Crydom control relays), timer relays, solid state relays, elapsed time indicators (non-1E), and auxiliary relays. All of these devices are passive, except for the timer relays, the non-1E elapsed time indicators, and the auxiliary relays. The timer relays are spares requiring engineering approval prior to use.

TVA CEB judged that the passive devices would tolerate the anticipated acceleration levels based on experience or similarity to other devices (e.g., other qualified fuses or terminal blocks).

TVA stated that the auxiliary relays (Westinghouse MG-6 and two Allen-Bradley models) were identical or sufficiently similar to relays qualified by the shutdown board or motor control center vendor, and that the TVA analysis performed during the inspection demonstrated adequate margins of qualification for the locations of the devices. TVA also determined that no more than two relays were ever added to the same compartment; this represents approximately 10 lbs. of additional weight per compartment. This comparatively small amount of added weight, TVA determined, would not compromise the seismic qualification of the instrument panels. TVA also stated that more recent practice prohibits field location of Class 1E devices without specific engineering evaluation. The item remains open pending the IDI teams inspection of TVA's completed seismic analysis.

(Open) Deficiency D5.6-1, Inadequate Specification of Background Radiation for ERCW Effluent Liquid Radiation Monitors

This item concerns the inability of the ERCW effluent monitors to detect radiological leakage during a design basis accident due to high accident background radiation levels. FSAR 11.4.2.1.2 takes credit for these monitors in detection and mitigation of a leak during an accident.

TVA has stated that this is an error in the FSAR, that the monitors are only required for effluent monitoring during normal operation, and that no credit is taken for these monitors during an accident.

This item remains open pending the submittal and NRC review of the proposed FSAR change.

(Open) Deficiency D5.6-2, <u>Inadequate Specification of Pressure and Ratings for ERCW Effluent Liquid Radiation Monitors</u>

This item concerns insufficient pressure and temperature ratings for the ERCW effluent liquid radiation monitors. While the specification values were deficient, TVA determined during the inspection that the pressure and temperature ratings of the installed monitors were adequate for the service conditions. Apart from this nonconformance to quality assurance requirements, the team was concerned that other instruments might have been inadequately specified.

This item remains open pending the team's acceptance of TVA's resolution of generic deficiencies in pressure and temperature specifications (Reference Mechanical Systems Deficiency D2.2-1, Design Pressure of ERCW System).

(Open) Unresolved Item U5.8-1, <u>Instrumentation and Control Design Documentation Deficiencies</u>

This unresolved item concerned apparent deficiencies in demonstrating inter-discipline review, lack of revision levels or dates on certain documents, and questions regarding the completeness of an instrument tabulation that did not appear current.

This item remains open pending review of TVA's formal response and supplemental documentation, and inspection by the NRC.

ELECTRICAL POWER

(Open) Deficiency D6.2-1, Insufficient Demonstration of Worst-Case Loading in Diesel Generator Loading Analysis

This item concerns the worst-case loading condition used in TVA's calculation SQN-E3-002, Revision 5. The calculation did not consider the effect of Unit 1 auxiliary loads in the diesel generator loading analysis.

This item remains open pending review of TVA's formal response and NRC inspection.

(Open) Deficiency D6.2-2, Insufficient Demonstration of Adequate Class 1E Motor Starting and Running Voltages

The item identified two concerns regarding the worst-case considerations used in TVA's calculation OE2-EEBCALOOI, Revision 8. First, the study did not consider the condition when the onsite diesel generators are the source of AC power and second, part of the calculation considered Unit 1 in cold shutdown rather than in hot shutdown following full load rejection.

TVA identified the recently issued study SQN-E3-011, Revision 0 (dated 10/2/87) "Diesel Generator Voltage Analysis," which addresses the first concern. This study estimates the worst-case generator voltage versus-time profile during a LOCA with loss of off-site power, based on recent undocumented load tests on one of the diesel generators. Corrections were applied to the tested voltage profile to account for worst-case conditions which would prevail during a LOCA but which could not be accurately simulated during off-load testing, including the worst-case set of LOCA loads, full-flow conditions on pumps, coincident starting of random (non-sequenced) loads, and tolerances in load sequencing. The study's results indicate adequate voltage and frequency levels for required safety-related equipment operation and compliance with NRC Regulatory Guide 1.9, Revision 0. In addition, one of the assumptions in the calculation, that the worst-case voltage drop in the circuit from a 480 V distribution substation to a motor control center is 4.2 percent, conflicts with the 5.2 percent drop computed in Appendix B to the calculation. The results in calculation SQN-E3-011 will be acceptable provided that TVA corrects this erroneous assumption and substantiates the unverified assumptions.

In response to the team's second concern, calculation OE2-EEBCALOO1 will be revised to consider the Unit 1 auxiliary loads before Unit 1 restart. This is acceptable to the team.

TVA should confirm that the calculational assumptions have been substantiated and that the commitment to modify calculation DE2-EEBCALDOD prior to Unit 1 restart has been entered in the CCTS. This item remains open pending NRC inspection of completed corrective actions.

(Open) Deficiency D6.2-4, Absence of Neutral Grounding and Ground Fault Detection on 480V AC Auxiliary Power Systems

This deficiency was based on the lack of effective system neutral grounding and the apparent absence of any facilities for ground fault detection in the SQN 480V ac auxiliary power systems. The criterion violates FSAR commitments to the "no single failure" principle in IEEE Standard 279 and the power cable insulation requirements in NEMA Standard WC5 (ICEA Standard S-61-402).

TVA's response to this issue first pointed out that all of the 480V distribution substations are in fact equipped with manually-actuated local ground fault detector circuits capable of sensing solid ground faults on the distribution system on the distribution circuits (although this was not apparent from drawings the team originally examined, and the TVA/EEB engineering contacts were not aware of it). Furthermore, under an existing routine inspection instruction, an auxiliary plant operator tests for ground faults at each substation once per shift.

The "single-failure" issue involved a postulated scenario in which an undetectable intermittent ground fault could cause overvoltage-related electrical failures disabling safe-shutdown equipment in one train, coinciding with a detectable random failure disabling redundant equipment in the other train and an initiating event requiring safety-system actuation. (The existing ground detectors cannot reliably sense intermittent ground faults, which can cause surge voltages high enough to damage insulation.) TVA's position is that this scenario is not credible because it involves a coincidence of highly improbable events, so no action is needed to address it. The inspection team concurs with this view, and we consider this aspect of the problem to be satisfactorily resolved subject to formalization of the testing procedure as discussed below.

The second FSAR issue involved a violation of the ICEA/NEMA cable standards requiring the use of conductors whose insulation rating is at least 173 percent of system phase-to-phase voltage in ungrounded power systems in which ground faults can persist for more than one hour. This requires an insulation rating of 1.73 x 480V = 830V. The cable actually installed is rated at the 133 percent insulation level on a 600V basis, or 1.33 x 600V = 790V. While the cable rating is technically deficient, the team agrees with TVA that it is acceptable provided that the corrective actions discussed in the next paragraph are instituted. TVA's position is acceptable based on the enforced practice of frequent ground testing and immediate repair to be established before restart, the small margin of deficiency (less than 4 percent) in the voltage rating, and the conservatism of the ICEA/NEMA standard. (The standard is based on typical practices for non-redundant industrial power distribution systems, where ground faults may be allowed to remain for days until a convenient shutdown can be arranged.)

The corrective action proposed in TVA's initial response to item D6.2-4 was only to evaluate the need to upgrade the existing circuitry to provide main control room alarms after plant startup. The team found this to be inadequate. In discussions during the reinspection, TVA agreed to institute the following corrective actions: (1) to upgrade the informal once-per-shift ground fault test procedure to a formal, documented surveillance instruction before Unit 2 restart, (2) to amend the Sequoyah FSAR to justify the technical discrepancy between the plant design and NEMA WC5 requirements, and indicate that the plant is only in substantial compliance with the intent of the standards, and (3) to evaluate the need for further hardware and procedure modifications after restart. The team considers this to be a satisfactory resolution of the cable issue. This item remains open pending TVA's confirmation that the agreed to corrective actions have been completed and a subsequent NRC inspection.

(Closed) Deficiency D6.3-1, Inadequate Voltage Drop Calculations for 125V DC and 120V AC Control Circuits

This deficiency involved three items: (1) several critical unverified assumptions in the three major safety-related control voltage calculations, (2) incomplete corrective actions from two nonconformance reports which addressed inadequate calculated control voltages at the terminals of several components, and (3) use of an apparently non-conservative vital battery voltage in the dc voltage calculations, in violation of an implied FSAR commitment.

All of the significant unverified assumptions in the three key control voltage calculations have now been satisfactorily resolved by plant walkdowns, testing, or reference to original source documentation.

The previously incomplete corrective actions have also been resolved to the team's satisfaction. Resolutions included vendor tests confirming adequate vital inverter performance at the final battery discharge voltage of 105V, calculations showing that some of the solenoid valves whose calculated voltages are deficient are not required for safe shutdown, and that the remaining critical solenoid valves have sufficient terminal voltages; and issuance of an ECN specifying replacement or re-routing of control power cables to correct the low-voltage conditions which were not resolved by the above actions.

The edition of the Sequoyah FSAR originally made available to the team contained vital dc system loading information implying that the final 2-hour battery discharge voltage of 105V should be used as the worst-case source voltage for dc control voltage calculations. TVA has since revised the FSAR (Amendment 4, issued April 20, 1987) and eliminated the implied commitment to operation of all loads at 105V battery voltage. Also, the latest revisions of the dc voltage calculations show that the terminal voltages of all equipment which may credibly be required to operate late in a loss-of-ac-power incident are adequate with 105V battery voltage. The team considers TVA's resolution of this item acceptable.

(Open) Deficiency D6.6-1, Unsubstantiated Motor-Operated Valve Performance at Degraded Voltage

This item concerns TVA's failure to specify minimum operating voltage in procurement documentation for a number of safety-related motor-operated valves used in the ERCW system specifically and perhaps in other safety-related systems as well (only documentation for the ERCW valve motor-operators were reviewed during the inspection). Calculation OE2-EEBCAL001, which analyses the capabilities of the auxiliary power system assumes motor-operated valves will open with 80 percent rated voltage applied to motor terminals and will close with 75 percent rated voltage except for valves with brakes which will require 80 percent rated voltage. The calculation demonstrates that all of the ERCW system motor-operated valves, when required to operate in a DBE will have at least 80 percent rated motor terminal voltage.

TVA's response to this concern has indicated that 31 out of 57 ERCW system motor-operated valves have no procurement documentation to identify their minimum operating voltages. Further, of these 31 motor-operated valves only 12 are required to operate to mitigate a DBE. TVA's position is that 4 of these valve operators will have at least 90 percent rated voltage applied to their motors and therefore, will operate. The team feels that this is an acceptable assumption based on normal industry practice for motor-operator applications. For the remaining 8 motor-operator applications, TVA claims that these units have an 80 percent rated voltage operating capability based on similarity to those for which documentation exists. TVA has shown in their referenced Quality Information Release QIR EEB87460 that the valves have similar actuators, (limitorque type SMB-888) and motors (0.33 NP, 1.0 service factors, 5/1 ft-lb running/starting torque, 1100 RPM, Class B insulation).

The team concludes that TVA's method to establish the minimum operating voltage for the eight motor-operators of concern by similarity to those for which documentation is available is an acceptable approach but does not go far enough. Similarity of motor-operators is shown by QIR EEB87460 but not the similarity of application. That is, the load or valve characteristics for the similar motor-operators have not been shown to be similar. Typical motor-operator data sheets imply the importance of such valve data to an application as size, type, torque required, operating time and maximum differential pressure.

In their response to this deficiency, TVA has committed to evaluating the minimum operating voltage of safety-related valves that are required to operate in other systems in the event of a DBE. Their expressed intent is to do this after Unit 2 restart. The team concludes that postponing this action until after restart is not acceptable. The resolution of this concern, pre-restart, should be addressed for all safety-related systems and not just the ERCW system. This item remains open.

APPENDIX B

PERSONNEL CONTACTED

MECHANICAL SYSTEMS

Name	Title	Organization
F. Carr	Engineering Specialist	TVA/MEB
R. Daniels	Lead Mechanical Engineer	TVA/MEB
S. Fried	Consultant - Chief Mechanical/ Nuclear Engineer	Bechtel
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B. F. Crosslin	Principal Mechanical Engineer	TVA/MEB
E. Farrow	Authorized Nuclear In-Service Inspector	Hartford Steam Boiler
Q. Seals	Principal Nuclear Engineer	TVA/NEB
N. Welch	Assistant SRO	TVA/OPS/SQN
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PERSONNEL CONTACTED

MECHANICAL COMPONENTS

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R. Zimmerman	Engineer	Gilbert
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