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UNITED STATES NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

TVA PROJECTS DIVISION

Report No.: 50-260/89-59

Licensee: Tennessee Valley Authority
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1101 Market Street
Chattanooga, Tennessee 37402-2801

Docket No.: 50-260

Facility Name: Browns Ferry, Unit 2

Inspection Conducted: December 4-8, 1989

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Special Inspection Related to

Electrical Issues

1 Introduction and Background

The Browns Ferry Unit 2 (BFN-2), Nuclear Performance Plan identified many electrical issues related to BFN-2 design and construction.

The NRC staff has been reviewing the programs which identified the corrective actions taken by TVA to correct plant deficiencies. This inspection was conducted to verify the implementation of these programs.

2 Scope

From December 4 through December 8, 1989 an NRC team reviewed the adequacy of the implementation of the programs addressing various electrical issues. These issues are as follows:

(a) cable ampacity
(b) cable separation
(c) instrument sensing lines
(d) thermal overload
(e) fuses
(f) diesel generators
(g) batteries
(h) cable tray grounding

3 Summary

The NRC team found that the implementation of the programs for various electrical issues, in general, meet the requirements. However, the team identified some items that TVA needs to further address. These items are listed below:

(1) TVA in their ampacity calculations has not considered loading of cables in tray 2HO-ESII from motor heaters and plug receptacles. TVA should either provide justification for this omission or the ampacity calculations for this tray should be done again with these loads energized. (Section 4.1.3)

(2) In order to ascertain proper cable separation, the team was only able to walkdown the signal tracing of one circuit. Schedule constraints did not permit the additional walkdowns that were planned for the inspection. The team will walkdown the remaining circuits at a later date. (Section 4.2.3.3)

(3) The specification for installation of instrument sense lines, ER-BFN-EEB-001, does not require that the potential hazard posed by missiles caused by equipment failure be considered when routing redundant instrument tubing. TVA committed to revise the specification to require consideration of this hazard in the routing of redundant sense lines. (Section 4.3.3.1)

(4) Review of as-built instrument line slope excluded pressure instruments that employ sealed capillary tubes for pressure transmission. TVA justified this exclusion on the basis that slope is not critical in these devices because all gas is removed from the lines at manufacture. While this is true, sometimes the sense element at the end of a capillary tube connects to the process via an unsealed sense line. The inspection identified two such instruments, both channels of Torus Wide Range Level. At least one sense line for these sensors is oriented such that liquid could collect in the gas sense line. During the inspection TVA confirmed that the two instruments in question are the only critical instruments that employ capillary tubing and are connected to the process via an instrument tube. Further, TVA committed to evaluate the impact of the incorrect slope on the torus level instruments and correct the installation if necessary. (Section 4.3.3.2)

(5) The inspection found some stainless steel instrument lines bear ink marks that were made to track walkdown activities. TVA could not confirm during the inspection, that the markings were made with chloride free pens. They committed to determine if the marking material contains chloride and if so clean the markings from the sense lines. (Section 4.3.3.2)

(6) The inspection for the Fuse Program found that the drawing revision and permanent labeling of the fuses will not be completed prior to startup. TVA should provide a commitment to complete this effort prior to startup following the first refueling outage after the Unit 2 restart. (Section 4.5.4)

(7) The surveillance procedures for the battery test should be revised to reflect both electrolyte temperature and level correction. (Section 4.7.4)

(8) TVA was unable to demonstrate by design drawing that the cable trays in the drywell are adequately grounded. TVA has elected to demonstrate by test that the cable trays in the drywell are adequately grounded. TVA should submit the test results to NRC. (Section 4.8)

4 Inspection Details

The NRC team sampled several items for review from each of the eight areas identified before. The team inspection findings and conclusions for each of the areas and their activities are as follows:

4.1 Cable Ampacity

4.1.1 Purpose

The purpose of this inspection was to review TVA's implementation of their cable ampacity program. The diversity concept used in the program was previously reviewed by Sandia and NRC and found acceptable. The previous review included comparison of TVA's test results and ampacity program results. The focus of this inspection was: 1) to review how the program was implemented, 2) to review the data input to the computer program and its sources, and 3) to review the results of the computer calculations.

4.1.2 Ampacity Program Description

The ampacity program was divided into three phases. If a particular cable tray segment passed at any phase of the program, the analysis was terminated and that segment was accepted. Each phase reduced the effects of conservative assumptions at the expense of providing more detailed information for the analysis.

Phase I of the program applies TVA design specification 12.6.3. This is the same specification used for new cable installations. This specification uses the following inputs (in addition to others):

a) Temperature rating of each cable, with all cables derated to the temperature of the lowest-rated cable.

b) Cable loadings which are typically based on fuse or breaker rating.

c) Load multiplying factors which are applied to the loads in b.

d) Actual tray fill or 30% tray fill, whichever is larger.

e) Actual configuration of flammastic and tray covers (derating based on test data).

Phase IIa of the program is similar to Phase I, except that some of the inputs are relaxed based on actual installed conditions. Inputs a) and e) from Phase I are not changed. Cable loadings are based on actual operational loads with a multiplying factor which is less conservative than in Phase I (typically a factor of 1.03 is used in Phase II). Both of these changes reduce the required ampacity of the cables. Input d) is modified to use the actual cable tray fill if the actual is less than 30%. This change has the effect of increasing allowable ampacity.

Phase IIb of the analysis takes credit for loading diversity within a tray segment. All cables are assumed loaded except MOV cables, and individual cable temperatures are evaluated with the ampacity diversity computer program. Any safety cable whose temperature exceeds its manufacturer's rating or its 10CFR50.49 qualified temperature fails this phase of the analysis.

Phase III of the program takes credit for time diversity as well as the loading diversity of Phase IIb. Time diversity is assessed using a cable operational mode analysis (COMA) for cables that are not continuously energized at peak capacity. Cables for valve motors, valve motor shunts, spares, and grounds are assumed de-energized without a COMA and lighting cables are assumed continuously energized. The COMA considers both normal and accident loadings on the cables.

4.1.3 Finding

Review of Results of the Ampacity Program

TVA analyzed 45 cable trays that contain safety related cables. A total of 1528 cables were analyzed (cables in more than one tray are counted multiple times). In the final analysis, 76 safety related cable failures in Phase III, were in fact only 66 distinct cables that failed.

The final analysis was presented in ED-Q2000-87135, "Cable Ampacity Calculation - V4 and V5 Safety-Related Trays for Unit 2 Operation." Results of the analysis for each cable tray are given in separate attachments numbered 1-45. An overall program description is given in the main section. Attachment A gives the cable load responses for each cable for the Phase I analysis and for the Phase II and III analyses. For each load, a reference is given for how the load was determined.

Each of the 45 attachments provides results of the Phase I, IIa, IIb, and III analysis as needed. The Phase III analysis includes three sections; one section determines the cable temperature during the past 15 years of operation, one determines the temperatures for future operation of Unit 2 with Units 1 and 3 shut down, and another determines the temperature for Unit 2 accident mode with Units 1 and 3 shut down. For each phase of the analysis, each tray is broken down into sections based on nodes where cables enter and exit the tray. Each cable tray section is analyzed separately.

The remainder of each attachment consists of the input data for the tray. The computer data input section lists each cable in the tray along with its size, loading, service, and routing. The COMA sheets section includes a COMA for each cable used for time diversity in Phase III. The Final Data Package section summarizes the cable routings in the tray with the node of entry and exit for each cable. Walkdown packages give detailed information about each section of each tray including flame retardant coatings used, tray covers, tray dimension, profile of the cables/flammastic in the tray, distances between node points, etc.

Several of the individual tray evaluations were reviewed and are discussed in the following sections. A walkdown was performed for part of one tray to verify the TVA walkdown. Consistency of data and reasonableness of the results were also checked.

Cable Tray 2HO-ESII - Tray with Failures in All Phases

Tray 2HO-ESII experienced failures in all phases of the program, with 9 safety cables and 5 non-safety cables failing the Phase III analysis. The 9 safety cables will be replaced prior to restart. In the Phase I analysis, 18 safety cables and 20 non-safety cables had failed. A significant benefit was derived from considering the less conservative cable load multipliers used for Phase II and III. Only limited benefit was gained by the Phase III time diversity. The analysis of this tray included 23 Q-listed and 23 non-Q listed cables at 19 nodes along the tray.

As an example of the changes to ampacity of a given cable, the Q-listed cable #2ES2813-II will be considered between nodes 6 and 7 of this tray. This cable is a 250 Vdc supply line to the HPCI System Inboard Discharge Valve (FCV-73-44). The valve operator full load amperage of 51.0 was used in Phase I with a load multiplying factor of 2.0 to account for a locked rotor condition on the motor, giving a required ampacity of 102.0 A. A Phase I derated ampacity of 78.3 A was calculated, resulting in Phase I failure of this cable. In Phase II, the load multiplying factor was reduced to 1.15, for a required ampacity of 58.7 A. The derated ampacity was the same as for the Phase I because the cable tray fill exceeds 30%. Thus, this cable passed Phase II. In Phase IIb and III, the required ampacity was reduced to 0.0 A because of the short duration of valve operations. Thus, this cable did not contribute to the heating of other cables. In Phase IIb, there was insufficient load diversity, which caused all cables between nodes 6 and 7 to fail. Application of time diversity in Phase III allowed many cables to be saved. However, several motor heater circuits (37.8 A total) and one plug receptacle (70 A) were listed on the COMA as being continuously energized, while these cables were assumed deenergized in the Phase III analysis. TVA is evaluating this inconsistency to determine whether there is adequate justification for deleting these loads. This is an open item.

The part of tray 2HO-ESII, from node 9 to node 17 was inspected during the plant walkdown. The TVA walkdown sheets for the segments of the tray between these nodes were checked for accuracy and were found to reasonably reflect the actual cable/flammastic profiles in the trays and the entry and exit of other trays and conduits. Actual cables in the tray could not be verified because of the flammastic on the cables.

Because of the discrepancy discovered for the heater and plug receptacle cables, several additional trays with heaters and plug receptacles were checked. In all cases, the loads were considered energized for the Phase III analysis. TVA indicated that they had checked all trays with motor heaters and found they were energized for the analysis. Thus, the discrepancy that was found regarding the heater and plug receptacle loadings in tray 2HO-ESII appears to be an isolated case with no generic implications.

Cable Tray 1EN-ESII - Tray that Only Passed Phase III

Tray 1EN-ESII had 35 Phase I failures and 13 Phase IIa failures. Major factors contributing in the decrease of failures in this tray were the reduced load multiplying factors and the increased allowable ampacities based on the actual cable tray fill. Phase IIb load diversity calculations with all MOVs deenergized could not confirm adequacy of the tray, with 6 cables still failing. The Phase III analysis allowed several loads to be neglected because of short time usage of equipment. The maximum calculated cable temperature for Phase III was 86°C. Thus, no cables in this tray require replacement.

Cable Tray 2EU-ESI - Tray that Passed Phase IIb

Tray 2EU-ESI had 22 failures in Phase I. In Phase IIa, significant benefit was gained from consideration of actual cable fill rather than the 30% minimum used in Phase I and from reduced load multiplying factors. Many of the cables had a load factor of 2.0 in Phase I which was reduced to 1.15 in Phase IIa. With the changes for Phase IIa, only 1 cable failed the analysis. The diversity calculation of Phase IIb showed that the maximum temperature of the one cable which failed Phase IIa, would be 71°C (90°C rated) thus allowing all cables to pass Phase IIb.

Tray 2FP-ESI - Cable That Passed Phase IIa

Tray 2FP-ESI experienced 20 failures in Phase I. Phase IIa was successful because of reduced load multiplying factors and increased allowable ampacity based on the actual tray fill. The actual tray fill allowed an ampacity increase of about 50% over Phase I, and some of the cables' required ampacity was reduced as much as about 40%. Thus, no cables needed to be replaced in this tray.

Tray 2BU-ESII - Cable That Passed Phase I

Tray 2BU-ESII was the only tray of the 45 that passed at Phase I. This tray has only 3 cables, all safety-related. For all the cables, the derated ampacity was 118.4 A, while 2 of the cables were loaded to 66.5 A and one cable to 100.0 A. Thus, all the cables passed and no further analysis was needed.

Several trays, in addition to the above, were reviewed in varying levels of detail with no discrepancies noted in the analysis. These included trays 2CE-ESI, 7GN-ESII, 3EV-ESII, 3GH-ESII, and 2FK-ESII.

4.1.4 Open Items

1. The unloading of several cables in tray 2HO-ESII during the Phase III analysis needs to be justified by TVA or the analysis for this tray should be rerun.

4.2 Cable Separation

4.2.1 Purpose

By letters dated October 23, and December 14, 1989, TVA submitted their evaluation of the cable separation issue at BFN-2. The purpose of this inspection was to confirm that TVA adequately implemented their cable separation evaluation program and that cable separation at BFN-2 meets the plant design basis.

4.2.2 Scope

The following areas related to electrical cable separation were reviewed during this inspection:

(a) Effects of external hazards on V_1/V_2 cables.

(b) Separation criteria for redundant cables in free air space.

(c) Cable Walkdowns.

(d) Review of V3, V4 and V5 cables walked down by TVA.

4.2.3 Findings

4.2.3.1 Effects of External Hazards on V_1/V_2 cables

TVA has used Civil Engineering Branch report CEB88-06-C (B41 88114005) to demonstrate that all safety related trays and conduits for V1/V2 are protected from pipe rupture inside and outside containment and from externally generated missiles inside containment. The NRC team reviewed the report and inspected break locations 2F004, 2F008 and 2F014 in order to verify that no safety related cable trays or conduits are within the impact area. The team did not find any safety related cables and conduits in the pipe break zone. It should be noted however, that during this inspection the team did not pass any judgement on the break location or acceptance criteria. However, during a conference call with the TVA Knoxville office, Bob Lancaster and J. Ruchelle of TVA stated that they will reevaluate break locations sometime in mid 1990 to confirm that modifications made after the report was issued have not violated the conclusions of the report.

The NRC team also reviewed report, # QIR BFEBFN 89086, (B22890928009) used by TVA to conclude that V1/V2 cables of redundant functions are not affected in any area outside containment susceptible to externally generated missiles. This QIR is based on a Nuclear Engineering Branch (NEB) report (B30871230 404). The team questioned whether this report covers the complete plant or just what is included under NEB responsibility. TVA responded that the report covers the entire plant. The NRC team inspected three areas (the HPCI room, the RCIC room and the DG-C room) which were identified as susceptible to externally generated missiles. The team noted that most of the cables were terminated in the room and very few conduits were traversing the room. The NRC team asked TVA to list all cables which pass through Junction Box 3277 located in the DG-C room. All cables going through this junction box were V3. Hence, based on the sample, the NRC team agrees with the TVA's conclusion that redundant V1/V2 cables in the HPCI, RCIC and DG rooms will not be affected by the externally generated missiles.

4.2.3.2 Separation Criteria for redundant cables in free air

During the Safety System Quality Evaluation (SSQE) inspection, an open item was identified by the NRC inspection team. This open item is concerned with the lack of any requirements in the BFN design criteria BFN-50-728 for separation of redundant cables in the free air space. TVA evaluated this concern and had performed several walkdowns previously. The walkdowns determined that redundant cables do not come in contact in free air. TVA has also revised BFN-50-728 to assure that redundant cables do not come in contact in free air space. The team determined that since hot spots caused by internal cable faults will be restricted to cable trays or conduits, TVA would not be required to take any further action.

4.2.3.3 Cable Walkdown

In order to ascertain proper cable separation, the NRC team identified certain cables for the field walkdown. For this inspection, the staff selected only associated cables for walkdown because SSQE inspection was planning to walkdown all divisional cables. However because of schedule constraints the team was only able to walkdown one cable, 2SG163. The team will walkdown the remaining cables at a later date.

4.2.3.4 Review of V_3, V_4 and V_5 cables which were walked down by TVA

The NRC team reviewed the document QIR EEB BFN 88095 (B22 881220010) to ascertain the adequacy of TVA's evaluation of separation discrepancies. Attachment 7 and 8 of this report document the review of the walkdown data on V_3, and V_4 and V_5 cables against the design documents and evaluation of safety significance of these discrepancies against the separation criteria. These attachments did not support the information provided to the staff in the submittal dated October 23, 1989. TVA later confirmed that these attachments are superseded by QIR TEP BFN 89038, also QIR EEB BFN 095 was revised to reflect the correct information. Hence the staff considers this item closed.

4.3 Instrument Sense Line Issues

4.3.1 Purpose

By letter dated August 14, 1989, TVA submitted a report on the resolution of instrument sense line issues at BFN2. During this inspection, the NRC team focussed on verifying selected aspects of these issues.

4.3.2 Scope

The inspection evaluated TVA's action to confirm that installation of sensing lines used to convey process pressure to safety pressure instruments (including differential pressure instruments which may measure flow and level) conform with the following three basic principles:

(a) Separation of redundant components
(b) Provision of sense line slope
(c) Specification of material quality requirements

4.3.3 Findings

4.3.3.1 Separation of Redundant Instrument Lines

The Browns Ferry FSAR commits to separation of redundant instrument tubing for the Reactor Trip System (RTS), Emergency Core Cooling System (ECCS) Actuation, and Primary Containment Isolation (PCI) functions as necessary to prevent a single event from disabling redundant measurements. Separation was accomplished by locating redundant divisions of instrument racks on opposite sides of the Reactor Building. Pressure sense lines coming to these racks from the reactor vessel originate on opposite sides of the vessel, penetrate the drywell on opposite sides and are then routed directly to the instrument racks. Instrument lines for functions that do not connect to the RPV are similarly arranged. There are, however, cases where the pressure taps must be close together to monitor the desired parameter.

TVA did not commit to separating redundant instrument tubing for other safety related functions. Nonetheless, TVA reviewed instrument line separation for five events which might affect redundant lines:

1) Fire
2) Drops of Lifted Loads
3) Seismic Failure of Block Walls
4) Pipe Breaks Outside of Containment
5) Missiles Generated by Equipment Failure.

TVA's analyses confirmed that none of these events can cause failure of redundant instrument lines needed to mitigate the event.

The inspectors walked down sense lines for instruments used in RTS, ESSC, PCI actuation and for other functions. The walkdown found adequate separation for RTS, ECCS and PCI as described in the FSAR. Furthermore, equivalent separation was found for all other sample functions even though TVA has not committed to separate instrument lines for functions other than RTS, ECCS and PCI. Consequently, the inspection concluded that separation of redundant instrument tubing at Browns Ferry Unit 2 exceeds the commitments of the FSAR.

TVA has committed to perform future instrument tube installation in accordance with their Engineering Requirements Specification ER-BFN-EEB-001. This specification requires at least 18 inches of separation between redundant instrument lines. It also requires evaluation to determine the need for additional separation if redundant lines might simultaneously be subject to the first four special hazards listed above. The inspector questioned the omission of the fifth item, missile hazards. TVA determined that this omission was an oversight and committed to revise ER-BFN-EEB-001 to require consideration of this hazard as well during instrument line routing.

4.3.3.2 Instrument Line Slope

TVA implemented an extensive program to verify adequate slope in instrument lines that are important to safety. The team performed a walkdown to assess the adequacy of implementation of the program. Deficiencies identified by the team were documented and TVA either implemented modifications or provided an engineering analysis.

The following three documents established the scope of the program.

- QIR-EEB-87453, which provides a listing of Unit 2 instrumentation for which measurement accuracy is "important-to-safety" as identified by the System Requirements Calculations.

- QIR-EEB-BFN-87334, which documented the review of QIR-EEB-87453 and slightly modified the listing of Unit 2 instrumentation.

- QIR-BFPBFN-88006, which added to the scope those instruments that operators need to implement the Emergency Operating Procedures.

Calculation ED-Q2000-88255 evaluated each instrument from the above lists and determined whether or not instrument line walkdown was necessary. Instruments were excluded from walkdown if 1) they have no pressure sensing lines, and 2) if gas or liquid collection in the sensing lines can, at worst, cause negligible errors or errors only in the conservative direction. Calculation VENTRES-001JAN developed the specific criteria for excluding instruments for reason 2).

The inspection team reviewed the methodology and criteria used to define the walkdown scope and, with one exception, concluded that walkdown would identify all instruments for which sensing line slope is critical. The one exception was TVA's exclusion of pressure instruments with sealed capillary lines from the walkdown scope. While slope is not critical for sealed capillary lines, the sense end of capillaries are sometimes normal sense lines which connect the sense end of a capillary instrument to the measured process. Exclusion of these instruments was not justified. As a result of this finding, TVA reviewed ED-Q2000-88255 and found only two such instruments, LT-65-154 A and B (Torus Narrow Range Level) had been excluded. Walkdowns confirmed that short instrument lines exist for these instruments and that improper slope is provided in at least one case. TVA committed to evaluate the sense line slope for these two instruments and to disposition them according to the slope evaluation criteria applied to other sensing lines. Given this commitment, the inspection concluded that the slope verification scoping methodology and criteria are acceptable.

The inspection team compared the walkdown scope for the Reactor Feedwater System and the Reactor Core Isolation Cooling System with FSAR commitments, System Technical Evaluation Reports, and system control diagrams. This comparison concluded that all important instruments utilizing pressure impulse lines were included for the two sample systems. Based upon this sample, the inspection concluded that the walkdown scoping was properly implemented.

Once the walkdown scope was established, TVA performed field walkdowns and prepared as-built isometric sketches showing instrument line slope for all sense lines connected to instruments in the walkdown scope. This effort was controlled by walkdown Data Package EEB-002. The inspection team walked down instrument lines for LT-3-56 (A, B, C and D), LT-3-53, PT-64-56B and PT-64-160A.

This walkdown found the sampled lines to have slopes equal to or better than those documented on TVA's isometric sketches. Where slope was found to be better than that documented on the walkdown sketches, the improvement was attributable to maintenance or modification activities that had been initiated or reviewed by the TVA team involved in the slope issue. The inspection walkdown identified one open item, however. Ink markings were noted on some stainless steel instrument sense line. Apparently these markings had been used to track walkdown activities. TVA could not confirm during the inspection, that the markings were made with chloride free inks. TVA has committed to determine the chloride content of the inks and clean the instrument lines if necessary to prevent chloride damage.

Following the development of the isometric sketches, TVA reviewed the sketches and dispositioned each instrument line as acceptable "as-is" or as requiring rework. Instrument lines were accepted "as-is" if all segments of reverse slope were such that the rise for liquid lines or the fall for gas lines was less than ½ the line diameter. This criterion assures there is a migration path for gas lines and a pressure path for liquid in liquid lines. Similarly, it assures a drain path for liquid and a pressure path for gas lines. Testing conducted at TVA's Norris Engineering Laboratory showed that air in liquid sense lines has no tendency to completely fill the sense line cross section either along straight sections or at obstructions. Therefore, short sections of zero or reverse slope cannot induce error under static conditions unless the reverse slope rise is one line diameter or greater. Under dynamic conditions, trapped gas may allow the reading to oscillate around the measured value. For instrument inputs to trip functions such oscillation could slightly affect trip timing, but will not prevent the trip. Indications used by operators may appear noisy during or slightly after rapid parameter changes, but such noise is expected to be small in magnitude and will dampen out quickly after the parameter change.

For the typical Browns Ferry instrument line of ½ inch diameter, the acceptance criterion translates to a allowable reverse slope of ¼ inch per foot per foot of run. Also a curve was developed to give the specific acceptance criteria as a function of slope and run length. In a few cases where reverse slopes were found acceptable, but very close to the rise or fall limit, the slope measurements were repeated in the field to assure accuracy.

In a few cases, lines which did not meet the ¼ inch/foot/foot reverse slope criterion were accepted on other bases. These bases included detailed calculations to demonstrate that the amount of gas or liquid that could possibly collect in the reverse slope direction was too small to noticeably affect instrument readings.

The inspection sampled several cases in which reverse slope was accepted and confirmed that the acceptance criterion had been correctly applied. Based upon this sample and the audit of the walkdown notes, the inspection concluded that instrument sense line slope problems at Browns Ferry have been identified and appropriately dispositioned. Future instrument line installations and modifications are subject to the provisions of ER-BFN-EEB-001 which requires at least ¼ inch/foot slope for gas migration or liquid drain.

4.3.3.3 Instrument Line Material Quality Requirements

During the original plant construction, instrument sense line fabrication and installation was controlled by construction specification G-28. This specification required that materials and fabrication conform with the requirements of ASME Code section B31.1. TVA confirmed that all purchase orders issued for instrument line materials specified at least B31.1 requirements.

General Electric imposed additional requirements for certain instrument sense lines such as those which connect to the Reactor Vessel. G-28 identifies the specific lines to which the additional requirements apply. TVA reviewed the fabrication drawings and bills of material for these special case lines and confirmed that the drawings reflected the additional quality requirements. The inspection team sampled the drawings and bills of material for the reactor vessel level instrument sense lines and verified TVA's findings. Therefore, based upon this sample, the inspection team concluded that TVA has adequately confirmed that appropriate quality requirements were specified for instrument sense lines during original construction.

4.3.4 Documents Examined During The Inspection

1. Browns Ferry Updated Final Safety Analysis Report.

2. Condition Adverse to Quality Report, BFN870012, Revision 0, Subject: Instrument Line Separation, 3/6/89.

3. Condition Adverse to Quality Report, BFP870013, Revision 0, Subject: Instrument Line Slope, 4/28/89.

4. Condition Adverse to Quality Report, BFN-87014, Revision 0, Subject: Quality Classification of Instrument Line Material, 4/28/89.

5. Calculation ED-Q2000-88255, Revision 0, "Instrument Sense Line Slope," 9/13/88.

6. Quality Information Release EEB87453, "Unit 2 Restart Accuracy Calculations, Important to Safety Instruments," 9/4/87.

7. Quality Information Release NEBBFN87334, "Unit 2 Restart Accuracy Calculations, Important to Safety Instruments," 12/4/87.

8. Quality Information Release BFPBFN88006, "Instrumentation in Emergency Operating Instructions for Unit 2 that must be added to Slope Reduction Calculation," 5/25/88.

9. Configuration Control Drawing 47W610-3-1, Revision 33, "Mechanical Control Diagram, Reactor Feedwater System," 5/17/86.

10. System Technical Evaluation Report 03, "Reactor Feedwater System," 5/2/88.

11. System Technical Evaluation Report 64 A/D, "Primary Containment System."

12. System Technical Evaluation Report 71, "Reactor Core Isolating Cooling," 5/20/88.

13. Safety Evaluation Report, "NEB Safety Evaluation of Targets Impacted by Heavy Loads, NUREG-0612," Revision 0, 8/13/82.

14. CEB Report CEB-88-06-C, "Pipe Rupture Evaluation Program for Inside and Outside Primary Containment for the Browns Ferry Nuclear Plant, Unit 2," Revision 0, 11/14/88.

15. Sketches ISO PNL 25-5A, Isometric sketches of instrument line routing for instruments located on panel 25-5A, 2/21/89.

16. Sketches ISO PNL25-6A, Isometric sketches of instrument line routing for instruments located on panel 25-6A, 1/18/89.

17. Configuration Control Drawing CCD47W600-20,, Revision 0, "Mechanical Instrumentation and Control."

18. Configuration Control Drawing CCD47W600-20, Revision 1, "Mechanical Instrumentation and Control," 7/24/69.

19. Configuration Control Drawing CCD47W600-20, Revision 14, "Mechanical Instrumentation and Control, 12/16/86.

20. Construction Drawing 47BM600-121, Revision 0, "Piping Bill of Materials,", 9/19/69.

21. Engineering Requirements Document ER-BFN-EEB-001, "Instrument and Instrument Line Installation and Inspection," Revision 0, 10/26/87.

22. Design Change Notice W1522A to EEB-001, 9/28/88.

23. Design Change Notice W1249A to EEB-001, 9/26/88.

24. Design Change Notice W1931A to EEB-001, 8/24/88.

25. Design Change Notice W1120A to EEB-001, 7/6/88.

26. Design Change Notice F0347B to EEB-001, 10/21/89.

27. Design Change Notice W6335A, "Correct Instrument Sense Line Slope," 8/5/79.

28. Maintenance Request MR-A-899551, 5/25/89.

29. Maintenance Request MR-A-899554, 5/13/89.

30. Design Change Notice W62584, "Correct Instrument Sense Line Slope," 8/4/89.

31. Partial Modification Evaluation Notice for Design Change Notice W186-P1, 10/30/89.

32. Design Change Notice W6497A, "Correct Instrument Sense Line Slope."

33. Calculation VENTRES001JAN, Revision 0, "Sizing of High Point Vent Reservoir for Instrument Lines," 1/21/87.

34. Walkdown Data Package EEB-002, Revision 2, "Browns Ferry Nuclear Plant Slope Evaluation Walkdown Data Package," 1/26/89.

35. Quality Information Release QIR-BFEBFN89073, Revision 0, Subject: Engineering Evaluations of Walkdown Data," 8/8/89.

36. TVA Report WR28-1-85-122, "Bubble Migration in Sensing Lines Sloped at Small Angles," 7/86.

37. TVA Report WR28-1-85-124.R1, "Laboratory Tests of Air Entrapment in Slightly Sloped Sensing Lines and the Consequent Pressure Transmission Error," 3/87.

38. TVA Report WR28-2-88-107, "Bubble Migration in Inclined Sensing Lines," 8/85.

39. TVA Report, "Evaluation of Browns Ferry Nuclear Plant Instrument Sense Line Issues," 8/89.

40. As Designed Drawing, 47W931-3, Revision 11, "Mechanical Heating Ventilation and Air Conditioning Controls," 1/24/84.

41. As Designed Drawing, 47W610-64-1, Revision 42, "Mechanical Control Diagram Primary Containment System," 12/5/87.

4.4 ELECTRICAL THERMAL OVERLOAD PROTECTION FOR 480 V LOADS

4.4.1 Purpose

The purpose of this inspection was to determine TVA's adequacy of implementation of the Thermal Overload (TOL) program. This program is documented in the Browns Ferry Nuclear Performance Plan, Volume 3, Section III, Item 13.4. The staff has previously found the thermal overload program acceptable.

4.4.2 Scope

The staff reviewed sample TOL calculations and compared them with the engineering change notices, work packages, and TOL devices installed.

The following electrical equipment were selected for this inspection:

Motor Operated Valves (MOVs)

480 V Reactor MOV Board 2A

- FCV 74-62 RHR discharge to the main condenser valve
- FCV 75-11 Core spray pump 2C suction valve
- FCV 75-22 Core spray test valve
- FCV 75-23 Core spray outboard valve
- FCV 75-2 Core spray pump 2A suction valve

480 V Reactor MOV Board 2D

- FCV 68-79 Recir. Pump 2B Discharge valve
- FCV 74-53 RHR inboard valve
- FCV 74-59 RHR test valve
- FCV 74-7 RHR pump A & C min. flow bypass valve

4.4.3 Findings

The staff reviewed TVA's calculation ED-Q2999-880715 for TOL device selection for the above MOVs. The TOL devices selected were verified for agreement with TVA's design change documents and work packages. The staff inspection of the 480 V Reactor MOV Boards 2A and 2D verified that the selected thermal overload devices installed agreed with the other documents reviewed.

The staff discussed with TVA the involvement of QA/QC in the implementation of the TOL program. All TOL devices that were replaced are design verified and supported by design output documents. The Modification/Addition Instruction (MAI) -3.8 "Installation of Electrical Components" requires Field QC to document inspections of all critical structures, systems and components

(CSSC)/safety related items. Testing of the TOL devices after installation is done in agreement with plant procedure ECI-0-000-BKR008 "Electrical Corrective Instruction Testing and Troubleshooting of Molded Case Circuit Breakers and Motor Starter Overload Relays".

4.4.4 Conclusion

The staff did not find any disagreement between the documents reviewed nor with the installed thermal overload devices inspected. Therefore, the staff concludes that TVA has fulfilled the thermal overload program commitments. The staff had no further questions concerning the QA/QC aspect of the TOL program.

4.5 FUSE PROGRAM

4.5.1 Purpose

The purpose of this inspection was to determine TVA's adequacy of implementation of the fuse program. This program is documented in the Browns Ferry Nuclear Performance Plan, Volume 3, Section III, Item 13.6. The staff has previously reviewed the fuse program and found it acceptable.

4.5.2 Scope

The staff reviewed selected fuse calculations and compared the calculated values with the fuses on the respective schematic diagrams, master fuse list, engineering change notices, work packages, and those fuses installed on the electrical equipment.

The following electrical equipment was selected for the fuse program inspection:

Pump Motors

4,160 V Shutdown Board 2A

RHR pump 2A
Core spray pump 2A

Motor Operated Valves

480 V Reactor MOV Board 2A

FCV 74-62 RHR discharge to the main condenser valve
FCV 75-11 Core spray pump 2C suction valve
FCV 75-22 Core spray test valve
FCV 75-23 Core spray outboard valve
FCV 75-2 Core spray pump 2A suction valve

480 V Reactor MOV Board 2D

FCV 68-79 Recir. Pump 2B Discharge valve
FCV 74-53 RHR inboard valve

FCV 74-59 RHR test valve
FCV 74-7 RHR pump A & C min. flow bypass valve

4.5.3 Findings

The staff reviewed TVA's calculations ED-Q0211-88138 and ED-Q0268-88462 for fuse selection of the above electrical equipment. The fuses selected by TVA were verified by the staff for agreement with TVA's design change documents, work packages and the fuse tabulation. The staff inspection of the 4,160 V Shutdown Board 2A, 480 V Reactor MOV Board 2A, and 480 V Reactor MOV Board 2D verified that the fuses installed agreed with the other documents reviewed.

The staff discussed with TVA the involvement of QA/QC in the implementation of the fuse program. All fuse purchases, inventory, installation, and replacement are controlled by procedure BFN Site Director Standard Practice (SDSP) 16.8 "Fuse Control." BFN Site Quality Surveillance Program is used to monitor the fuse program activities.

The fuse sizing electrical calculation for the RHR and Core Spray Pump breaker control circuits referred to the schematic shown in Figure 8 that showed a lockout relay in the circuit that did not agree with the pump schematic diagrams. TVA indicated that the figure was correct for the bus supply breakers and was used as typical for the load breakers. The fuse sizing would be conservative and equal to 5.77 amperes. The smallest fuse size used in the trip circuit is 15 amperes.

The staff review of "Wiring Diagram 4160V Shutdown Aux Power Schematic Diagram" drawing number 2-45E765-4, Revision 001, for the RHR pump 2A noted that the positive trip fuses were designated as 15 ampere and the negative fuses were designated as 35 ampere. Also, the RHR pump 2A compartment was designated as compartment 18 but should have been designated as compartment 19. TVA corrected the drawing by removing the fuse ampere rating and replacing it with the fuse identification number from the fuse tabulation controlled document and corrected the compartment numbers. A copy of the drawing as corrected, Revision 003, was given to the staff at the end of the inspection.

TVA has committed to remove all reference to amperage from the drawings and replace them with the identification from the fuse tabulation controlled document, post Unit 2 restart. TVA has also committed in SDSP 16.8 to install permanent fuse labeling after Unit 2 restart. Temporary labeling material to be used is vinyl-coated cloth peel-off labels. During the walkdown the staff observed that the fuse blocks had temporary labels with additional information on the inside equipment panel doors.

4.5.4 Conclusion

The staff did not find any disagreement between the documentation and the installed fuses inspected. Therefore, the staff concludes that TVA has fulfilled the fuse program commitments. The staff had no further questions concerning the QA/QC aspect of the fuse program. However, temporary labeling method and material observed was not as stated in procedure SDSP 16.8. This is an Inspector Follow-up Item 89-59-01.

TVA should provide the NRC with a commitment that both the drawing revision and permanent labeling will be completed before startup from the Fuel Cycle 6 Outage.

4.6 EMERGENCY DIESEL GENERATORS

4.6.1 Purpose

The purpose of this inspection was to ascertain whether TVA has adequately implemented their Nuclear Performance Plan, Volume 3, Section III, Item 13.4 Calculations Program. The staff has previously found the emergency diesel generator (EDG) loading analysis and tests acceptable.

4.6.2 Scope

The staff reviewed selected electrical parameters that were used by TVA as inputs into the EDG calculation ED-Q2000-87071 and compared these design inputs with the name plate data of the electrical loads.

The following electrical equipment were selected for the design input verification inspection:

Emergency Diesel Generators

A,B,C,D,3A,3B,3C and 3D

Pump Motors

RHR pump 2A
Core spray pump 2A

Motor Operated Valves

FCV 75-2 Core spray pump 2A suction valve
FCV 74-53 RHR inboard valve
FCV 74-52 RHR outboard valve

4.6.3 Findings

The staff during the walkdown could not verify the name plate data for MOV FCV 74-73 because the name plate on the MOV was missing. The name plate data on the other motors and the EDGs for Unit 2 agreed with the design load input to the EDG loading calculation. There were no name plate data however, for Unit 3 EDG ratings. TVA should replace the missing nameplate for MOV FCV 74-73 and attach name plates to Unit 3 EDGs. The staff also verified that the cable designation at the RHR pump 2A motor and the Core Spray 2A motor agreed with the " Conduit and Cable Schedule. " The data from the "Conduit and Cable Schedule" agreed with the input data used in the EDG loading calculations.

The staff reviewed LER 296/88-001 failure of EDG breakers to reclose during the loss-of-off-site-power (LOOP)/LOCA test. This review was to confirm the root cause of the failures. The staff's review concluded that TVA's root cause identification and corrective action was adequate.

4.6.4 Conclusion

The electrical loads and cable identification, field verified by the staff, agreed with the input data used for the EDG loading calculations. Therefore, the staff concludes that TVA has fulfilled their commitment to the calculation program with respect to the EDGs. The staff's review of the LER, electrical power supply to the shutdown boards, test charts, and discussions with TVA personnel conclude that TVA's root cause identification and corrective action was adequate.

4.7 BATTERIES

4.7.1 Purpose

The batteries at BFN have not been identified either as an employee concern or addressed in TVA's corrective program. However, the staff determined that the batteries should be inspected since they are vital to the operation of many safety systems and battery failure has been identified in PRA studies as a high core melt contributor. Further, battery reliability has been identified as being necessary during station blackout, and this will address Open Item 1 on batteries in the DBVP Inspection Report 89-07, Paragraph 4.3.2.2.

4.7.2 Scope

The staff inspected the batteries for the following:

- o age
- o present capacity
- o surveillance program
- o physical condition
- o load profile

The batteries inspected were the following:

- o 250 V Unit 1,2 & 3 Control batteries
- o 250 V Shutdown Board Batteries A,B,C,D,3EA,3EB,3EC & 3ED
- o 125 V Diesel Generator Batteries A,B,C,D,3A,3B,3C & 3D

4.7.3 Documents Reviewed

The staff reviewed the following surveillance procedures for compliance with the Technical Specifications:

Procedure No.	Title		Date
2-SI-4.9.A.2.C, REV. 1	Main Bank 1 Battery Discharge Test		01-12-89
2-SI-4.9.A.2.C, REV. 3	Main Bank 2 Battery		07-15-89
2-SI-4.9.A.2.C, REV. 5	Main Bank 3 Battery		09-23-87
	Shutdown Board Battery Discharge Test		
1-SI-4.9.A.2.C, REV. 4	Battery	A	09-26-89
1-SI-4.9.A.2.C, REV. 4	Battery	B	10-14-89
2-SI-4.9.A.2.C, REV. 3	Battery	C	08-15-89
2-SI-4.9.A.2.C, REV. 3	Battery	D	08-21-89
3-SI-4.9.A.2.C, REV. 2	Battery	3EB	09-13-89

	DG Battery Discharge Test		Date
0-SI-4.9.A.2.C, REV. 0	Battery	A	11-05-87
0-SI-4.9.A.2.C, REV. 1	Battery	B	09-10-89
0-SI-4.9.A.2.C, REV. 0	Battery	C	11-14-87
0-SI-4.9.A.2.C, REV. 0	Battery	D	11-24-87
3-SI-4.9.A.2.C, REV. 0	Battery	3A	02-22-88
3-SI-4.9.A.2.C, REV. 0	Battery	3B	03-01-88
3-SI-4.9.A.2.C, REV. 0	Battery	3C	03-22-88
3-SI-4.9.A.2.C, REV. 0	Battery	3D	04-09-88
0-SI-4.9.A.2.A, REV. 6	Weekly Check For Diesel Generator A,B,C,& D Batteries		06-07-89
3-SI-4.9.A.2.a-2, REV.5	Weekly Check For Shutdown Board 3EB Battery		10-18-89
1-SI-4.9.a.2.b-2, REV. 5	Quarterly Check For Shutdown Board A AND B Batteries		10-11-89
2-SI-4.9.A.2.b-1, REV. 4	Quarterly Check for 250 volt Main Bank Number 2 Battery Surveillance		11-28-89
EMI-111, REV. 2	Annual Station Battery Inspection		

The staff reviewed the following documents regarding battery sizing, qualification, and installation.

Calculation

ED-Q2000-87041, REV.1	Battery Duty Cycle Main Battery 1	02-23-89
ED-Q2000-87042, REV.1	Battery Duty Cycle Shutdown BD A	11-22-88
ED-Q2000-87046, REV.1	Battery Duty Cycle EDG	08-26-88

Report

QR3-29985	C & D Environmental and Seismic Qualification Report for 250 V Station Batteries	01-09-87
D-INJ-3-29985, REV. 0	C & D Discharge Characteristics Main Station Battery	

4.7.4 Finding

(1) Battery Age and Capacity

Battery	Age Years	Capacity Percent	Date
Main Bank 1	20.33	109.9	01-12-89
Main Bank 2	02.92	123.5	07-19-89
Main Bank 3	18.75	105.8	02-23-87
Shutdown Board A	12.00	89.6	10-02-89
Shutdown Board B	12.00	109.6	11-04-89
Shutdown Board C	12.20	82.8	08-20-89
Shutdown Board D	12.20	95.2	08-23-89
Shutdown Board 3EB	10.40	84.6	09-18-89
Emergency Diesel A	15.25	110.9	11-08-87
Emergency Diesel A	15.25	109.2	02-22-88
Emergency Diesel B	15.25	115.0	09-10-89
Emergency Diesel C	15.25	121.8	11-14-87
Emergency Diesel D	15.25	111.0	11-25-87
Emergency Diesel 3B	10.00	111.2	03-13-88
Emergency Diesel 3C	09.00	113.2	03-22-88
Emergency Diesel 3D	10.00	91.6	04-10-88

(2) Battery Capacity Tests

These tests are conducted every 24 months. The capacity tests for the main station batteries are conducted at a discharge rate as follows:

Main Battery 1 805 amperes for 90 minutes
Main Battery 2 805 amperes for 90 minutes
Mine Battery 3 525 amperes for 180 minutes

The capacity tests for both the shutdown boards and emergency diesel batteries are conducted for 30 minutes at a discharge rate of 76 amperes.

The staff's review of the Shutdown Board C battery capacity test of August 20, 1989, indicates 82.8 percent capacity. At the end of the test 24.8 percent of the cells were below 1.75 volts with the following distribution:

- o 12.5 percent at 1.74 volts
- o 04.0 percent at 1.73 volts
- o 05.0 percent at 1.72 volts
- o 03.3 percent at 1.71 volts

The capacity values above 100 percent were the result of continuing the capacity test until the battery terminal voltage dropped to the individual cell discharge voltage of 1.75 volts times the number of cells. The terminal voltage for the 250 V main battery and shutdown board batteries is 1.75 volts times 120 cells, or 210 volts. The terminal voltage for the 125 V emergency diesel generator batteries is 1.75 volts times 60 cells, or 105 volts. The test is continued until the average of all the cells is equal to 1.75 volts. The vendor's capacity discharge time curves that are used in the capacity calculation are based upon an individual cell capacity discharging to a value of 1.75 volts.

The staff finds that these discharge rates are in agreement with the vendor's discharge curves and were properly corrected prior to starting the test for electrolyte temperature.

(3) Battery Load Profile

The load profile for the Main Station Battery 1, with Battery 3 out of service, Shutdown Board A Battery and the Emergency Diesel Generators Batteries were reviewed. The load profiles were compared with the battery one minute rating and the battery capacity test discharge rate. TVA does not provide a service test using the load profile. However, the staff finds the capacity test discharge rate adequately includes the load profile.

TVA by telecopy dated March 23, 1988, requested that the battery manufacturer, C & D Charter Power Systems, Inc., review the battery sizing based upon the load profile that reflects the latest loading. C & D, in a letter dated April 28, 1988, concluded that the DCU-9 battery has sufficient performance margin to meet TVA's latest duty cycle. The staff finds the battery vendor analysis acceptable and this is an adequate basis for closing Open Item 1 of the DBVP Inspection Report 89-07, Paragraph 4.3.2.2 regarding the sizing calculation of Battery SB-D of Division II, 4160 VAC Shutdown Board BD-D.

Because the maximum discharge current during the first minute of load demand is not part of the capacity test, the staff had a concern that problems of inner cell resistance may not be discovered during the capacity test. TVA provided the staff with the procedure, "Annual Station Battery Inspection Procedure EMI-111", that provides inner cell resistance measurements of all batteries. The staff finds this procedure acceptable for determining inner cell resistance.

(4) Weekly and Quarterly Surveillance

TVA has specified acceptance criteria for the electrolyte specific gravity to be 1.200 or greater. However, neither the weekly nor the quarterly surveillance procedures provide guidance for correcting the electrolyte specific gravity for electrolyte temperature deviations from 77 degrees F or electrolyte level from the vendor's level value that represents an electrolyte specific gravity of 1.200. The electrolyte specific gravity that is measured and not corrected for temperature and level is incorrect. These incorrect readings can mislead operating personnel concerning the operability of the batteries.

(5) Walkdown

During the walkdown, the staff observed that the electrolyte level was normal and there was no indication of electrolyte spill or leakage on the floor. Also there was no excessive corrosion of the battery racks and the dust/flame arrester covers were in place. The staff did not see any large sediment buildup at the bottom of the battery cells. However, the tags attached to some batteries needed cleaning.

4.7.5 Conclusion

TVA has informed the staff that Main Battery 1 will be replaced before the Unit 2 restart since the battery has reached its twenty year life. The Shutdown Board Battery C capacity is starting to approach the minimum acceptable capacity level of 80 percent. When monitoring this battery during the weekly and quarterly surveillance it is important that TVA correct the as measured electrolyte specific gravity for electrolyte temperature and level to be in agreement with the vendor's recommendations. The surveillance procedures should be revised to reflect both electrolyte temperature and level corrections.

4.8 CABLE TRAY GROUNDING IN THE DRYWELL

An allegation was made that the cable trays in the drywell were not adequately grounded. TVA's method of grounding cable trays inside and outside the drywell takes credit for the bolted connection of the cable trays and connection from the cable tray to the tray supports by fasteners. The cable tray supports are connected or welded to the building support steel which is connected to the electrical ground grid. Outside the drywell there is a ground cable in the top tray that is also connected to the tray system and the building steel. However, within the drywell there is no separate ground cable. TVA contends that the cable tray system is adequately grounded to the drywell steel that is also connected to the ground grid. Further review however, indicated that the internal steel is not connected to the drywell at the interface. In fact, there is a lubricant between the internal steel beams and the drywell. The drywell does have a ground connection by cable to the ground grid near the equipment hatch. This connection does not adequately ground the cable tray system. TVA said the inner ring steel, that the cable tray is connected to, is grounded via ground cables within the concrete support. The staff would accept this grounding approach provided TVA could show on either conduit and grounding drawing or concrete drawing that grounding cables were installed. Since TVA could not furnish conclusive documentation concerning this ground system, TVA has proposed to conduct a grounding test. The test will measure resistance between the cable tray system and the ground grid connecting at the drywell equipment hatch. Acceptance criteria for the measured ground resistance will be that value in ohms specified in the National Electric Code Article 250-84. The staff finds the test plan to be acceptable.