UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

ENCLOSURE 1

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ELECTRICAL CABLE INSTALLATION ISSUES

BROWNS FERRY NUCLEAR PLANT - UNIT NOS. 1 AND 3

DOCKET NOS. 50-259 AND 50-296

Introduction

By letter dated May 10, 1991, the Tennessee Valley Authority (TVA) provided its corrective action plans to resolve electrical cable installation issues for the Browns Ferry Nuclear Plant (BFN), Units 1 and 3. This safety evaluation documents the staff's detailed review of TVA's proposed action plan. The staff's evaluation also considered similar issues and specific action plans previously reviewed by the NRC staff for the restart of BFN Unit 2, prior staff safety evaluations and inspection results regarding these issues and action plans, and the fact that cable installation procedures and practices for the three Browns Ferry units were essentially identical.

Background Information

Cable installation concerns at TVA nuclear plants initially resulted from the Employee Concerns Program for the Watts Bar Nuclear Plant and included a variety of issues concerning improper or inadequate installation practices. TVA extended this review to BFN because installation practices and procedures were similar to those used at Watts Bar.

The TVA program for investigating and resolving the cable installation issues for BFN Unit 2 was originally described in Section III.13.1 of the Browns Ferry Nuclear Performance Plan. TVA submitted to the NRC cable installation concerns summary reports which addressed corrective actions for the various cable installation issues. The TVA approach to resolving the cable installation issues at BFN Unit 2 was based on:

1) A review of the extent to which the installed cables at the BFN were enveloped by the resolution of the cable issue program which was implemented at the TVA Sequoyah Nuclear Plant,

2) Comparison of the safety-related cable and conduit materials used between the Sequoyah and Browns Ferry Nuclear Plants,

3) Evaluations to compare installation requirements and practices at BFN with those used in the industry during the period when Browns Ferry was constructed, and,

4) Plant walkdown inspections to assess the cable installation practices and overall quality of the resultant installation.

The BFN summary reports addressed specific cable installation issues. These specific issues were sidewall pressure, pullbys, jamming, vertical supports, bend radius, pulling cable around 90-degree condulets and through mid-run flexible conduit, and use of condulets as pull points for large 600 volt cables. Additional concerns were identified for two other areas during the course of the investigations and testing performed to resolve these issues. These additional concerns involved Brand Rex cable and missing conduit bushings. The paragraphs below address these areas and provide an evaluation of them for Browns Ferry Units 1 and 3.

The TVA program for resolution of cable installation issues at BFN, Unit 2 was evaluated by the NRC staff. The staff's safety evaluation is documented in Section 3.11.5 of NUREG-1232, Volume 3, Supplement 2, dated January 23, 1991. The NRC staff concluded that TVA had adequately addressed the issues regarding cable installation practices for Browns Ferry Unit 2.

Sidewall Pressure, Cable Pullbys, Cable Jamming and Pulling Around 90-Degree Condulets and Through Mid-Run Flex Conduit

The issue of cable sidewall pressure is concerned with possible damage to cable shielding or insulation due to excessive radial force exerted on the insulation and jacket of a cable at a bend point during pulling operations. The pullby issue concerns cable insulation damage when one or more new cables are pulled over previously installed cable in a conduit. Cable jamming may occur when the ratio of the inside diameter of a conduit to cable diameter is close to 3.0 and three single conductor cables are pulled in a conduit, one of the cables slips between the two other cables and wedges in the conduit, causing a sudden, large increase in pull tension. The issue relating to pulling through mid-run flex conduit involves the tendency for a cable to have its surface caught by corrugations of the flex conduit during the pull, causing a substantial increase in sidewall pressure, and possibly leading to cable damage. The issue of pulling around 90-degree condulets involves potential damage to the cable due to the small bend radius of the condulet.

The above issues were addressed at BFN through walkdowns to determine the extent or possibility of cable damage. From walkdown results in conjunction with related engineering calculations, it was concluded that no corrective actions were required for the sidewall pressure, cable jamming, or pulling through 90-degree condulets and through mid-run flex conduit issues. For the pullby issue, TVA evaluations concluded that cable pullby was not an issue at BFN. This conclusion was primarily based on good installation practices regarding pullby length, pull lubricant and use of non-abrasive pull lines. However, TVA provided an extensive plan for identifying and testing those Browns Ferry cables judged to have the highest credible chance of having sustained pullby damage. After completion of this extensive review and testing plan, no evidence of pullby damage was identified at Browns Ferry.

In summary, no cable damage resulting in functional degradation due to the above issues was identified during the TVA evaluations of Browns Ferry Unit 2. This was primarily attributed to good installation practices. In addition, TVA has provided documentation to the NRC which establishes that the installation procedures and cable materials were the same for all three units at the Browns Ferry Station.

To resolve the above cable installation issues for Browns Ferry Unit 1 and 3, TVA has committed to implement confirmatory walkdowns using the same cable walkdown methodology that was used for Browns Ferry Unit 2. These walkdowns are to confirm that the conclusions reached for the above issues on Browns Ferry Unit 2 are equally applicable to Browns Ferry Units 1 and 3.

On the bases of the staff's safety evaluation of Browns Ferry Unit 2, TVA's use of the same cable installation procedures and materials for all three Browns Ferry units, and TVA's proposed related walkdown activities, the staff concludes that TVA's corrective action plan, when properly implemented, is adequate to satisfactorily resolve the aforementioned cable installation issues for Browns Ferry Units 1 and 3.

Medium Voltage Cable Bend Radius

The bend radius issue concerns damage that may result when cables are bent beyond a minimum radius. As part of the Browns Ferry Unit 2 efforts to resolve this issue, Class 1E medium voltage cables required for operation were inspected for cable bend radius using the acceptance criteria contained in Construction Specification G-38. All nonconformances were noted and ranked according to severity. The 15 worst-case cables were Hi-Pot tested using maintenance voltage levels. All 15 cables passed this testing. The cables were then categorized according to severity levels into three groups. Group 1 cables (most severe) were scheduled for replacement during the next refueling outage. Group 2 cables are to be tested during the next refueling outage and subsequent outages to assess the need for continued trending. Group 3 cables (least severe) are to be subjected to only normal maintenance testing.

Safety-related medium voltage cables for Browns Ferry Units 1 and 3 are to be identified, walked down and evaluated against the bend radius acceptance criteria contained in Construction Specification G-38. These cables are to be dispositioned according to the same criteria as used for BFN Unit 2. Specific corrective actions are to be taken for cables within each group. Replacement prior to restart of BFN Unit 1 or 3 is to be the corrective action for Group 1 cables with bend radius of less than 6 times the cable outside diameter. Group 2 cables with bend radius from 6 to less than 8 times the cable outside diameter are to be tested prior to restart of BFN Unit 1 or 3 and during subsequent outages to facilitate a trend analysis. Group 3 cables with bend radius 8 times or greater than the cable outside diameter are to remain in service and be subjected to only normal maintenance testing. These actions are consistent with those provided for Browns Ferry Unit 2.

Based on the safety evaluation results for BFN, Unit 2, along with the activities identified above, the staff concludes that the TVA's proposed corrective actions, actions when completed, are adequate to satisfactorily resolve this issue for Browns Ferry Units 1 and 3.

Vertical Cable Supports

The vertical cable supports issue concerns cable damage due to excessive strain resulting from improperly supported cables in a vertical section of conduit. Conduit fittings, boxes or termination devices at the top of a vertical section may worsen the condition by causing the cable to make a sharp change in direction at these points.

Class 1E medium voltage cables required for BFN, Unit 2 operation were walked down to determine conformance to the acceptance criteria contained in Construction Specification G-38. Vertical sections of cable with unsupported lengths greater than that allowed by the criteria contained in G-38 were Hi-Pot tested at maintenance voltage levels. All cables tested in this manner were found to have acceptable test results. Following testing, static sidewall bearing pressure calculations were performed to determine if they were within an acceptable range. Cable supports were added for those cables not technically justified by this analysis.

With respect to low voltage power, control and instrumentation cables for Browns Ferry Unit 2, TVA committed to evaluate these cables prior to restart from the next refueling outage.

To resolve this issue for BFN Units 1 and 3, Class 1E medium voltage cables are to be identified, walked down and evaluated against the vertical cable support criteria contained in Construction Specification G-38. Cables not meeting the vertical cable support criteria contained in G-38 are to be evaluated for sidewall bearing pressure using the same acceptance criteria as that used for BFN Unit 2. Acceptable sidewall bearing pressure results indicate that insufficient force exists to cause insulation damage and since no BFN Unit 2 cables with acceptable sidewall bearing pressure failed Hi-Pot testing, BFN Units 1 and 3 cables with acceptable sidewall bearing pressure are to be left as installed. Cables with unacceptable sidewall bearing pressure are to be Hi-Pot tested at maintenance voltage levels and evaluated against the acceptance criteria in TVA Special Electrical Maintenance Instruction to assure that existing conditions have not resulted in functional damage to the cable insulation. Cables passing the Hi-Pot test are to be left as installed and supported in accordance with the criteria in G-38 so as to prevent cable insulation degradation with time. Cables failing the Hi-Pot test are to be replaced.

For low voltage power, control and instrumentation cables, the program established for BFN, Unit 2 is to be implemented for BFN Units 1 and 3 prior to restart. Class 1E low voltage cables which could fail the support criteria provided in Construction Specification G-38 are to be identified through a review of drawings. The identified cables are to be walked down and evaluated further using the vertical cable support criteria contained in G-38. Cables not meeting the vertical cable support criteria and exhibiting jacket deformation or high strain are to be evaluated for static sidewall bearing pressure using the same acceptance criteria as that used for medium voltage cables. Cables with acceptable static sidewall bearing pressure are to be left as installed. For cables with unacceptable static sidewall bearing pressure, insulation resistance testing is to be performed. Cables passing the insulation resistance test are to be supported in accordance with the criteria provided in Construction Specification G-38. Cables failing the insulation resistance test are to be replaced.

On the bases of the staff's safety evaluation for Browns Ferry Unit 2, and activities indicated above, the staff concludes that the TVA's proposed action plan, when properly implemented, is adequate to satisfactorily resolve the vertical support issue for cables at Browns Ferry Units 1 and 3.

Use of Condulets as Pull Points for Large 600 Volt Cables

This issue involves postulating that 300 MCM and larger 600 volt cable could have been damaged as a result of inserting large, stiff, single conductor cables in standard form condulets at the completion of a cable pull. TVA's evaluation of this issue for BFN, Unit 2 determined the type of conduit configurations susceptible to this problem was limited to several cases of three single conductor 600 volt 400 MCM cables in three-inch conduits with standard form condulets. These Class 1E cable/conduit configurations were reworked to increase the conduit size. Cable damage was found to be confined to inside the condulets.

For BFN Units 1 and 3, a TVA evaluation, as was conducted for BFN Unit 2, is to be performed to identify susceptible 600 volt safety related cables. Conduits containing these cables are to be walked down to determine the presence of standard form condulets within their length. The cables are to be inspected for evidence of damage in any of these condulets and corrective actions performed to include cable replacement.

The staff concludes that TVA's proposed action plan to address this issue for Browns Ferry Units 1 and 3 is consistent with that conducted on Browns Ferry Unit 2 and, as such, is satisfactory.

Missing Conduit Bushings

During the investigation of pullbys for Browns Ferry Unit 2, six type PN (single conductor with polyethylene insulation and 4 mil nylon jacket) conductors exhibited high leakage currents under test. These six conductors were noted to have small tears in the jacket and insulation. This damage was determined to be the result of pulling the cables over a conduit end with a missing bushing and was clearly not indicative of pullby damage. However, as a result of this determination, a corrective action program was established for identifying additional conduits with missing bushings and which contained 10 CFR 50.49 (environmentally qualified) circuits. This program identified additional conduits with missing bushings. The cables found in these conduits were tested. No additional test failures were identified that were due to damage from missing conduit bushings. The test failures identified for Browns Ferry Unit 2 occurred only in cable type PN and were attributed to the significantly thinner jacket (4 mil, nylon) than the other cable types. The six identified damaged conductors were replaced. In addition, the majority of the remaining BFN Unit 2 type PN cables were replaced for environmental qualification reasons even though they passed Hi-Pot testing.

To resolve this issue for Browns Ferry Units 1 and 3, TVA will replace PN type cables in 10 CFR 50.49 circuits prior to restart of the respective units. The staff considers this proposed corrective action, when completed, adequate to satisfactorily resolve the issue for Browns Ferry Units 1 and 3.

Brand Rex Cable

TVA's corrective actions for Brand Rex cables used at Browns Ferry Units 1 and 3 are to be implemented prior to restart of each unit, and are to be in accordance with those for BFN Unit 2. The staff considers this action plan adequate to resolve the issue depending on the results from additional TVA testing being performed to verify the qualified life of these cables.

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Dated: