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MAR 28 1990

U.S. Nuclear Regulatory Commission
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Gentlemen:

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

SEQUOYAH NUCLEAR PLANT (SQN) - REEVALUATION OF CABLE TESTING PROGRAM - WATTS BAR NUCLEAR PLANT (WBN) PULLBY DAMAGE

A reevaluation of the SQN restart cable testing program was performed as a result of the cable pullby damage found at WBN. Comparisons were made with the specific sister conduits and with conduit installations in general at SQN for certain key considerations that have direct impact on the success of the pullby operation. These parameters included raceway configuration, conduit fill, frequency of pull points, and the utilization during pullbys of an abrasive, previously installed parachute cord. Each such comparison identified the presence of practices at SQN that have minimized the potential for pullby damage in the cable system.

An additional review was undertaken of the validity of the SQN screening process in light of the WBN findings. This review determined that the damaging mechanism identified at WBN (abrasion) was precisely the thrust of the SQN criteria, wherein emphasis was placed on material susceptibilities. TVA finds that its original ranking criteria were well designed for finding the worst case.

In addition, the results of the SQN high potential withstand tests on a group of cables that had been identified as worst case with respect to the pullby concern were reviewed. The tests were found to be in accordance with typical industry methodology for the performance of dielectric testing in general, yet far more conservative than standard in situ tests utilized to identify defective installed cables. The test results provide positive, concrete evidence of the integrity of cables subject to pullbys at SQN.

TVA finds that the previous conclusions drawn regarding the integrity of the SQN Class 1E cable systems continue to be valid. The details of the reevaluation of the SQN cable test program are included as an enclosure to this letter.

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Very truly yours,

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ENCLOSURE

REEVALUATION OF THE CABLE PULLBY ISSUE AT SEQUOYAH NUCLEAR PLANT (SQN) IN LIGHT OF RECENTLY DISCOVERED PULLBY DAMAGE AT WATTS BAR NUCLEAR PLANT (WBN)

1.0 PURPOSE

This report summarizes the results and conclusions of TVA's evaluations of the SQN cable installation in response to the discovery of pullby damage in Class 1E cable systems at WBN.

2.0 BACKGROUND

During the summer of 1986, NRC began a review of concerns relating to the adequacy of construction practices at TVA's WBN. The review identified that many of the concerns centered on potential damage to electrical cables because of alleged improper or inadequate installation practices. A comprehensive review was performed by TVA to determine if significant damage had occurred to cables during their installation at WBN. The review was extended to the cable installation at SQN since the SQN and WBN plants are of the same overall design.

TVA performed a comprehensive evaluation of the issues identified in the NRC's Technical Evaluation Report (TER) for SQN. One issue involved a concern for potential damage to cables as a result of the practice of pullbys (the pulling of cables into occupied conduits).

In order to evaluate the concern, TVA developed screening criteria to ". . . identify a population of conduits that have some credible chance of having sustained conductor insulation damage because of pullbys." Within that population a worst-case (i.e., highest damage potential) family was identified. Fifteen of those worst-case conduits were then subjected to high potential, in situ testing at 4,800- to 7,200-volt direct current. All 873 conductors in the 298 cables passed the subject test.

TVA concluded that the testing results provided reasonable assurance that past pullby practices at SQN, though now outdated, had resulted in satisfactory cable installation (i.e., no systematic pullby damage). Following a review of these test results, NRC issued a Safety Evaluation Report (NUREG-1232, Volume 2) that found the SQN installation to be adequate.

In June 1989, damage was discovered at WBN to five cables in three conduit segments comprising a single run of conduit. The damage was discovered while performing work intended to resolve an employee concern related to potential heat damage to cables as the result of alleged improper welding activities near conduits at WBN. Subsequent visual and laboratory evaluations confirmed that the damage occurred during a pullby. An additional 33,500 feet of cable was removed to assess the scope of that damage and one further instance of pullby damage was noted.

These findings were considered to be of significant magnitude to warrant reevaluating the pullby analysis previously performed for the SQN cable installation. This work is described below.

3.0 SUPPLEMENTAL CABLE PULLBY ANALYSIS FOR SQN

3.1 The following items were evaluated as part of a supplemental cable pullby analysis for the SQN cable systems performed as a result of the WBN findings. A detailed evaluation was performed of the SQN conduits and cables that have the same functions as their WBN counterparts where the pullby damage was identified. This evaluation is described in paragraph 3.2. Further evaluations were performed of other differences in each plant's overall cable installation practices. These evaluations are described in paragraphs 3.3 and 3.4. The SQN pullby screening criteria were reviewed to assess their validity. In addition, an assessment of the conduits that were screened out using the original criteria was performed to ensure that the "lessons learned" from WBN would not significantly alter the previous SQN ranking. This review is described in Section 3.5. A review of the SQN high-voltage withstand testing is provided in paragraph 3.6.

3.2 Following discovery of the damaged cables at WBN and the initial determination that the damage had been inflicted during a pullby, the decision was made to investigate the "sister" conduits and cables at SQN. This review was undertaken to establish the degree of similarity to the WBN installation with respect to configuration, conduit fill, and cable pull sequencing. Walkdowns were performed to obtain dimensioned isometric sketches of the SQN routes. The pulling sequence was determined from the pull cards. Pull tension and sidewall bearing pressures were calculated using industry standard methods.

The calculations established that each of the pullbys in the SQN conduits was within acceptable limits, as defined by TVA General Construction Specification G-38 entitled, "Installing Insulated Cables Rated for Up to 15,000 Volts."

A comparison of the sketches of the sister conduits at the two plants established that the SQN conduits were shorter, had more frequent pull points, and had a lower fill than the WBN conduits. SQN more closely adhered to the practice of bulk pulling, resulting in fewer and smaller pullbys.

3.3 SQN controlled conduit fill in an effective manner. A review of the 770 conduits evaluated at SQN for the issue of pullbys revealed only one conduit that was overfilled (40 percent allowable, 42 percent calculated). In contrast, conduit overfill has been identified as an issue to be resolved at WBN. As a result, the WBN pullby corrective action plan included direct consideration for overfill in the screening process.

The industry has only recently recognized the significance of conduit fill as a risk factor when performing pullbys. Lower fills increase the potential for obtaining a clear path during the pullby operation. The raceway fill at SQN, coupled with bulk pulling, further ensures that fewer pullbys occurred and that those which did would be small and with less potential for pullby damage.

3.4 The final assessment of the WBN cable damage was that it had been inflicted during a pullby from a combination of pulling forces and the rather abrasive parachute cord. In contrast, no evidence exists to indicate that parachute cords were used for making pullbys at SQN. Instead, insulated pull wires were utilized, resulting in a lower coefficient of friction and reduced abrasiveness as compared with the parachute cord.

3.5 The first three conduits at WBN in which pullby damage was discovered were determined not to be in the worst-case group as defined by a project specific calculation. Since the criteria for the ranking process applied were a close derivative of that developed for use at SQN, a reanalysis of the SQN criteria was warranted. One criterion in both programs was that at least three polyvinyl-chloride (PVC) jacketed cables must be present in the conduit prior to the final pullby. It was this criterion that was found to be responsible for the elimination of the first three conduits containing damaged cable at WBN and for the exclusion of the sister conduits at SQN.

That criterion was developed to select particular conduits, containing specific jacket materials based on the knowledge of their abrasion resistance. Such an approach correctly assumes that if pulling practices are uniform (good or bad), the cables most likely to have experienced significant damage are those with thermoplastic jackets. Among the thermoplastic jackets, PCV was acknowledged as the most readily violated under abrasive loading. Furthermore, the screening method assigned even higher susceptibilities to such conduits when rubber-like jackets (e.g., Hypalon) were pulled over resident thermoplastic jacketed cables.

Subsequent to the WBN findings, two additional evaluations at SQN were performed between the 15 conduits that were determined to be worst case and those conduits that were eliminated. (This latter group of 366 included the sister conduits identified above.)

The first of these evaluations involved a calculation of forces anticipated during the pullby process on the original 15 worst-case conduits and the top 30 from the family of 366. A uniform coefficient of friction was used. Based on sidewall bearing pressure, the highest rated conduit (i.e., greatest potential for damage) is still from the original worst-case group. Otherwise, the two groups seem to have experienced similar forces.

The second evaluation was based on application of coefficients of friction that are specific to the materials involved in each pullby. In the absence of standard data for the various jacket-to-jacket combinations, TVA conducted tests using conventional incline plane methodology. Based on this data, expected installation forces during pullbys were recalculated for the top 15 conduits of the combined family described in the preceding paragraph. The forces for <u>all</u> 15 conduits were well below their allowables.

In summary, laboratory analysis confirmed that the damaging mechanism at WBN had been abrasion of the outer jackets and primary insulation caused by a combination of the pulling forces and the parachute cord. TVA's screening criteria gave special emphasis to material susceptibilities. Those conduits and cables deleted from the review have a higher resistance to this mechanism. Evaluation of the forces encountered during pullbys in those eliminated conduits reveals that they are in the same range as the "tested" conduits and thus, when coupled with their superior abrasion resistance, have a lower damage potential. Cable removal activities at WBN, undertaken to assess the scope of the pullby issue, further confirmed the screening process when pullby damage was found to two cables in a worst-case conduit. Therefore, TVA finds that its original screening criteria used to select a group of worst-case conduits at SQN are still valid in light of the WBN findings.

3.6 The evidence provided by the 873 successful, high-potential withstand tests of conductors in worst-case pullby conduits provides the greatest degree of confidence in the integrity of the SQN cable systems.

In those tests, a stress of 240-volt direct current per mil of cable insulation thickness was applied based on the SQN specific, minimum environmentally qualified insulation thickness for the voltage rating, insulation type, and manufacturer. This voltage level is in accordance with guidance for establishing environmental qualifications for Class 1E cables as given in Institute of Electrical and Electronics Engineers Standard 383-1974. In each conduit, all conductors, with the exception of the one under test, were tied together (along with any shields and drain wires) and tied to ground. This technique ensures an effective ground plane. This method is consistent with industry standard methodology (i.e., Insulated Power Cable Engineers Association Standard S-61-402) for the final acceptance testing of multiconductor cables prior to shipment from the factory. Of the 298 cables tested for pullby concern, 297 are of multiconductor construction. The sole remaining cable (2-1/C 14 AWG) has a braided fiber jacket, which is regarded as being one of the most durable, abrasion-resistant jackets available.

While these test voltages were intended for factory or laboratory use, their adaptation to installed cables provides a very conservative assessment of a plant's installation process. This test program represents the most comprehensive in situ, high-potential evaluation of low-voltage cables in the industry.

In every conduit where pullby damage was identified at WBN, multiple conductors were exposed on at least one cable. Given the close proximity of a grounded conductor, separated only by a low resistance path, it is clear that if such damage existed in the 15 worst-case conduits at SQN, it would have been detected.

4.0 CONCLUSION

In the preceding analysis, a review has been performed of the WBN pullby findings. Comparisons were made with the specific sister conduits and with conduit installations in general at SQN for certain key considerations that have direct impact on the success of the pullby operation. These parameters included raceway configuration, conduit fill, frequency of pull points, and the utilization during pullbys of an abrasive, previously installed parachute cord. Each such comparison identified the presence of practices at SQN that have minimized the potential for pullby damage in the cable system.

An additional review was undertaken of the validity of the SQN screening process in light of the WBN findings. This review determined that the damaging mechanism identified at WBN (abrasion) was precisely the thrust of the SQN criteria, wherein emphasis was placed on material susceptibilities. Alternate evaluations were performed based on pulling forces encountered in tested and "screened out" conduits and determined that both groups would have experienced approximately the same tensions and sidewall pressures. Since the durability of the two groups to those forces is distinguished by their respective abrasion resistances, TVA finds that its original ranking criteria were well designed for finding the worst case.

In addition, the results of the SQN high-potential withstand tests on a group of cables that had been identified as worst case with respect to the pullby concern were reviewed. The tests were found to be in accordance with typical industry methodology for the performance of general dielectric testing, yet far more conservative than standard in situ tests utilized to identify defective installed cables. The test results provide positive, concrete evidence of the integrity of cables subject to pullbys at SQN.

The findings herein are consistent with previous evaluations at SQN regarding cable system integrity and consistent with the plant's cable maintenance history. In summary, TVA finds that the previous conclusions drawn regarding the integrity of SQN Class 1E cable systems continue to be valid.