SAFETY EVALUATION BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

CORRECTIVE ACTION PROGRAM PLANS FOR CABLE AND ELECTRICAL ISSUES

TENNESSEE VALLEY AUTHORITY

WATTS BAR NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-391

1.0 INTRODUCTION

1.1 Background

During the 1980s, the Tennessee Valley Authority (TVA), through its employee concerns program for the Watts Bar Nuclear Plant (WBN), identified areas where inadequate cable installation practices may have caused damage to installed cables. TVA had conducted a review of the cable installation practices at its Sequoyah Nuclear Plant (SQN) and Brown Ferry Nuclear Plant (BFN). Based on this review, TVA agreed that cable installation practices may have caused damage to cables and presented its evaluation program to the U.S. Nuclear Regulatory Commission (NRC) to ensure cable integrity at these plants.

In a letter dated September 17, 1985 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082320079), the NRC noted problems with TVA's nuclear program and stated that the underlying causes of the problems in most areas of TVA's nuclear activity represent significant programmatic and management deficiencies. Accordingly, the NRC identified general areas of concern for which specific corrective actions had to be addressed by TVA, including concerns regarding the adequacy of construction of WBN. Therefore, pursuant to Section 50.54(f) of Title 10 of the *Code of Federal Regulations* (10 CFR), the NRC requested information on the actions that TVA was taking to resolve the NRC's concerns. In response to this request for information, TVA prepared a corporate nuclear performance plan, along with separate plans to address site-specific problems at each of its nuclear plants including WBN. The NRC staff documented its review of the corrective actions taken by TVA to resolve the problems at WBN in NRC report NUREG-1232, Volume 4, "Safety Evaluation Report on Tennessee Valley Authority: Watts Bar Nuclear Performance Plan, Watts Bar Unit 1," (WBNNPP) January 1990 (ADAMS No. ML073450544). TVA's WBNPP did not address all licensing matters required for NRC approval prior to authorization of an operating license for WBN. The remaining licensing issues were either addressed in previous safety evaluations or in accordance with routine NRC licensing practices.

Regarding electrical cable issues, TVA agreed in the WBNPP that installation practices may have caused damage to cables and presented its evaluation program to the NRC to ensure cable integrity at WBN. As discussed in Section 3.2.1 of NUREG-1232, Volume 4, TVA issued Revision 1 to a corrective action program (CAP) plan for cable issues at WBN Unit 1 by letter dated June 27, 1989. This CAP plan was based on the resolution of similar issues at the SQN and BFN facilities. The staff reviewed the cable issues CAP and found it unacceptable for WBN Unit 1. TVA submitted a revised program by letters dated December 20, 1989, and June 15, July 31, October 11, and November 5, 1990 (ADAMS Nos. ML073541157, ML073541204, ML073541237, ML073550196, and ML082380711). The revised CAP was reviewed and approved by NRC, as documented in Section 1.13.1 of, and Appendix P to, Supplement 7 of NUREG-0847, "Safety Evaluation Report [SER] Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2" (ADAMS No. ML082420254).

In Appendix P to Supplement 7 of the SER (SSER 7), the NRC staff found the CAP plan for the cable issues acceptable. The staff would perform inspections to assure adequate implementation of the program and would further supplement its safety evaluation when the inspections were completed and all the open items resolved. In Appendix T of SSER 9 (ADAMS No. ML072060469), the NRC staff evaluated TVA's methodology to address an issue with cable proximity to hot pipes and found the issue resolved. Further, in Appendix Y to SSER 9, the staff documented the results of its audit to assess the adequacy of the corrective actions to resolve significant cable installation issues that remained open from previous audits. The staff concluded that the CAP for cable issues was conducted in a way that would resolve all concerns. By letter dated January 13, 1994, TVA submitted Revision 3 of the Cable Issues CAP to incorporate all the changes that had been previously approved by the NRC staff.

1.2 Proposed Changes in CAP Plans

By letter dated May 29, 2008, as supplemented on January 14, April 06, and May 18, 2009 (ADAMS Nos. ML081560183, ML090210473, ML091120183, and ML091410284), TVA submitted a request for approval of the cable issues CAP plan for WBN Unit 2. Specifically, TVA provided the program methods that it would use to resolve those subissues of the cable issues CAP that are different from those used for resolution at WBN Unit 1. In its letter of January 29, 2008 (ADAMS No. ML080320443), describing the regulatory framework for completion of construction and licensing activities for Unit 2, TVA had committed to describe such differences and provide appropriate justifications for use of a different approach in Unit 2 to demonstrate equally effective alternate resolutions to these cable issues. In this regard, TVA proposed exceptions to resolving five subissues of the cable issues CAP for WBN Unit 2 that differed from that used on WBN Unit 1. The five subissues are:

1. Cable Jamming
2. Cable Pullbys
3. Cable Sidewall Bearing Pressure (SWBP)
4. Pulling Cables Through 90-Degree Condulets and Mid-Route Flexible Conduits
5. Computerized Cable Routing System (CCRS) Software and Integrated Cable and Raceway Design System (ICRDS) Database Verification and Validation

In a letter dated September 26, 2008, TVA provided the summaries of other CAPs and Special Projects (SPs), including their subissues, describing proposed actions, current status of licensing review, analysis of conformance, effect on the Final Safety Analysis Report (FSAR), effect on the technical specifications and technical requirements manual, items requiring verification and inspection, and the interdependencies of these issues. The NRC staff reviewed the information provided by TVA and determined that, based on the TVA description and the staff's review (documented in NUREG-1232, Volume 4, and the applicable supplements of NUREG-0847), there is reasonable assurance that, when implemented as described, certain CAP and SP issues can be designated as acceptable for implementation at WBN Unit 2. In the September 26, 2008, letter, TVA additionally identified and provided the bases for changes to the implementation of several CAP issues. The NRC staff documented its conclusions regarding the status of the CAPs and SPs in a letter to TVA dated February 11, 2009 (ADAMS No. ML090210107). The staff stated that it needed additional clarifying information about the scope of the corrective actions and methodologies used by TVA to address the other subissues in these CAP plans. In a letter dated May 18, 2009, TVA provided additional information for the staff to make a determination about status of these other subissues.

In the February 11, 2009, letter, the NRC staff listed the CAP plan issues that remained open for program review. In particular, the following subissues in the Cable Issues CAP and Electrical Issues CAP plans were open:

<u>Cable Issues</u>

a. Silicon Rubber Insulated Cable
b. Cable Support in Vertical Conduit
c. Cable Support in Vertical Trays
d. Cable Proximity to Hot Pipes
e. Cable Bend Radius
f. Cable Splices

<u>Electrical Issues</u>

a. Flexible Conduit Installations
b. Physical Cable Separation and Electrical Isolation
d. Torque Switch and Overload Relay Bypass Capability for Active Safety-Related Valves

2.0 REGULATORY EVALUATION

Appendix B of 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," establishes the quality assurance requirements for the design, manufacture, construction, and operation of structures, systems, and components that prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. The pertinent requirements of this appendix apply to all activities affecting the safety-related functions of those structures, systems, and components; these activities include designing, purchasing, fabricating, handling, shipping, storing, cleaning, erecting, installing, inspecting, testing, operating, maintaining, repairing, refueling, and modifying.

3.0 TECHNICAL EVALUATION

In the CAP, TVA identified the following technical areas related to WBN Unit 2 cable issues that will have a different path for resolution than that used for WBN Unit 1. The NRC staff's review of the CAP plan for cable issues does not include an evaluation of the environmental qualification of cables and their associated components, which will be addressed separately.

3.1 Cable Jamming

In a Technical Evaluation Report (TER) dated January 30, 1987 (ADAMS No. ML073610326), the NRC staff identified the potential for undetected cable damage from cable jamming. Cable jamming can occur when three single cables of the same size are pulled into a conduit, and the ratio of cable-to-conduit size is of a certain value such that the cables may align in a flat configuration and jam inside the conduit. This could cause an excessive radial force to be exerted on the cable jacket and conductor insulation, possibly resulting in damage to the cable. As stated in the TER, TVA did not consider jam ratio in its specifications and procedures used during the sizing of cable and conduits. Thus, TVA could not assure that cable damage had not occurred because of jamming. TVA attempted to resolve this issue by using the results of its cable jamming evaluation that was performed at SQN. However, cable damage was subsequently identified at WBN, requiring a separate evaluation of this issue.

The staff reviewed TVA's proposed resolution of the cable jamming subissue in the cable issue CAP to ensure that no cable damage has occurred due to jamming. In the resolution, a cable jam ratio is calculated to predict the possibility for jamming in the conduit or duct occurring. The jam ratio is the ratio of the inside diameter of the conduit to the outside diameter of one cable, in a situation where three cables of equal size are being pulled simultaneously into a conduit. Cable jamming can occur when the jam ratio falls into a range of values from 2.8 to 3.1. A ratio near 3.0 greatly increases the likelihood of cables jamming or wedging in the conduit, and may result into serious cable damage. Cable jamming is more likely to occur when cables of equal size are pulled around a bend rather than when being pulled in a straight run of conduit.

TVA evaluated safety-related (Class 1E) conduit segments at WBN Unit 1 to identify those cable segments most likely to have experienced jamming during installation. TVA's approach for resolving the cable jamming issue was to identify cables with jam ratios that fell into the susceptible range. TVA used a jam ratio range of 2.8 - 3.1, which is consistent with range of values specified in the Institute of Electrical and Electronics Engineers (IEEE) Standard 690-1984, "IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations." TVA also visually inspected cables, which were removed for other reasons, for possible damage from cable jamming. The cable segments within the population were ranked according to the calculated percent of allowable SWBP for each cable. The SWBP is defined as the radial force exerted on cable insulation at a bend while the cable is being pulled in a raceway. The maximum allowable SWBP is determined by the cable manufacturer. TVA noted that 6 of the 39 cables identified by the above selection process were replaced as a result of other issues. After removing these six cables, TVA inspected them and found no evidence of cable damage due to jamming. This inspection included the cables with the highest calculated percentage of allowable SWBP. Because no damage was identified, TVA considered cables with lower calculated SWBP to be bounded by the results of this inspection. Therefore, TVA determined that there were no other cables in the predicted population at WBN Unit 1 with a risk of jamming.

For the cables currently installed at WBN Unit 2, TVA used a jam ratio range of 2.8 – 3.1 in its prediction analysis. In a response on April 6, 2009, to a request for additional information (RAI), TVA stated that jamming may occur at bends in a conduit system when the summation of the cable diameters approximately matches the conduit diameter. TVA further stated that when pull tension is high, a sufficient SWBP may be developed to force the middle conductor in between the two outer conductors to freeze in the conduit. The NRC staff verified that this narrative is consistent with the description provided in IEEE Standard 690-1984.

In its May 29, 2008, letter, TVA stated that as part of the corrective actions for WBN Unit 2, it calculated the cable pull tensions and the SWBPs to help identify cable installations that were more likely to incur cable damage from jamming. The NRC staff questioned TVA's approach in using the calculated SWBP to resolve the cable jamming issue. In its RAI dated November 25, 2008 (ADAMS No. ML083260202), the staff requested that TVA justify the acceptance criteria regarding the assumed relationship between SWBP and jamming. In its response dated January 14, 2009, TVA stated that it had evaluated and documented its justification for the acceptance of the assumed relationship between SWBP and jamming in TVA calculations WBPEVAR8905050 and WBPEVAR9008003. The NRC staff reviewed these calculations and was concerned that TVA's methodology and calculations for SWBP did not consider that the cables could experience high tension during pulls if jamming occurs. Based on this concern, the NRC staff requested TVA confirm that cables were typically hand pulled and that no indications of jamming had occurred. In its response on April 6, 2009, to the staff's RAI, TVA stated that the TVA Quality Control Procedure WBNP-QCP-3.5 requires the responsible engineer to provide the following pulling instructions for individual cables on the cable pull cards: (1) maximum allowable pull force in pounds, (2) rope pull device size, (3) indication if the pull required power assist, and (4) special pull instructions. Further, TVA stated that it was reviewing the cable pull cards for each WBN Unit 2 Class 1E cable to verify and validate the as-installed configuration. If a single-conductor Class 1 E cable is found to be installed using a power assisted pull, TVA stated that it would evaluate the controls in place during the pull and the jam ratio of the cable, and then take the appropriate corrective action based on the evaluation. The evaluation and corrective action would be made available for review.

TVA reviewed the pull cards for each Class 1E cable to determine if a power assist pull was documented for that cable by the responsible engineer. In a letter dated May 18, 2009, TVA stated that of the 4097 Unit 2-only Class 1E cables, 234 cables had unknown pull information (215 cables did not have a pull card and 19 cables had no marking about power-assist on the pull cards), 186 cables were never installed, and 2 cables were pushed. Therefore, of the remaining population of 3677 cables, which have cable pull records, none of the cables were identified to have undergone mechanical assisted pull. However, TVA stated that for the 234 cables with unknown pull data, 230 cables were either multiconductor cables or cables not in a three single conductor (3-1/C) configuration in conduit; therefore, these cables were not susceptible to jamming. The cable jamming ratio was calculated for each of four remaining cables as 2.08 for three single conductors (3-1/C) of #12 American wire gauge (AWG) and 4.4 for 3-1/C #10 AWG. These ratios are outside the critical jam ratio of 2.8-3.1; therefore, cable jamming is not a concern for these four cables.

As preventive measure for future cable installations, TVA revised its General Construction Specification G-38, "Installing Insulated Cables Rated up to 15,000 Volts [15 kV]," to require that the cable jam ratio not be between 2.8 and 3.1 prior to pulling cables in conduits and duct banks. Cables rated above 15 kV are not installed in a manner that would cause jamming to occur. If new cables need to be installed where the jam ratio cannot be met, TVA requires prior approval by TVA Engineering before installation. Thus, the NRC staff finds TVA's approach to these situations acceptable because the proposed installations would require review by TVA Engineering prior to pulling the cables and limitations would be placed on the pull to avoid the likelihood for jamming and exceeding the allowable SWBP.

On the basis on its review, the NRC staff considers TVA's approach to resolve the cable jamming subissue acceptable for WBN Unit 2 because TVA's methodology and calculations are adequate. However, if TVA should find a single-conductor Class 1E cable was installed using a power-assisted pull, TVA will evaluate the controls in place during the pull and the jam ratio of the cable, and take appropriate corrective action based on this evaluation. TVA will make the evaluation and corrective action available for NRC review. Additionally, in Supplement 7 to NUREG-0847, the NRC staff indicated that acceptability of the installation would be determined by the sample size inspected. The NRC staff finds that the sample size must be of sufficient size to allow a statistical inference to be made about the integrity of the overall installation. If damage is found, TVA must perform a root cause analysis, increase the sample size, and inform the NRC staff of the results. The NRC staff may opt to perform a visual inspection of the damaged cables.

3.2 Cable Pullby

In June 1989, to resolve an employee concern that an arc from welding during construction had struck a conduit run in the reactor protection system of WBN Unit 2, TVA removed cables from the conduit to inspect for damage. Although TVA found significant damage in the insulation of some cables, the damage was not from heat generated by the alleged welding arc. The damage was principally attributed to the pulling stresses exerted during the initial installation of the cables. By overlaying the location of the cable damage onto plant isometric diagrams of conduit runs, TVA found that the cables appeared to have been damaged at locations in the conduit runs where pull tensions and SWBP had exceeded certain safe threshold values. SWBP values are calculated as a function of the physical parameters of the cables and the conduit configuration. In Supplement 7 to NUREG-0847, the NRC staff previously confirmed that TVA's cable installation procedures (General Construction Specification G-38) included conservative values of SWBP that the cable installation crews may not have followed at the time of major construction at WBN.

By letter dated December 20, 1989, TVA submitted the CAP plan for resolving the cable pullby issues to the NRC staff for review. TVA also included a report on the damaged cables, which were removed in 1989 for possible damage due to a welding arc.

To assess the adequacy of Class 1E cable installations at its nuclear plants, TVA developed the following approach for resolving the issue of cable pullbys. A cable pullby occurs when a cable is added to other cables already installed in a conduit, which subjects the cables to stresses from sliding friction between the cables. TVA developed pull charts, with conservative assumptions, to determine SWBP using the following characteristics: conduit size, conduit length, percent fill, and cable construction. TVA conservatively assumed that: (1) pullbys have always occurred; (2) as much as 50 percent of the final fill weight was involved in a pullby in small conduits with the percentage decreasing to 20 percent for 5-inch raceways; (3) a total of 360 degrees of bends were distributed between pull points; (4) within each length, the maximum footage was utilized in the calculation and the expected SWBP was calculated for various ranges of conduit lengths; and (5) a coefficient of friction of 0.75 was used in evaluating pullbys where the final fill was less than 45 percent. For greater fill percentages, the coefficient of friction was increased to as high as 1.0 in recognition of the difficulty of pulling into conduits where the pullby results in a substantial overfill. Separate pull charts were developed for voltage levels V1, V2, V3, and V4 for various ranges of conduit fill, where:

V1 - Consists of shielded cables predominantly rated for 300 volts (V) AC in low-power instrumentation applications such as thermocouples, strain gauges, thermal converters, and resistance temperature detectors (RTDs) that are 100 millivolts (mV) and less.

V2 - Consists predominately of shielded cables in medium-level signal applications such as transmitters, RTDs (greater than 100 mV), rotor eccentricity and vibration detectors, and annunciators. The cables are predominantly rated 300 V AC.

V3 - Consists of cables rated for 600 V AC in control or control power applications with service voltages of 277 V AC/direct current (DC) or less. These cables are not shielded.

V4 - Consists of cables rated at 600 V AC that provide low-voltage power at service voltages from 277 to 480 V AC. In addition, heavily loaded control power and DC power cables are designated as V4 regardless of their service voltage. These cables are not shielded.

Using this approach, TVA identified three levels of potential risk from pullby damage to Class 1E cables (i.e., low, moderate, and high risk). The low-risk category consisted of those combinations of parameters that yielded expected SWBP less than or equal to the values specified in TVA's General Construction Specification G-38. These values were based on testing performed specifically for WBN Unit 1. The moderate-risk category was defined as that group of Class 1E conduits in which the expected SWBP under the assumed conditions could have exceeded the TVA's permissible values. The high-risk category included those Class 1E conduits in which damage could potentially be found with considerable frequency because of the severity of the assumed configuration and installation.

Cables in the low-risk category were “accepted as is" based on successful completion of DC high-potential (high-pot) withstand test or visual inspection of a worst-case sample from the low-risk category population. The high-pot test consists of applying a high voltage to the cable and observing in microamperes the leakage from the cables as a measure of insulation degradation. The testing and inspection validated the SWBP threshold between the moderate-risk and low-risk categories.

The high-pot testing was performed in accordance with a criteria agreed upon by the NRC staff utilizing the recommendation of IEEE Standard 400-1980, “IEEE Guide for Making High-Direct-Voltage Tests On Power Cable Systems In the Field,” for high-pot testing and using negative polarity DC voltage. The test sample consisted of 20 conduits from voltage levels V1 and V2 and 20 conduits from voltage levels V3 and V4. TVA reviewed the pull records for cables categorized as moderate-risk to determine if any pullbys occurred during the cable installation process. If no pullbys occurred, the subject cables were accepted as is. If a pullby occurred and the conduit was overfilled (40 percent actual inside area for conduits containing three or more cables), the subject cables were reclassified as high risk and replaced. If the conduit was not overfilled and a pullby occurred, walkdowns were performed to determine the presence and location of mid-run pullpoints. The initial classification process assumed the absence of intermediate pullpoints. If intermediate pullpoints existed, the length of the individual segments was determined, SWBP recalculated and compared to their limitations, and those segments were re-categorized. If any segments remained in the moderate category, the cables were classified as high risk and replaced, except for cables contained in five of these conduits, which were of short length and "accepted as is" based on inspections that found no cable damage.

For the remaining conduits, TVA reviewed the pull records to confirm that the largest pullby did not exceed SWBP limitations. If SWBP limitations were exceeded, the cables were classified as high risk and were replaced. If the SWBP limitations were not exceeded, the cables were classified as low risk and "accepted as-is." TVA reviewed the pull records for cables in the high-risk category. If no pullby occurred, then the subject cables were "accepted as is." If a pullby occurred, then the cables were replaced, except for cables contained in three of the conduits, which were short and "accepted as is" based on high-pot inspections that found no cable damage. TVA reviewed medium voltage cables (V5) routed in safety-related raceways, and required for WBN Unit 1 operation, separately to confirm the absence of pullbys or the performance of satisfactory post-pullby high-pot tests on active cable so that these cables could be de-coupled from the pullby issue. This proved to be the case.

As stated above, TVA determined that cables not having exceeded the safe threshold values would not have been damaged and were acceptable without any further action. The NRC staff questioned TVA's determination because TVA's threshold value for damage may not have been conservatively defined. Therefore, during a meeting on February 15 and 16, 1990, the NRC staff suggested that TVA either high-pot test a sample of the 20 of the worst-case conduits from the V1/V2 voltage level and 20 of the worst-case conduits from the V3/V4 voltage level, or remove the cables for visual inspection to assure that cables were not damaged by cable pullby. During a subsequent meeting on May 22, 1990, TVA agreed to high-pot test 20 of the worst-case conduits of each group, and documented its intent in a submittal dated June 15, 1990.

TVA's CAP plan stipulated that cables damaged from pullby, as identified by failure during the high-pot testing of the worst-case sample, would require replacement of all cables in that conduit and the inspection sample size would increase to 20 additional worst-case conduits in the voltage level group. TVA's program plan stipulated, however, that cables in the sample in conduits that passed the test, would be accepted as undamaged cables although the cables may be of a higher calculated risk ranking from those identified as damaged. The NRC staff disagreed with this approach and requested that TVA replace or inspect all cables ranked above the damaged cables. Because the high-pot test can only determine gross damage to cables, the staff was concerned that cables at a higher ranking but passing the test may have unacceptable damage. In response, TVA completed testing all worst-case conduits and did not identify any cable failures as a result of cable pullby. However, the NRC staff became aware that TVA had not included spare and abandoned cables in the test program. Because the cable pullby concern affects all cables in the conduit, the NRC staff requested TVA test all those cables unless it was determined that they were abandoned because of known damage to those cables.

In its June 15, 1990, submittal, TVA further proposed including some high-risk category conduits in the low-risk population. During a meeting on August 1 - 3, 1990, TVA wanted to remove five conduits from the high-risk population and include them in the test sample because the calculated value of SWBP for these conduits was not much above the low-risk value and assumptions used in the calculations were very conservative. The staff disagreed with TVA for one conduit, and TVA agreed to retain that conduit in the high-risk population. Based on the damage risk determination and testing, the NRC staff found TVA's program to resolve the cable pullby issue at WBN Unit 1 acceptable.

In its May 29, 2008, submittal, TVA stated that it had performed a scope assessment for WBN Unit 1 by removing 358 cables, consisting of approximately 33,500 linear feet, in 28 conduits. These cables were inspected for damage and exposed conductors were found on two of the cables removed from one of the conduits. The damage mechanism was attributed to cable pullby. TVA proposed a different corrective action for the pullby subissue for WBN Unit 2. The risk categories established for WBN Unit 1 would be used for WBN Unit 2. The basis for utilizing the same risk categories on WBN Unit 2 is that the worst-case samples used in the high-pot testing performed to validate the SWBP threshold between the moderate and low-risk categories on WBN Unit 1 are representative of the WBN Unit 2 cable population. Therefore, high-pot testing will not be repeated for WBN Unit 2. The WBN Unit 2 Class 1E cables not evaluated under WBN Unit 1 scope will be evaluated for the cable pullby issue using the same approach used on WBN Unit 1, except for those in the high-risk category. In this category, cable pull records will be reviewed to determine if a pullby occurred during the cable installation process. If no pullby occurred, then the cables will be “accepted as is.” If pullby occurred and the conduit is overfilled, the cables in that conduit will be replaced. If a high-risk conduit is not overfilled, a walkdown will be performed to determine the presence and location of mid-run pullpoints. The length of the individual segments will be determined and SWBP recalculated to determine if the cable segment can be re-categorized. If any segment remains in the high-risk category, the cables in that conduit will be replaced.

Based on the previous TVA actions for WBN Unit 1, the NRC staff finds that it is not necessary to perform high-pot testing to establish risk categories for WBN Unit 2. The staff also finds that, if mid-run pull points have been used, the SWBP can be re-calculated on a segment basis to determine whether the high-risk cable segment can be re-categorized and not replaced.

The NRC staff was concerned with TVA’s assumption that pullbys have always occurred. This could imply that any cable could be subject to pull-by damage, and the lack of evidence on any cable selected could be used for justification of not having a problem with cable damage due to pullbys. Given this scenario, the staff requested TVA describe how the assumption that pullbys have always occurred is conservative. On January 14, 2009, TVA stated that this assumption was only used to develop conservative screening criteria for determining which conduits needed further evaluation. After the screening, TVA reviewed the pull records for the high and medium risk conduits to determine if cables were pulled at the same time. If all cables in a conduit were pulled at the same time, they were eliminated as requiring re-pull. Thus, the inspections performed were representative of actual pullbys. The NRC staff found the TVA approach satisfactory in Appendix P of Supplement 7 to NUREG-0847. However, to address potential cable damage due to pullbys, TVA committed that WBN Unit 2 cables remaining in the high-risk category after evaluation and those in the following circumstances will be replaced: (1) cables that are routed entirely in a conduit will be replaced; and (2) cables that are routed in a cable tray with part of the route in a conduit will have the portion routed in conduit replaced.

In an RAI dated November 25, 2008 (ADAMS No. ML083260202), the NRC staff requested TVA explain its basis for crediting a coefficient of friction less than 1.0. On January 14, 2009, TVA stated that coefficient of friction tests historically evaluated the coefficient of friction between conduit and cable. Cable-to-cable tests had not been previously performed. TVA conducted tests in its Central Laboratory using the methodology inherited from the earlier cable-to-conduit assessments. These tests indicated that a 0.75 value of coefficient of friction was conservative, since the highest coefficient of friction measured for lubricated cables was 0.612. In developing pull charts, TVA varied the coefficient of friction because, as the conduit fill increases, it becomes more and more difficult for cables to find a clear path based on its tests. For 10, 20, 30, and 40 percent fill categories; the value of 0.75 from G-38 was applied. In the 50 to 60 percent fill categories, values of 0.85 and 1.0, respectively, were used for developing the pull charts. All conduit fills of 65 percent and above were automatically classified as being in the high-risk category. Conduit in the high-risk category that contained cable pullby was targeted for rework without further evaluation. However, in its letter dated April 6, TVA stated that none of the conduit fills are greater than 49 percent in WBN Unit 2. As such, it is the staff's understanding that the coefficient of friction values of 0.85 and 1.0 will not be applicable for WBN Unit 2 cables.

The NRC staff questioned TVA's use of the higher conduit fills than identified in the WBN Unit 2 FSAR. FSAR Section 8.3.1.4.1, "Cable Derating and Raceway Fill," states that (a) conduit containing only one cable is sized for a maximum of 53% cable fill; (b) conduit containing two cables is sized for a maximum of 31% cable fill; and (c) conduit containing three or more is sized for a maximum of 40% cable fill of the inside area of the conduit. TVA stated that for the cases where the conduit fill limits have exceeded the WBN 2 FSAR limits, TVA will perform an engineering evaluation for acceptability. Thus, TVA will need to submit an amendment to FSAR to allow the evaluation of the conduit fill exceeding the WBN Unit 2 FSAR conduit fill limits.

During a meeting on March 17, 2009 (ADAMS Accession No. ML090910150), the NRC staff requested TVA include a commitment to pull new cables in accordance with TVA's General Construction Specification G-38. In response to this request, TVA provided a commitment (ADAMS Accession No. ML091120183) that all new Class 1E cable pulls that involve cable pullby will be accomplished in accordance with TVA's specification G-38.

Based on TVA's evaluation and testing of cables and the criteria for replacing cables, the NRC staff considers TVA's approach for resolving the cable pullby subissue acceptable for WBN Unit 2. TVA will submit an update to the FSAR Section 8.3.1.4.1 to allow engineering evaluations if fill percentages are exceeded.

3.3 SWBP

SWBP is the radial force exerted on the cable insulation at a bend while the cable is being pulled in a raceway or around a sheave. At WBN, SWBP was not properly addressed in the design and installation process and the allowable values may have been exceeded. By letter dated June 15, 1990, TVA submitted its CAP plan to resolve this issue. TVA stated that since industry and manufacturers' guidance at the time of cable installation were inconsistent or nonexistent, TVA developed its own test program to determine the maximum SWBP and had them independently reviewed by an industry consultant. TVA also provided the results of its SWBP tests, including the independent evaluation by the industry consultant. In addition, TVA developed calculations to determine the magnitude of SWBPs exerted on Class IE cables in existing conduit installations at WBN. Screening calculations were conducted that reduced the number of conduits containing Class IE cables, which had the potential of having exceeded their allowable SWBPs, from about 10,400 to about 1900. A field inspection team then selected a worst-case sample of 81 conduits from the 1900 conduits to be used for SWBP calculations. From the calculations, TVA found only 1 out of the 81 conduits exceeded the new design limits established from the test results. As such, TVA replaced the cables in that conduit and resolved this issue. The NRC staff requested TVA to walkdown an additional 40 conduits that were located in harsh environments to confirm that no other violations of SWBP were present. By letter dated November 5, 1990, TVA documented that these conduits had been walked down and no violations of SWBP limits were observed.

In its May 29, 2008, submittal, TVA stated that it had established the maximum SWBP criteria as 1000 pounds per foot (ppf) of bend radius for low voltage power and control cables, 500 ppf of the bend radius for the medium and low level signal cables, and 300 ppf of the bend radius for the coaxial and tri-axial cables.

The staff reviewed the submittal, as supplemented, and the NRC Inspection Report No. 50-390, 391/95-17 for WBN Unit 1 on this subissue. The purpose of the staff's review was to verify that TVA's established criteria for maximum SWBP value were consistent with the cable manufacturers' recommended maximum SWBP values. The staff was concerned that TVA's established maximum SWBP criteria was less conservative than the manufacturers' specified value. In an RAI on November 25, 2008 (ADAMS No. ML083260202), the staff requested that TVA verify that the installed cable SWBP values did not exceed the cable manufacturers' maximum allowable SWBP value. Additionally, in letter dated April 2, 2009 (ADAMS No. ML090910150), the staff requested TVA provide the cable manufacturers' allowable pulling tensions and SWBP for each type of Class 1E cable used at WBN Unit 2.

In its response to the staff's RAIs, TVA provided the cable manufacturers' recommended maximum SWBP values for some cables used at WBN Units 1 and 2. TVA also stated that the low voltage power and control cables have a minimum SWBP margin of 56.3 percent, and as much as 188.9 percent, based on the TVA established criteria of 1000 ppf of bend radius. The staff requested that TVA provide a copy of the cable manufacturers' test certificates that show the maximum allowable SWBP values. In a letter dated May 18, 2009, TVA provided a copy of the test certificates and certificate of compliance from Okonite and Rockbestos Company. Both test certificates reflected a maximum SWBP value of 1000 ppf of bend radius. Although the manufacturers' information shows no SWBP margin exists for low-voltage power and control cables, the staff found that TVA's established maximum SWBP criteria is consistent with the maximum allowable SWBP values recommended by Okonite and Rockbestos. In light of the lack of SWBP margin for low-voltage power and control cables, TVA will verify that its maximum SWBP criteria for all signal level and coaxial cables do not exceed the cable manufacturers' maximum SWBP values.

Based on the cable manufacturers' data and TVA's calculations for SWBP, the NRC staff considers TVA's approach for resolving the SWBP subissue acceptable for WBN Unit 2.

3.4 Pulling Cable through 90 Degree Condulet and Mid-route Flexible Conduits

Damage to cables during installation in 90-degree condulets is possible because the inside corners of condulets provide a small supporting surface for cables under tension. The sharp inside corners can in time cut into the insulation, or the conductors can creep through the insulation, reducing the insulation level of the cable. As part of the WBN Unit 1 CAP plan for this subissue, TVA evaluated the effects of the 90-degree condulets on silicone rubber insulated cables, which are more susceptible to damage than cables with other types of insulation. TVA selected a worst-case sample of silicone rubber insulated cables based on cable runs with a minimum of two 90-degree condulets within their route. This effort identified 10 potential conduits (3 of which were in WBN Unit 2). To ensure that the installation of these cables had been acceptable, TVA removed these cables and conducted tests by subjecting them to the thermal and radiation levels that would be expected as a result of a loss-of-coolant-accident (LOCA). The testing demonstrated that the subject cables would be qualified for a 40-year life.

The NRC staff raised concerns regarding flexible conduits used at WBN in the middle of a conduit run. Since the inside surface of a flexible conduit has overlapping corrugations, the entire surface of the cable pulled through a flexible conduit segment in a bend will be subjected to very high frictional forces that can tear the cable jacket and insulation. At an August 1-3, 1990 meeting, the staff requested TVA provide a program for resolving the concern with pulling cable through mid-route flexible conduits. As part of the WBN Unit 1 CAP, TVA evaluated the cables pulled through mid-route flexible conduits that had been tested for pullby damage. TVA also inspected some cables removed for other reasons to confirm that no damage was caused by the mid-route flexible conduits. TVA revised its cable installation procedures, which now require that cables not be pulled through flexible conduits unless it is a straight section of a flexible conduit or a flexible conduit with a maximum 15-degree offset.

The NRC staff reviewed the implementation of the TVA program to resolve this subissue and documented its review in Inspection Report Nos. 50-390, 391/95-17 for WBN Units 1 and 2. As a result of its review, the staff considered TVA's resolution approach and implementation at WBN Unit 1 acceptable.

In its submittal for resolving this subissue for WBN Unit 2, TVA stated that high-pot testing of cables confirmed that no damage resulted from pulling cables through mid-route flexible conduit. The NRC staff reviewed the information in TVA's submittal of May 29, 2008, as supplemented, and NRC Inspection Report No. 50-390, 391/95-17 on this subissue. Based on the acceptability of the corrective actions and the further testing by TVA, the NRC staff finds the TVA approach to resolve this subissue for WBN Unit 2 acceptable.

3.5 <u>CCRS and ICRDS Database Verification and Validation</u>

At WBN, TVA was using the CCRS to document information regarding cable routing. The CCRS included information on cable routing in trays and conduits, cable type, cable weight, cable splices, circuit function, cable separation, etc. Concerns regarding the adequacy of CCRS were documented in various corrective action quality reports, employee concerns, and NRC inspection reports for WBN Unit 1.

In its submittal of May 29, 2008, TVA stated that as a part of the corrective action for this subissue at WBN Unit 2, the CCRS software was replaced by a program titled ICRDS. TVA verified and validated the ICRDS program in accordance with TVA Quality Assurance procedures. The data for both WBN Units 1 and 2 was transferred from CCRS into ICRDS database. TVA also verified and validated this data transfer from CCRS into ICRDS for WBN.

The NRC staff reviewed the information in the submittal, as supplemented, and in NRC Inspection Reports No. 50-390, 391/95-77 for WBN Unit 1 (ADAMS No. ML072610797). The staff also reviewed a sample of the cable and raceway information in the ICRDS database. The purpose of the staff's review was to verify the quality of cable and raceway data in ICRDS (such as the current as-installed cable lengths, sizes, insulation types, raceway types, sizes, etc.). This was to ensure that the calculations and analyses using such data were based on the current plant configuration.

The staff questioned the as-designed cable lengths and the as-installed cable lengths in ICRDS. In its response on January 14, 2009, to a staff RAI, TVA indicated that at WBN Unit 2, it will be using the cable lengths from the cable pull cards for environmental qualification (EQ) and Appendix R cables only and that those lengths will be used for WBN Unit 2 calculations and analyses. The staff was concerned that the pull cards, being historical records, may not reflect the current plant configuration. Thus, the staff disagreed with TVA's approach to fully rely on cable lengths on the pull cards and use them in the ICRDS, calculations, and analyses. The staff considers the ICRDS, calculations, and analyses as plant documents; and therefore, these documents should reflect the current plant configuration, including length of cables. The staff finds that the cable lengths used in the ICRDS, calculations, and analyses should be based on the current plant configuration.

Based on the use of a verified and validated program and data, the NRC staff finds TVA's approach to resolve this subissue for WBN Unit 2 acceptable. The NRC staff will review the changes to the ICRDS database to include current plant configuration to confirm that the conclusions remain valid.

3.6 Other Cable Issues CAP Plan Subissues

3.6.1 Silicon Rubber Insulated Cable Subissue

Failures in silicone rubber insulated cables were initially found during high-potential testing at SQN. The failures were caused by impact-induced damage. Further, TVA noted that silicone rubber insulated cables manufactured by American Insulated Wire (AIW) appeared to be more susceptible to this type of damage than those from Rockbestos and Anaconda. In Revision 3, dated January 13, 1994, of the WBN Cables Issues CAP Plan, TVA stated that silicone rubber cables were removed from 10 critical case conduits and subjected to testing to qualify them for 40 years of radiation and thermal aging followed by LOCA conditions. After completion of the LOCA simulation test, the cables were subjected to a mandrel rebend and high-potential withstand testing for margin assessment.

For WBN Unit 1, TVA confirmed that no AIW cables were used. Rockbestos and Anaconda cables from WBN Units 1 and 2 were tested at Wyle Laboratories and met the 40-year qualified life. TVA concluded that the successful test performance demonstrated that the installation methods for silicone rubber insulated cables were adequate to have prevented significant impact-induced damage. In its safety evaluation dated April 25, 1991, the NRC staff had concluded that based on the results of the testing, TVA had adequately resolved this issue for WBN.

During a meeting on the Cable Issues CAP plan on March 13, 2009, the NRC staff noted that the silicone rubber insulated cables were installed at WBN Unit 2 in late 1980s or early 1990s. Because the WBN Unit 2 cables have been exposed to the field conditions for years and the cable insulation may have degraded, the NRC questioned the continued applicability of the EQ testing. In its response of April 6, 2009, TVA stated that the silicone rubber insulated cables are rated at 125° C. Although these cables have been installed in situ for over 25 years, most of the Unit 2 cables have never been energized and have remained in an ambient environment. This situation is no different than if a reel of these cables was stored in the warehouse for that duration. As part of the EQ program, the impact on life due to external heating (i.e., ambient temperatures) will be assessed. It is expected that this impact will be minimal since the ambient temperature is significantly less than the cable rating.

On the basis of the review of TVA's justifications and the review of cables under the EQ program and the implementation of the CAP plan previously approved for WBN Unit 1, the NRC staff finds the plan for resolution of the silicon rubber insulated cable subissue to be acceptable.

3.6.2 Cable Support in Vertical Conduit

In its CAP plan, TVA stated that cables in long vertical conduits and cable trays may be inadequately supported, which could potentially cause unacceptable cable insulation degradation. Random failures due to cutting of the insulation and conductor creep may occur during normal service conditions, especially for silicone rubber insulated cables. TVA stated that the root cause of the problem was a failure to include industry standard support requirements in design and installation documents.

For WBN Unit 1, TVA identified the critical cases of silicone rubber insulated cables in vertical conduits. Vertical cables tend to creep downward and pull on the upper horizontal cable section, causing high stresses at the 90° bend and cutting the insulation. In a letter dated October 11, 1990, TVA agreed not to take credit for frictional resistance of horizontal run and to provide additional restraints upstream of the first access point for conduits that exceed the National Electric Code Article 300-19 (1987), "Supporting Conductors and Vertical Raceways."

In its letter of September 26, 2008, TVA stated that the WBN critical cases had been compared with those already tested at SQN. If SQN conduit configuration enveloped WBN, no cable testing by WBN was performed. If SQN conduits did not envelope WBN, the cable was replaced or in situ cable testing was performed; any cable found unacceptable was replaced. TVA also evaluated Class 1E conduits containing cables of all insulation types and added cable supports when acceptance criteria were not satisfied. In addition, cable installation specification and site procedures were revised to incorporate appropriate cable support requirements for cable installed in vertical conduits, and thereby prevent recurrence. Conduits that exceeded the support requirements of General Construction Specification G-38 were analyzed, and conduit support points with bearing pressure greater than allowable were inspected and supports added as required.

In its letter dated April 6, 2009, TVA responded to questions regarding the characterization of "rework" of conduits. TVA stated that "rework" meant that the installation will be modified such that it meets the requirements of TVA specifications. Section 8.7.1, "Cables Routed in Vertical Conduits-Support Intervals," of Specification G-38 provides the spacing requirements for vertical conduit supports. Cable supports will be added to Class 1E conduits according to the methods described in Section 8.7.2 of G-38, which includes selection of support type and installation practices. TVA was also asked to provide a justification for determining that "creep" did not occur in the vertical conduits. TVA stated that the "looseness" of the cable will be assessed to demonstrate that the cable was subjected to minimal pressure. TVA calculation assessed the impact of the SWBP on the cable at the transition due to the weight of the cable vertical drop. This was done based on the cable being at rated temperature. Because the WBN Unit 2 specific cables have been deenergized and have been at a much lower temperature than rated. This lower temperature, in conjunction with the verification that the cable is "loose," provides assurance that insulation creep has not occurred.

The NRC questioned the basis for "hand-lifting" cables to determine looseness. TVA responded that a visual inspection of those conduits that do not meet the G-38 vertical support requirements will be conducted to determine if the cables are loose. This will be measured by a craft's ability to lift the cables off the support point with one hand and without mechanical assistance. The basis for this is that looseness of the cable indicates an insignificant pressure on the cable jacket that is in contact with the surface supporting it. If the cables are found to be under tension, which is indicated by the craft's inability to lift them off the support point, the portion of these cables that has stayed under tension since their original installation will be replaced.

On the basis that TVA will implement the plan for the subissue using the same approach as used at WBN Unit 1 and using the requirements in General Construction Specification G-38, which meets current standards, the NRC staff finds that the plan for resolution is acceptable.

3.6.3 Cable Support in Vertical Trays

TVA stated its specifications require that cables in vertical trays be supported in accordance with the National Electric Code (NEC) to prevent long-term cable damage and that this support may be provided by tie wraps. However, TVA had no basis to verify that cable ties could provide adequate support. In response to this concern, TVA evaluated the acceptability of various tie wrap configurations as support systems. If a configuration was found to be inadequate, it was shown by analysis, similarity to other installations, or testing that no cable damage had occurred or would occur. TVA stated that cable support was added when manufacturers' limits were exceeded. To prevent recurrence, TVA revised the cable installation specification and site procedures to identify acceptable methods for support of cables in vertical trays.

In its review of this issue for WBN Unit 2, the NRC staff asked TVA to summarize how the vertical cable trays were assessed to determine that no cable damage had occurred. In its response on April 6, 2009, TVA stated that the following actions were used to determine that no damage occurred to the safety-related cables in long vertical tray runs:

a. Identified those families of cable trays containing safety-related cables where the potential existed that an adequate support was not provided to meet the recommended requirements of the 1987 version of NEC Article.300-19.

b. Performed walkdowns of the trays to determine their exact configuration.

c. Where the length of the vertical drop exceeded the support requirement stipulated in the NEC and a discrete support was not present, prepared a calculation to determine the impact of unsupported load with respect to cable and any connected equipment at the top resulting from: (1) the weight on the copper conductors and potential for the load to stretch the copper; (2) pullout of conductors from crimped lugs at termination;

(3) potential cutting of cables by tie wraps used to secure cables in trays; and (4) static SWBP at support points.

d. Issued design changes to add tray supports where required.

In addition, the NRC staff asked TVA provide a discussion that codifies that no credit was taken for tie-wraps to support vertical cables. TVA stated that General Construction Specification G-38, Section 8.6.3.2, allows the use of cable tie wraps for the following applications: (a) where required to maintain a neat orderly arrangement of cables, cable ties shall be installed at intervals not exceeding 10 feet, and (b) to maintain required nominal spacing between medium-voltage circuits. The NRC staff also verified that TVA's calculation took no credit for full support from tie wraps due to lack of EQ of the wraps. TVA stated that this calculation also evaluates the effect of the horizontal section above a vertical tray section. It states that the presence of the cable ties, Vimasco, and fire stops in a horizontal section is considered in establishing a coefficient of friction. However, credit cannot be taken for cable ties in a horizontal section to provide support to a vertical tray section since they are not qualified. The restraint provided by the horizontal section is based on the coefficient of friction between cable jacket and the bottom of the tray in the horizontal section.

On the basis that TVA is using the requirements in its General Construction Specification G-38 and the tie-wraps are not credited for support of vertical cables, the NRC staff finds that the approach for resolution is acceptable.

3.6.4 Cable Proximity to Hot Pipes

When hot pipes are located close to cables, the higher ambient temperature in the vicinity caused by the hot pipes may degrade the cable insulation and shorten the life of the cables. The cables are designed for 40-year life assuming certain ambient temperatures that could be exceeded by the proximity to hot pipes. In its CAP plan, TVA stated that cable design did not include the local effects of hot pipes. For WBN Unit 1, TVA developed criteria to detail the required clearances between cable/raceways and hot pipes/valves to eliminate this potential impact. Class 1E cables were walked down against the criteria to ensure that adequate separation existed between the cables and hot pipes/valves. Deviations were resolved by heat transfer analysis, change of pipe insulation, or raceway rework.

The clearance requirements were established for electrical cables run in conduits or cable trays, either parallel, or at an angle, to a hot pipe, and located in any of the environmental situations listed on environmental drawings. The clearance requirements are based on heat transfer analyses that determine the temperature rise in cables caused by the presence of a nearby hot pipe. These analyses account for: (1) the resistance heating of the cables, (2) the heat transfer with the surroundings by natural convection and radiation, (3) the heat transfer by radiation between the cable or conduit surface and the piping insulation surface, and (4) the heat transfer by convection between the cables and the boundary layer of the plume arising from the pipe. In its calculations, TVA analyzed various geometrical arrangements that it considered would cover most situations in the plant. Specific arrangements not bounded by these calculations were analyzed separately.

In its April 6, 2009, letter, TVA stated that it would conduct a final walkdown of the plant after construction is completed to determine if any deviations from the calculated clearance requirements between the hot pipes and Class 1E electrical raceways exist. TVA committed to evaluate and resolve these deviations.

TVA described the rework actions taken to correct the clearance deviations between Class 1E raceways and hot pipes. These included: installation of heat shield, restraining flexible conduit to obtain a 2-inch clearance, relocating conduit or tubing to obtain required clearance, and installing additional insulation on the pipe to obtain required surface temperature.

On the basis that TVA will use the same approach as used at WBN Unit 1, which continues to meet the bounding analyses, and will conduct a final walkdown to determine if the required clearances are maintained, the NRC staff finds the plan for resolution of this issue acceptable.

3.6.5 Cable Bend Radius

In its cable issues CAP plan, TVA determined that the minimum cable bend radius recommended by the Insulated Cable Engineers Association had been exceeded at WBN. Excessive bending has the potential to cause damage by: (a) elongation stress to the insulation system that may reduce the qualified life of the cable, (b) interfacial disruptions of medium voltage cable stress control layers of insulation and insulation shield, which may have likelihood of corona degradations, and (c) conductor creeping, which will put radial stress on the insulation system.

In SSER 7, as supplemented in SSER 9, the NRC staff found TVA's plan for resolution of this issue acceptable. In the plan, TVA described its criteria and circumstances for retraining bends, replacing cables not meeting requirements, and accepting based on margin analysis and on a long-term program. On WBN Unit 1, TVA established bend radius parameters (upper and lower bounds) for Class 1E cables and revised General Construction Specification G-38 to include the bend radius requirements for cable installation. Cable was then categorized based on equipment qualification requirements, classification and voltage level, and inspected and replaced, retrained, or their qualified life reduced, based on bending or kinking relative to upper and lower bound bend radii. Because TVA will implement the same plan, which contains applicable industry requirements and construction specifications, the NRC staff finds that it meets current standards and is acceptable for WBN Unit 2.

3.6.6 Cable Splices

TVA prepared a plan to resolve a concern that the installed electrical cable splices may not conform to the qualified configurations and materials tested by the vendor, a list of Class 1E cable splices in harsh and mild environments was developed. In its September 26, 2008, letter, TVA stated cables and splices were identified by reviewing equipment qualification binders and construction records to determine which equipment uses pigtails for field cable connection. All 10 CFR 50.49 harsh environment cable splices requiring Raychem Type N material were replaced, and some mild environment cable splices deemed susceptible to moisture intrusion were reworked. A sampling program was implemented to verify that the splice list was complete for intermediate splices.

For WBN Unit 2, TVA will use that same approach toward resolution used at Unit 1, which is still valid. TVA will verify splices by the walkdown of safety related cable. In response to a question from the NRC staff on the characterization of "rework" activities regarding splices for cables in mild environments, TVA stated in a response on April 6, 2009, that rework involved the replacement of intermediate splices for Class 1E cables in mild environments that are susceptible to moisture intrusion from flood, line break, or sprinkler activation. The NRC staff finds that implementation of this plan at WBN Unit 2 is acceptable.

3.7 Other Electrical CAP Subissues

In a letter dated February 15, 1989, TVA provided its CAP "Plan for Electrical Issues," which was initiated based on concerns related to electrical installations, materials, and equipment, and conditions-adverse-to-quality reports. The NRC staff reviewed the CAP plan and documented its acceptance in NUREG-1232, Volume 4, and found that the CAP plan established acceptable program guidelines for identification, resolution, implementation, and inspection for the specific electrical issues discussed in the CAP.

3.7.1 Flexible Conduit Installations

TVA identified problems with flexible conduits such as: (a) inadequate length to account for seismic or thermal movement, (b) lack of compliance with minimum bend radius requirements, and (c) loose fittings. To resolve these issues for WBN Unit 1, TVA revised design output documents to more specifically define flexible conduit requirements. TVA developed a list of flexible conduits attached to Class 1E pipe mounted devices to identify those flexible conduits that would experience both seismic and thermal movement. TVA walked down Unit 1 Class 1E flexible conduits and reworked those found to be damaged or in noncompliance with the design output documents. Section 3.6.2 of the General Construction Specification G-40 provides the methodology for the installation of flexible conduits.

On the basis that TVA will use the approach for resolution used at WBN Unit 1 and that the method for installation is in a construction specification, the NRC staff finds the plan for resolution at Unit 2 acceptable.

3.7.2 Physical Cable Separation and Electrical Isolation

TVA stated that there were cases at WBN where redundant closed raceways had less than the minimum required 1-inch separation. For WBN Unit 1, this issue was subdivided into three issues, and each was resolved separately: (a) separation between redundant divisions of Class 1E raceways, (b) internal panel separation between redundant divisions of Class 1E cables, and (c) coil-to-contact and contact-to-contact isolation between Class 1E and non-Class 1E circuits.

To address the inadequate separation between redundant divisions of Class 1E raceways at WBN Unit 1, TVA reworked the raceways to meet the minimum 1-inch separation requirement, and site implementing procedures were revised to require specific signoffs for raceway separation attributes. For inadequate internal panel separation between redundant divisions of Class 1E cables, TVA revised the design criteria to include more detailed requirements for cable separation internal to panels and issued an engineering output document defining these requirements. After developing a list of all panels with redundant divisions of Class 1E cables, TVA walked down the panels to identify cables that did not comply with the revised engineering requirements, and evaluated any deviations to determine acceptability or reworked to meet required separation distances. For coil-to-contact and contact-to-contact isolation between Class 1E and non-Class 1E circuits, TVA prepared a calculation to determine acceptability;

revised design criteria to specify acceptable isolation methods; and reviewed the existing Class 1E coil and contact devices used as isolators to determine if qualified for their intended use.

In response to a question from the NRC staff, TVA stated that safety-related, EQ, and Appendix R cables are included in the WBN Unit 2 Cable Issues CAP Plan. TVA will also evaluate associated cables for appropriate electrical separations.

On the basis that TVA will implement the plan used and found acceptable at WBN Unit 1, the NRC staff finds the approach to resolve the issue at Unit 2 acceptable.

3.7.3 Torque Switch and Overload Relay Bypass Capability for Active Safety-Related Valves

TVA found that thermal overload and torque switch bypass capability was not provided for certain active safety-related valves, as recommended by NRC Regulatory Guide 1.106. For Unit 1, TVA issued design criteria to provide the basis for determining which active valves were required to have their thermal overload relays and torque switches bypassed and issued a calculation to identify these valves. TVA revised the system design criteria or system descriptions to identify the valves within a system requiring this capability, revised the design output documents to provide the required capability, and installed thermal overload and torque switch bypasses as required. Thus, based on the use of the same approach as used at Unit 1, the NRC staff finds the plan for resolution of this issue at WBN Unit 2 acceptable.

4.0 TVA COMMITMENTS

4.1 Commitments Requiring Confirmation of Completion

TVA should submit information to confirm that proper resolution of the CAP plans has been completed. The NRC staff will conduct appropriate inspection activities to verify that resolution of the issues has been adequately implemented.

1. Cable Jamming

   If TVA should find a single-conductor Class 1E cable was installed using a power assisted pull, TVA will evaluate the controls in place during the pull and the jam ratio of the cable. Appropriate corrective action will be taken based on this evaluation. TVA will make the evaluation and corrective action available for NRC review.

2. Cable Pullby

   TVA will submit an update to WBN Unit 2 FSAR Section 8.3.1.4.1 to allow for TVA engineering evaluations if fill percentage limits are exceeded.

3. SWBP

   TVA will verify that its maximum SWBP criteria for all signal level and coaxial cables do not exceed the cable manufacturers’ maximum SWBP values.

4. ICRDS Database

TVA stated that it plans to use cable pull cards to verify cable as-installed configuration or signal trace, as required, for EQ and Appendix R cables. TVA will ensure that the cable lengths used in the ICRDS, calculations, and analyses will be based on the current plant configuration.

4.2 Other TVA Commitments

In addition to those commitments requiring submission to the NRC of information to document completion, TVA will include the following items, as discussed in its January 14 and April 6, 2009, letters, in its Commitment Management Program.

1. To address potential cable damage due to pullbys, WBN Unit 2 cables that remain in the high-risk category after evaluation and cables in the following circumstances will be replaced: (1) cables that are routed entirely in a conduit will be replaced; and (2) cables that are routed in a cable tray with part of the route in a conduit will have the portion routed in conduit replaced.

2. All new Class 1E cable pulls for WBN Unit 2 that involve cable pullby will be accomplished in accordance with TVA's General Construction Specification G-38.

3. TVA will statistically sample the WBN Unit 2 Quality Assurance records by record type to determine their retrievability, storage, and completeness. TVA will also resolve any technical or quality problems found.

4. TVA will perform back checks of the previously installed replacement items to ensure that a proper documentation trail exists from the warehouse to maintenance history for each of the small number of safety-related components that are not refurbished.

5. TVA will conduct a visual inspection of the supports for vertical conduits that do not meet General Construction Specification G-38 vertical support requirements. If cables are found to be under tension, the portion under tension will be replaced.

6. TVA will conduct a walkdown for “hot pipe” configurations after construction completion.

5.0 CONCLUSION

The NRC staff finds that TVA’s CAP plan for the WBN Unit 2 cable issues acceptable because TVA’s proposed approach for resolution of the issues establishes adequate program guidelines for identification, resolution, implementation, and inspection for each of the specific subissues as required by Appendix B to 10 CFR Part 50.

The NRC staff may perform inspections to assure adequate implementation of the program. The staff will document the completion of the inspections in future inspection reports to verify that the items have been properly implemented. The NRC may also conduct inspections or audits to verify that TVA is adequately addressing its commitments with the Commitment Management Program.

6.0 REFERENCES

1. TVA letter dated May 29, 2008, M. Bajestani to NRC, “Cable Issues Corrective Action Program for the Completion of WBN Unit 2” (ADAMS No. ML081560183)

2. TVA letter dated January 14, 2009, M. Bajestani to NRC, “Response to Request for Additional Information Regarding Cable Issue Corrective Action Program” (ADAMS No. ML090210473)

3. TVA letter dated April 6, 2009, M. Bajestani to NRC, “Additional Information Regarding WBN Unit 2 Corrective Action Programs” (ADAMS No. ML091120183)

4. TVA letter dated May 18, 2009, M. Bajestani to NRC, “Additional Information Regarding WBN Unit 2 Corrective Action Programs” (ADAMS No. ML091410284)

5. NRC letter dated April 25, 1991, P. Tam to D. Nauman, TVA, “Watts Bar Unit 1 - Corrective Action Program (CAP) Plan for Cable Issues” (ADAMS No. ML082420252)

6. NRC letter dated November 25, 2008, P. Milano to A. Bhatnagar, TVA, “Request for Additional Information Regarding Cable Issues Corrective Action Program” (ADAMS No. ML083260202)

7. Appendix P to Supplement 7 of NRC Report NUREG-0847, September 1991 (ADAMS No. ML082420254)

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