AMPACITY EVALUATION PROGRAM PLAN
REVISION 1

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1.0 INTRODUCTION

An INPO finding on Bellefonte Nuclear Plant concerning the lack of design calculations to show the adequacy of cable ampacities resulted in a Problem Identification Report (PIR GENEEB8605) covering all TVA nuclear plants. A detailed review determined that TVA design standards DS-E12.1.1 through DS-E12.1.4 were incomplete and did not properly account for the effects of environment and raceway configuration on ampacity. Since these standards were used for initial design, the potential exists for undersizing of safety-related cable in Browns Ferry Nuclear Plant (BFN). A new electrical design standard (DS-E12.6.3) based on various industry standards and test reports was subsequently developed which corrects the identified deficiencies. A program to determine the extent of conformance to that standard has been developed and is being implemented at BFN. This program meets or exceeds the Sequoyah Nuclear Plant (SQN) ampacity program (See attachment 1).

2.0 OBJECTIVE

The objective is to fully substantiate a 40 year design life, i.e., a remaining 26 years or more continued operation of unit 2 auxiliary and control power safety-related cables after removing any sizing conservatism which resulted in a loss of operating life. Safety-related cables not having a remaining life of 26 years after restart will be replaced before unit 2 restart.

3.0 SCOPE

The scope is to verify the adequacy of safety-related auxiliary and control power cables in voltage levels V3, V4, and V5, (as defined by DS-E12.6.3) designed before the issuance of DS-E12.6.3 R0. The evaluation shall be accomplished, in part, by applying a single or multisampling plan based upon the Nuclear Construction Issues Group (NCIG) sampling plan which has been accepted for visual reinspection of welds.

4.0 DESCRIPTION OF PROGRAM

The program plan is to 1) identify cables requiring evaluation; 2) implement a sampling plan; 3) verify raceway configuration; 4) evaluate and conduct 100 percent review in areas of common cause deficiencies; 5) perform calculations; 6) determine life expended and remaining operating life; 7) impose installation restrictions; 8) implement test programs and, 9) implement program interfaces.

4.1 IDENTIFY CABLES REQUIRING EVALUATION

Voltage level V3, V4, and V5 safety-related cables are being evaluated as well as nonsafety-related cables routed in safety-related raceways. Safety-related cables are identified from the BFN Q-List which is the minimum set of structure, systems, and components necessary to prevent or mitigate the consequences of Final Safety Analysis Report (FSAR), Chapter 14, design basis events and to safely shut down the plant following such events. Environmentally qualified cables are identified by the BFN 10 CFR 50.49 list.

4.2 IMPLEMENTATION OF SAMPLING PLAN

A sampling plan using inspection lots similar to SQN's nine (9) inspection lots for V3, V4, V5 cables has been implemented at BFN as follows:

V4, V5 Sampling Approach

A NCIG sample size and allowable discrepant items established a minimum of 95 percent confidence and a 95 percent reliability level. A discrepant item (or failure) is considered to be a cable whose 40 year design life allowable ampacity (which takes into consideration the derating requirements DS-E12.6.3) is less than the required actual load with margin to account for reduced voltage, service factor, etc.

V3 Approach

As done for SQN, the V3 voltage level has been divided into two subcategories: 1) "control power cables" that require evaluation and 2) "control function cables" that are used for controlling the operating status of equipment and do not require evaluation. Based on the SQN results, it is anticipated that the total population of BFN control power cables is small and as a result, TVA will review 100 percent of this subcategory. V3 Q-List control power cables which serve as primary feeds to panels and miscellaneous devices are being identified by review of BFN ac/dc voltage drop calculations for safety-related equipment. In addition, panels whose total load current exceeds 6 amps are being reviewed to identify cables leaving the panels that carry greater than 6 amps (the minimum size for a control cable is a #14 and that size is allowed to carry up to 6 amps before being designated as control power). In addition, identified control power cables are being evaluated for ampacity. Cables carrying this load are being reviewed against the load vs conductor size criteria in DS-E12.6.3 for classification as "control power" or control function.

4.3 VERIFICATION OF RACEWAY CONFIGURATION

To determine ampacity, cable routing, insulation temperature, and raceway configuration must be known. Route and raceway configuration, i.e., conduit and tray fill, tray covers and bottoms, thickness of flame retardant coatings, fire wrap, fire stops, pressure seals, and environment (mild or harsh) are being determined from the BFN As-Constructed Cable and Conduit Schedule (CCS), As-Designed Cable and Conduit Schedule when the As-Constructed CCS is not available and field walkdowns. As trays are walked-down, information identifying conduits entering and leaving trays along with any cables which leave tray by air is compared against the CCS to confirm its accuracy. If no discrepancy is found the cable route given in the schedule is considered to be correct and verified by review. Where discrepancies exist between the cable schedule and the walkdown data, further investigation is being conducted to resolve the discrepancy. Where required, signal tracing is being performed to determine the route.

4.4 EVALUATE CABLES AND CONDUCT 100 PERCENT REVIEW IN AREAS OF COMMON CAUSE DEFICIENCIES

Based upon SQN's results, it is anticipated that upon completion of the sampling program at BFN there will be no failures of V3 cables in tray or conduit and minimum failures of V4 and V5 cables in conduit. It is anticipated that failures may exist for 10 CFR 50.49 cables in V4 and V5 conduit which may also require 100 percent review. However, common cause deficiencies would be expected in V4 and V5 tray inspection lots of the sampling program which would require 100 percent review in V4 and V5 trays. Hence, 100 percent walkdown and evaluation is being performed for the cables in these inspection lots.

4.5 PERFORMANCE OF CALCULATIONS

Cables are being evaluated by calculations progressively performed in three phases designated as Phase I, Phase II, and Phase III as follows:

Phase I evaluates cables conservatively using design standard DS-E12.6.3.

Phase II takes a closer look at the conservatism in DS-E12.6.3 and permits higher cable ampacity when actual load current, adjusted load multipliers, and actual cable depth of fill are considered. Phase II also determines the operating temperature of cables in tray by evaluating load diversity provided no hotspot exists in the tray. Load diversity analysis evaluates the difference between worst case heat intensity (i.e., all fully loaded cables) and an actual average heat intensity for cables in the tray. A portion of this difference is applied, with margin, to selected cables that would otherwise be considered overloaded. At the same time, the ampacity of other cables in the tray is lowered accordingly.

Phase III includes a more detailed review of the equipment loads for those cables which do not pass Phase I and Phase II. Operating modes of the cable (e.g., normal, shutdown and test modes) and loading cycling (e.g., time diversity of loads sharing a raceway) are considered.

4.6 DETERMINATION OF EXPENDED AND REMAINING LIFE

Cables which are initially identified as operating above their 40 year life temperature based upon actual load current and present raceway configuration are being further analyzed to ensure a remaining life of 26 years minimum. In this analysis, the duration of each cable's maximum past and future operating temperatures (both in its loaded and nonloaded state) is determined based upon the installed configuration, its duty cycle loading (i.e., intermittent or continuous) and the duty cycle of cables surrounding it (i.e., tray diversity loading). Once the operating temperatures and durations are known, remaining life can be predicted by utilizing the Arrhenius methodology as commonly applied for insulation materials encountered throughout the nuclear industry. This methodology features the use of empirical test data to form the basis for each life prediction. In no case will safety-related cable, in its future operation, exceed its qualified maximum temperature rating (if an EQ cable) or its manufacturer's rating during any period of time.

4.7 CABLE REPLACEMENT

Those safety-related cables that do not have 26 years remaining operating life after restart (for a total of 40 years life) will be replaced before the restart of BFN unit 2. The BFN design criteria BFN-50-758 is the governing document with regard to these cable replacements.

4.8 CABLE INSTALLATION RESTRICTIONS

In order to ensure the raceway configuration used in the cable evaluations is not altered by additional cables, tray covers, flamemastic, fire wrap, etc., without assessing the impact to cables, TVA is developing a cable maintenance program.

4.9 TEST PROGRAMS

To provide additional information for the ampacity analysis, flamemastic (fire retardant coating) derating research is planned. Tests are underway to increase the presently reduced temperature ratings of 10 CFR 50.49 cable.

4.10 PROGRAM INTERFACES

Coordination with other BFN design review programs, such as voltage drop analysis, cable short circuit and coordination analysis, EQ, and any other program which may be dependent on cable temperature, is being performed to ensure those analyses are not invalidated.

5.0 PROGRAM IMPLEMENTATION:

TVA is performing the ampacity evaluation and is providing design modification changes for replacement cables. Evaluation, design and modification is being performed in accordance with TVA procedures and practices. Key TVA personnel involved in the SQN ampacity calculation evaluation ensures consistency between the BFN and SQN programs.

6.0 PROGRAM DOCUMENTATION

The sampling program for V3, V4, and V5 safety-related cables is being performed by approved project instructions and calculations (TI-E110-01). Calculations are performed and documented in accordance with TVA's Nuclear Engineering Procedure (NEP) 3.1. Walkdown data is of a QA level that it may be used as input to calculations. Cables not sized in accordance with DS-E12.6.3 are identified on Conditions Adverse to Quality Reports (CAQR) and are being further evaluated or replaced. Cables which are found acceptable for 26 years or more, but which are not sized in accordance with DS-E12.6.3 will be identified on an exception request to design criteria BFN-50-758. Program completion is being documented by installation of replacement cables, approval of design criteria exception requests and closure of existing BFN CAQR's regarding the ampacity issue.

The BFN Nuclear Performance Plan (NPP) and FSAR are being revised at the next update to reflect the program described herein.

7.0 CONCLUSION

The BFN Ampacity Evaluation Program implements an evaluation program similar to SQN. As result of the experience at SQN, BFN has elected to bypass initial sampling of V4 and V5 cable sizing in trays and perform a 100 percent verification. In addition, field walkdowns and signal tracing are being used to verify the V4/V5 portions of the BFN cable schedules. Cable failure and replacement is determined by cable remaining life. Cables determined to have a remaining operating life of less than 26 years after restart are being replaced before BFN unit 2 restart.

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TVA 64 (OS-9-85) (OP-WP-5-85)

ATTACHMENT 1

AMPACITY EVALUATION PROGRAM PLAN

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

B43 '86 1008 909

TO : Those listed

FROM : W. S. Raughley, Chief Electrical Engineer, W8 C126 C-K

QA Record

DATE : October 7, 1986

8611030329 (5)

SUBJECT: ALL NUCLEAR PLANTS - CORRECTIVE ACTION AND SAMPLING PROGRAM FOR ELECTRICAL CABLE AMPACITY

This memorandum supersedes the September 8, 1986, memorandum from W. S. Raughley to Those listed (B43 860909 902) in order to provide additional direction for the handling of defective units, further define V3-level control power cables, and provide multiplying factors for trays and fire wrap materials.

The purpose of this memorandum is to provide direction on the performance of corrective action and the establishment of a sampling program to determine the adequacy of electrical cables with respect to their ampacity rating. This is mandated by deficiencies in Design Standards E12.1.1 - E12.1.4 which were identified in Problem Identification Report PIRGENEEB8605. These design standards have been superseded and all inadequacies corrected by the recent issuance of DS-E12.6.3 "Ampacity Tables for Auxiliary and Control Power Cables (0-15,000V)."

In addition to the actions specified herein for confirming the adequacy of the cable with respect to ampacity, each project's Equipment Qualification section must address the impact of the new design standard on its efforts. This is necessary if the project has derated the cable's qualified conductor temperature below its insulation temperature rating using such computer programs as "CABCALC" or "CACTAC." The affected parameters include the specified allowable ampacity in conduit and tray, the derating effects of tray covers, and bottoms, and fire wrap, and the assumed conductor temperature when the conductor is deenergized. Each project should discuss and coordinate its efforts in this area with the cable specialist.

Prior to proceeding with implementation of the actions noted herein each project must confirm the adequacy of the following:

1. The specific cable number and cable type mark number for all auxiliary and control power Class 1E cables, and non-Class 1E cables routed with Class 1E cables must be known. These must appear in DS-E12.6.3 with an ampacity rating for the installed raceway configuration.

2. The exact installed routing of the cables identified in item 1 must be known.

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3. For V4- and V5-level the percent fill for the trays, and the number of conductors in the conduits in which the cables identified in item 1 are routed must be known. The effect of cables which are abandoned in the raceway but are not indicated in present cable schedules must be accounted for.

4. The existence and location of cable coatings, cable tray covers and bottoms and Appendix R fire wraps must be known.

In order to demonstrate the adequacy of the auxiliary and control power cables with respect to ampacity each project shall establish a sampling program. The guidelines will be developed and the sampling performed in accordance with Military Standard 105D dated April 29, 1963.

The sampling program will be developed by each project based on 9 inspection lots or batches. The inspection lots for each project are as follows (refer to Design Standard E12.6.3 for the definition of the various voltage levels):

1. V3 level cables routed in tray.

2. V3 level cables routed in conduit without Appendix R fire wrap.

3. V3 level cables routed in conduit with Appendix R fire wrap.

4. V4 level cables routed in tray without tray covers, bottoms or Appendix R fire wrap.

5. V4 level cables routed in tray with tray covers and/or bottoms and/or Appendix R fire wrap.

6. V5 level cables routed in tray without tray covers, bottoms or Appendix R fire wrap.

7. V5 level cables routed in tray with tray covers, and/or bottoms and/or Appendix R fire wraps.

8. V4 and V5 level cables routed in conduit without Appendix R fire wrap.

9. V4 and V5 level cables routed in conduit with Appendix R fire wrap.

For each of the inspection lots shown the project shall determine the total number of units (Class 1E cables or non-Class 1E cables routed with Class 1E cables) in that lot. Each such cable should be counted only once and included in the inspection lot reflecting the most limiting raceway configuration for ampacity in which it is routed.

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The order of raceway configurations by service level from most limiting to least limiting are as follows:

1. V3-level
   A. Inspection lot 1
   B. Inspection lot 3
   C. Inspection lot 2

2. V4-level
   A. Inspection lot 5
   B. Inspection lot 9
   C. Inspection lot 4
   D. Inspection lot 8

3. V5-level
   A. Inspection lot 7
   B. Inspection lot 9
   C. Inspection lot 8
   D. Inspection lot 6

Therefore, as an example, cables routed in V4 or V5 level trays with tray covers and/or bottoms and/or Appendix R fire wrap shall not be counted again in other inspection lots even if they are additionally routed in such.

After the total number of units in each inspection lot is determined the sample size code letter shall be selected from the Military Specification 105D Table I for General Inspection Level II. Following selection of the code letter the sample size is specified in Table IV-A. The acceptable quality level is 4.0.

Having established the first sample size the project shall randomly select cables from the inspection lot. Each cable shall have the allowable ampacity determined, considering its actual installed configuration, in accordance with Design Standard E12.6.3. This ampacity will be compared against the actual load ampacity including appropriate multiplying factors to determine the acceptability of the installed cable with respect to ampacity.

If the initial sampling indicates an acceptable quality level within the respective inspection lot, no further sampling is required. If the number of defective units in the initial sampling is above the specified allowable limit additional sample lots shall be selected and the adequacy of the cables determined. Refer to Section 10.1.2 of the Military Specification for specific direction. This process shall continue until an acceptable quality level is achieved in accordance with the Military Specification or until the lot is rejected. All cables within a rejected lot will have to have their adequacy with respect to ampacity determined individually.

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An SCR must be written to cover all defective units and the mode of failure for those units shall be explained and documented. A determination must be made as to the possible generic implications of any failure. If the failure can be shown to be due to an isolated cause, no further review in this regard is necessary. If the cause of failure could apply to a particular subset of cables, further review, which may include additional sampling, of the cables in that group is required to determine the extent of the problem.

For the purposes of this sampling program, control power cables are those cables routed in a V3-level raceway whose load current for the particular conductor size could produce sufficient heat to warrant consideration. As V3-level cables are, by definition, limited to less than 30 amperes this consideration is restricted to conductor size No. 8 AWG and smaller. Therefore, a control power cable is defined as a No. 8, 10, 12, or 14 AWG conductor installed in a V3 raceway with a load current greater than indicated below except No. 10, 12, or 14 AWG conductors whose load current does not exceed 15 amps and whose load operation does not exceed a total of 20 minutes in any 5-hour interval.

Cables which meet the exception or whose load currents are below those indicated do not warrant further consideration of ampacity and are not considered control power cables. Those cables which exceed these limitations must have the specific allowable ampacity of the cable selected verified for adequacy for the load current and installation configuration.

Conductor Size (AWG)	is a control power cable, if the load current exceeds (amperes):
14	6
12	8
10	12
8	22

This information will be substantiated by a DNE calculation to be issued by EEB Central Staff.

For the purposes of this sampling program, the multiplying factors indicated below are applicable for the configurations listed:

Cable Trays Only

Configuration	Multiplier
Sheet metal cover	0.75
Sheet metal bottom	0.81
Sheet metal top and bottom	0.60

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TSI Fire Wrap Material

Plant	Description/Attachment	Multiplier
BFN	1-Hr Conduit <2"	0.91
BFN	1-Hr Conduit ≥2"	0.925
WBN	3-Hr Conduit <2"	0.88
WBN	3-Hr Conduit ≥2"	0.90
SQN	Panels to Construct 1-Hr trays (V4 only)	0.87
SQN	Panels to Construct 3-Hr trays (V4 only)	0.79

3M Fire Wrap Material

Plant	Type	Description/Attachment	Multiplier
WBN	M-20A	Conduit - 5 Layers of Wrapping	0.625
WBN	M-20A	Cable Tray - 4 Layers of Wrapping	0.40
WBN	CS-195/M-20A	Cable Tray Rigid Panels	0.41

This information will also be substantiated by a DNE calculation to be issued by EEB Central Staff and will be incorporated into the next revision of Electrical Design Standard DS-E12.6.3.

Resolution of the concerns on cable ampacity has been tied to plant restart/fuel load. Implementation of the actions specified in this memorandum should be scheduled by each project accordingly.

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