CABLE AMPACITY PROGRAM PLAN

BROWNS FERRY NUCLEAR PLANT

REVISION 0

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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 to all TVA nuclear plants. As a result, it was 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 cable environment and cable installation configuration on cable ampacity. Since these standards were used for the initial design of cable installations at Browns Ferry Nuclear (BFN), the potential exists for undersizing of safety related cable in BFN. A new electrical design standard (DS-E12.6.3) based on various industry standards and test reports was subsequently developed which applies to cables installed in BFN. A program to determine the extent of nonconformance to the current standard, which meet or exceeds the Sequoyah Nuclear Plant (SQN) ampacity program (See Attachment 1), has been developed and is being implemented at BFN.

2.0 OBJECTIVE

The objective is to fully substantiate a remaining two (2) year (next scheduled outage) or more continued operation of all auxiliary and control power safety related cables after equating any lack of previous cable sizing conservatism with a loss of operating life. Cables not having a remaining life of two (2) years operation after restart will be replaced prior to Unit 2 restart. Those cables with a remaining operating life exceeding two (2) years will be scheduled for replacement prior to expending their determined remaining life.

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 prior to the issuance of DS-E12.6.3 R0. The evaluation shall be accomplished by applying single or multi-sampling 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 installed cable configuration 4) evaluate cables and conduct 100% review in areas of common cause deficiencies 5) perform calculations 6) determine cable life expended and remaining operating life 7) schedule cable replacements based on cable remaining life, 8) impose cable installation restrictions 9) implement test programs and, 10) implement program interfaces.

4.1 IDENTIFY CABLES REQUIRING EVALUATION

Cables requiring evaluation are voltage level V3, V4, and V5 safety related cables and non-safety related cables routed with safety related cables. All safety related cables will be identified by the BFN Q-List which is considered to be 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 will be identified by the BFN 10CFR50.49 list.

4.2 IMPLEMENTATION OF SAMPLING PLAN

A NCIG sampling plan using inspection lots similar to SQN's nine (9) inspection lots for the V3, V4, and V5 cables will be implemented at BFN. Sample size and allowable discrepant items will be for a 95% confidence and a 95% reliability level. For purposes of determining whether a 100% review of the inspection lot is required, a discrepant item (or failure) is considered to be a cable whose 40 year design life allowable ampacity (which takes into consideration the derating effects of tray covers and/or bottoms, flame retardant coatings, Appendix R fire wraps, and ambient) is less than the required actual load with margin to account for reduced voltage, service factor, etc..

4.3 VERIFICATION OF CABLE INSTALLED CONFIGURATION

For determining ampacity for cables which are being evaluated in the sampling program, cable routes through raceway and the cable limiting temperature factors must be known. Route and installation configuration of safety related cable, i.e., conduit and tray fill, cable tray covers and bottoms, thickness of flame retardant coatings, fire wrap, fire stops, pressure seals, and environment (mild or harsh), will be determined from the BFN As-Constructed Cable and Conduit Schedule drawings (CCS) and field walkdowns. As trays are walked-down, information identifying conduits entering and leaving trays along with any cables which leave tray via air is compared against the CCS to confirm the CCS accuracy. If no discrepancy is found the cable route given in the schedule is considered to be correct and verified by review. If there is a discrepancy between the cable schedule and the walkdown data further investigation is conducted to resolve the discrepancy. In most of those instances signal tracing of cables will be required to determine the cable route. Drawing discrepancies will be initiated to document and update the cable schedule.

4.4 EVALUATE CABLES AND CONDUCT 100% 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 in V3 voltage level cables in tray or conduit and minimum failures in V4 and V5 voltage level cables in conduit. However, common cause deficiencies are expected in V4 and V5 tray inspection lots of the sampling program which would therefore require 100% review of cables in V4 and V5 tray. Hence, 100% walkdown and cable evaluation will be performed of the cables in these inspection lots. It is anticipated that failures may exist for 10CFR50.49 cables in V4 and V5 conduit which may also require 100% review.

4.5 PERFORMANCE OF CALCULATIONS

Cables will be 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 Rev 1.

Phase II takes a closer look at the conservative design criteria given in DS-E12.6.3 and permits higher cable ampacity when actual cable depth of fill, load current and load multipliers are considered. Phase II also determines operating temperature of the cable.

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

4.6 DETERMINATION OF EXPENDED AND REMAINING LIFE

Cables which are identified as not having a 40 year design life based upon actual load current and cable installation configuration will be further analyzed to determine their expended and remaining life. In this analysis, the duration time of each cable's maximum operating temperature (both in its loaded and non-loaded 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. if in tray, tray diversity loading). Determination of operating temperature will include the effects of tray cover removal, reduction of conservative load type multiplier, and use of actual running load in lieu of equipment rating. Once the operating temperature and duration time is known, cable expected life can be determined by utilizing the Arrhenuis methodology commonly applied in calculating life values for cable insulation materials encountered throughout the nuclear industry. This methodology features the use of empirical test data to form the basis for each cable life prediction. For example, a cable that has an expected life of 40 years when operating at rated temperature of 90 degrees centigrade will have an expected life, depending on the insulation type and physical characteristics, of approximately 20 years when operating at 100 degree centigrade. However, for environmentally qualified (EQ) cable, verification that operation at a higher temperature does not void the qualification, is required, and will be performed.

4.7 CABLE REPLACEMENT

Those cables that do not have two (2) years remaining operating life after restart will be replaced prior to the restart of BFN Unit 2. For those cables having greater than two (2) years remaining operating life, a schedule will be developed for replacement as required. Cable replacement will be in accordance with BFN design criteria BFN-50-758 "Power, Control, and Signal Cables for use in Class I Structures".

4.8 CABLE INSTALLATION RESTRICTIONS

TVA will assure the cable installation configuration used in the cable evaluations are not altered by additional cables, tray covers, flamemastic, fire wrap etc without assessing the impact to cables.

4.9 TEST PROGRAMS

To provide additional information for the ampacity analysis, Flamemastic (cable fire retardant coating) derating test and tests to increase the presently reduced temperature ratings of 10CFR 50.49 cable are planned. These results may better define ampacity deration conservatism when used in determining allowable ampacity for cable.

4.10 PROGRAM INTERFACES

Coordination with other BFN design review programs such as voltage drop analysis, cable short circuit and coordination analysis, Appendix R analysis and Environmental Qualification (EQ) program and any other program which may be dependent on cable temperature, will be performed to assure those analyses are not invalidated.

5.0 PROGRAM IMPLEMENTATION:

TVA Division of Nuclear Engineering (DNE) will perform the ampacity evaluation of cables and will provide Design Modification Changes for replacement cables. Evaluation, design and modification will be performed in accordance with TVA procedures and practices. Key TVA personnel including DNE cable specialist/designee involved in the SQN ampacity calculation evaluation will assure consistency between the BFN and SQN programs. For this effort, DNE cable specialist designee is Bryan Reagan.

6.0 PROGRAM DOCUMENTATION

The sampling program for V3, V4, and V5 voltage level safety related cables will be performed by approved project instructions and calculations. Calculations will be performed and documented in accordance with TVA's Nuclear Engineering Procedure (NEP) 3.1. All walkdown data will be of a QA level that it may be used as input to calculations. Cables not sized in accordance with DS-E12.6.3 will be identified on Conditions Adverse to Quality Reports (CAQR). Cables not having a remaining life of 2 years after restart will be replaced prior to restart. Those having an operating life greater than 2 years will be identified and scheduled for replacement as part of BFN maintenance program for Class 1E equipment. All cables which are found acceptable for 2 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 will be 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 Final Safety Analysis Report (FSAR) will be revised to reflect the program described herein.

7.0 CONCLUSION

The BFN Ampacity Evaluation Program will implement an evaluation program similar to SQN. In addition to SQN, a conduit and cable schedule verification and 100% Flamemastic thickness walkdown verification program will be used to determine V4, and V5 voltage level allowable ampacity values of cable in tray. Cable failure and replacement will be determined by cable remaining life. Cables determined to have a remaining operating life of less than two (2) years after restart will be replaced prior to BFN Unit 2 restart.

TVA 64 (05-9-65) (OP-WP-5-85)

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : Those listed

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

DATE : October 7, 1986

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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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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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