**WATTS BAR NUCLEAR PLANT**

**CABLE ISSUES**

**CORRECTIVE ACTION PROGRAM PLAN**

REVISION 2

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CABLE ISSUES
CORRECTIVE ACTION PROGRAM PLAN
REVISION LOG

| REVISION LEVEL | DATE | AFFECTED PAGES | DESCRIPTION OF REVISION |
|---|---|---|---|
| 0 | 12/16/88 | | Initial Issue. |
| 1 | 06/27/89 | 2 | Revised to specifically identify those cable issues for which critical case evaluation techniques will be applied |
| | | 9 | Revised corrective action for splice issue to indicate that certain Class 1E splices will be replaced without further inspection or evaluation. |
| | | 10 | Revised corrective action for splice issue to indicate that completeness of the splice list for intermediate splices will be verified by a sampling process. |
| | | 12 and 13 | Revised to correct arithmetic errors in accordance with the March 15, 1989 submittal and provide clarification that cable route verification was done by signal tracing or visual inspection (see section 4.2.1, paragraph 1). |
| | | 14 | Revised for clarification, route verification was done by signal tracing or visual inspection (see section 4.2.2, paragraph 4). |
| | | 18 (Exhibit A) | Revised to reflect verification by site procedure rather than a specific site organization (NQA), since various quality assurance organizations are involved based on the activity being performed. |
| | | 1 through 12 (Exhibit A Table) | Remove reference to walkdown of cable splices from Page 8 (see text revision Page 9 above). Removed reference to QC organization's concurrence (See text revision Page 18 above). |
| | | 15 (Attachment 1) | Revised to reflect VSR discrepancy report in accordance with the March 15, 1989 submittal and add reference to VSR report DR-213. |
| | | 1 and 2 (Attachment 3) | Revised to update progress through May 6, 1989. |
| | | 7 (Attachment 2) | Revised to reflect current plan. |
| 2 | 08/31/90 | 4 | Revised to provide additional clarification regarding the methodology utilized to address cable jamming. |
| | | 6, 7 and 7a | Revised to provide the latest information regarding TVA's methodology to address pullby damage at WBN. |
| | | 10 | Revised to clarify results of TVA's conduit configuration evaluations with respect to SWBP limits. |
| | | 11 | Revised to reflect TVA's alternative methodology to resolve the cable pulling through midroute flexible conduit issues at WBN. |
| | | 11a | Added page to maintain consistency with original CAP. |

WBN will initiate the following actions to resolve this issue:

- WBN Class 1E conduit segments have been evaluated to identify those segments most likely to have experienced jamming during installation. This population will be ranked according to their calculated percent allowable SWBPs.

- Some of the cables identified by the above process will be replaced as a result of other issues. These cables will be removed and inspected for evidence of damage due to jamming. Cables in the worst-case conduit configuration of those removed, exhibiting no visible jamming damage, will be considered the "bounding" configuration. Lower-ranked configurations of the above identified population will be considered enveloped by this inspection. Cables in those conduits not bounded by these configurations will be analyzed, inspected, reworked, or tested. R2

The root cause of cable jamming is that Nuclear Engineering (NE) did not implement the manufacturer's recommendation to check for potential cable jamming prior to cable pulling.

The action required to prevent recurrence has been completed with the revision of the cable installation specification and site procedures to ensure that the cable-jam ratio is not between 2.8 and 3.1 prior to pulling in conduits and duct banks.

4.1.3 Cable Support in Vertical Conduit

In the NRC-issued TER for WBN, a concern was expressed that cables in long, vertical conduits were inadequately supported and that "... random failures due to cutting of the insulation and conductor creep may occur during normal service condition, especially silicone rubber cables" (Reference 1).

WBN will initiate the following corrective actions to resolve this issue:

- Identify critical case silicone rubber insulated cable in vertical conduits, using cable bearing pressure occurring at the edge of the condulet as the criteria. This methodology is similar to SQN's.

- Compare WBN critical cases with those identified and tested at SQN. If SQN conduits for the same issue envelop WBN, no cable testing by WBN will be performed. If SQN conduits do not envelop WBN, is situ tests will be performed at WBN or the cables will be replaced. If the testing option is selected, any cables found unacceptable will be replaced.

- To prevent any long-term cable degradation, Class 1E conduits containing cables of all insulation types, will insulation strength, or resultant loading imparted to the cable terminations or splices exceed manufacturers' limits, as a result of the cable weight.

The root cause of this issue is that NE did not evaluate the limitation of tie wraps as cable supports.

The action required to prevent recurrence is to revise the cable installation specification and site procedures to identify acceptable methods for support of cables in vertical cable trays should the existing support system prove to be inadequate.

4.1.5 Cable Proximity to Hot Pipes

NRC Information Notice 86-49, highlighted the potential for cable damage resulting from close proximity to hot pipes.

WBN will initiate the following actions to resolve this issue:

° Develop criteria that will detail required clearances between cables/raceways and hot pipes/valves to eliminate impact on the cable's allowable ampacity and qualified life. SQN performance data and corrective action will be considered when developing this criteria.

° WBN will walkdown Class 1E cables against the criteria to ensure that adequate separation exists between cables and hot pipes/valves.

° All deviations will be resolved by analysis, change of pipe insulation, or raceway rework.

The root cause of this issue was that NE did not specify clearance requirements.

The action required to prevent recurrence is to revise the pipe, pipe insulation, cable, and raceway installation specifications and site procedures to include spatial separation requirements between pipes/valves and cables/raceways.

4.1.6 Cable Pullbys

In June 1989, TVA performed a pullback and inspection of electrical cables to resolve an employee concern related to welding activities on or near conduit with regard to the potential heat damage to cables within. No heat damage related to welding activities was found; however, cable insulation damage was noted. This damage resulted in the exposure of the conductors of five instrumentation cables in R2 the Unit 2 Reactor Protection System. Laboratory analysis confirmed TVA's initial assessment that the damage occurred as a result of cable pullbys. During the scope assessment effort, additional cables were removed and additional damage was found. Nonpullby jacket damage to coaxial cables was identified during this activity. R2

Method of Resolution

An evaluation methodology was developed and implemented to categorize the potential for pullby damage into low and high-risk categories. Cables in conduits determined to be "high-risk" will be replaced. Cables in low-risk category conduits are accepted "as-is" pending successful completion of high potential withstand tests performed on a sample of the low-risk conduits. This methodology considered key pulling parameters such as raceway size, fill, length, cable type, and assumed configuration. Also, this methodology ensured that worst-case pullby configurations are considered in the selection of conduits for cable replacement. R2

Results

Corrective actions have been developed resulting in the replacement of safety-related cables which were determined to have significant potential for damage during installation. For pullby damage, recurrence control measures have been identified and will be implemented to ensure the adequacy of future installations. Cable replacement will be performed consistent with these recurrence control measures, as well as other applicable design requirements (e.g., cable splicing, cable bend radius, etc.). R2

The root cause is that TVA and industry standards did not recognize the potential for cable damage when performing cable pullbys. R2

The completion of the above activities will ensure that the WBN safety-related cable systems will perform their intended safety functions. R2

### 4.1.7 Cable Bend Radius

TVA has identified through nonconforming condition reports (NCRs) and Nuclear Safety Review Staff (NSRS) reports that the minimum recommended cable bend radius was violated during the installations of some cables. The impact on cable performance is that in shielded power cables, a tight radius can cause the metallic shield to cut into the insulation. For coaxial and triaxial cables, improper radius may result in distortion of the shield and dielectric resulting in an unacceptable change in the cable electrical characteristics. For unshielded cables, which are the majority, an excessive bend in the cable can produce high elongation stress in the insulation portion of the cable.

Concerns are separated into the following two categories:

- NE Design and NC Implementation

  Inadequate NE design output and NC installation requirements for cable bend radius limits are of concern for cable installation, including termination locations (e.g., panels, motorboxes, condulets, and junction boxes). Cable inspection may have taken place prior to "stuffing" whatever cable slack there was back into the condulet box or enclosure.

- WBN will implement a sampling program to verify that the splice list is complete for intermediate splices. R1

The root cause was that NE, NC, and Nuclear Quality Assurance (NQA) did not adhere to the strict installation and inspection requirements established by the vendor of the splice material.

The action required to prevent recurrence is the revision of splice installation instructions and site procedures to conform to existing qualified designs.

4.1.9 Cable Sidewall Bearing Pressure

The July 9, 1985 NSRS Report (Reference 3) stated that cable sidewall bearing pressure (SWBP) was not addressed properly during installation. SWBP is the radial force exerted on the insulation of a cable at a bend point when the cable is being pulled. WBN developed selection criteria, identified 81 critical case conduits, and performed a walkdown. SWBP was calculated for these conduits. Results of the calculation showed that cable SWBP, based on existing limits, was exceeded in some cases. TVA then conducted a test program (Reference 4) to determine more realistic SWBP limits for WBN cables. Test results showed that the existing SWBP limits were conservative and established new, less restrictive limits. Based on these new limits, TVA identified one conduit from the 81 representative severe-case configurations that contained cables which exceeded the SWBP limits when calculated in one direction. TVA will replace the R2 cables contained in this conduit.

Additionally, TVA will randomly select a sample of conduits located in harsh environments. SWBPs will be calculated for these conduits and compared to the established allowable limits defined in the General Construction Specification, G-38. R2 Those cables determined to have potentially exceeded the allowable SWBP limits will be analyzed and/or replaced, as necessary.

A meeting was held with the NRC on July 17, 1986 to report the successful completion of the test report (Reference 5). As requested by the NRC, a third-party review of the report was performed. The review by D. A. Silver & Associates (Reference 6) produced minor comments that did not change the conclusions of the report.

Stone & Webster Engineering Corporation (SWEC), a TVA contractor, issued an evaluation report on November 4, 1987 (Reference 7) indicating that the only action required by TVA to close out this issue was to verify some data used in the critical case conduit calculation, which will not change the conclusions of the report.

The root cause of cable SWBP being exceeded was that NE did not implement cable industry installation guidelines related to cable pulling in conduits.

The action required to prevent recurrence, which has been completed, was to revise the cable installation specification and site procedures to add explicit cable SWBP restrictions to cable pulling limits.

4.1.10 Pulling Cable Through 90-Degree Condulet and Flexible Conduit

In the TER (Reference 1), concerns were expressed that "... considerable damage is likely to occur if cables are pulled under tension around the inside edge of a 90-degree condulet...," and that flexible conduit severely tears the cable jacket and insulation. Even though no evidence of damage was observed, the TER recommended further investigation.

WBN will initiate the following actions to resolve this issue:

° 90-Degree Condulets

The 90-degree condulet issue will be addressed in the aforementioned Silicone Rubber Insulated Cable Program. Under this program, the cable selection criteria to identify critical case silicone cable insulation requires that, as a minimum, the cable to be evaluated will have two 90-degree condulets within its route. Since silicone rubber insulation is more susceptible to damage than other types of cable insulation, this will envelop all types of insulation at WBN.

° Flexible Conduit

Evaluate conduit runs with midroute flexible conduits high-potential withstand tested (to resolve the cable pullby issue) to determine if sufficient quantities of midroute flexible conduits having significant offsets were evaluated to adequately resolve this issue. The results of ongoing inspections of cables removed for all issues may also be utilized to resolve this issue. R2

If adequate results are not achieved through the above testing, TVA will identify, by walkdown, flexible conduits installed in midroute of rigid conduits. These cables will be examined visually at conduit end points and pull points to determine whether there is visible cable damage. R2

The action required to prevent recurrence, which has been completed, required the revision of the cable installation specifications to address cable pulling through flexible conduits. Site procedures will also be revised to be in agreement with the NE design output documents.

4.2 Computerized Cable Routing System

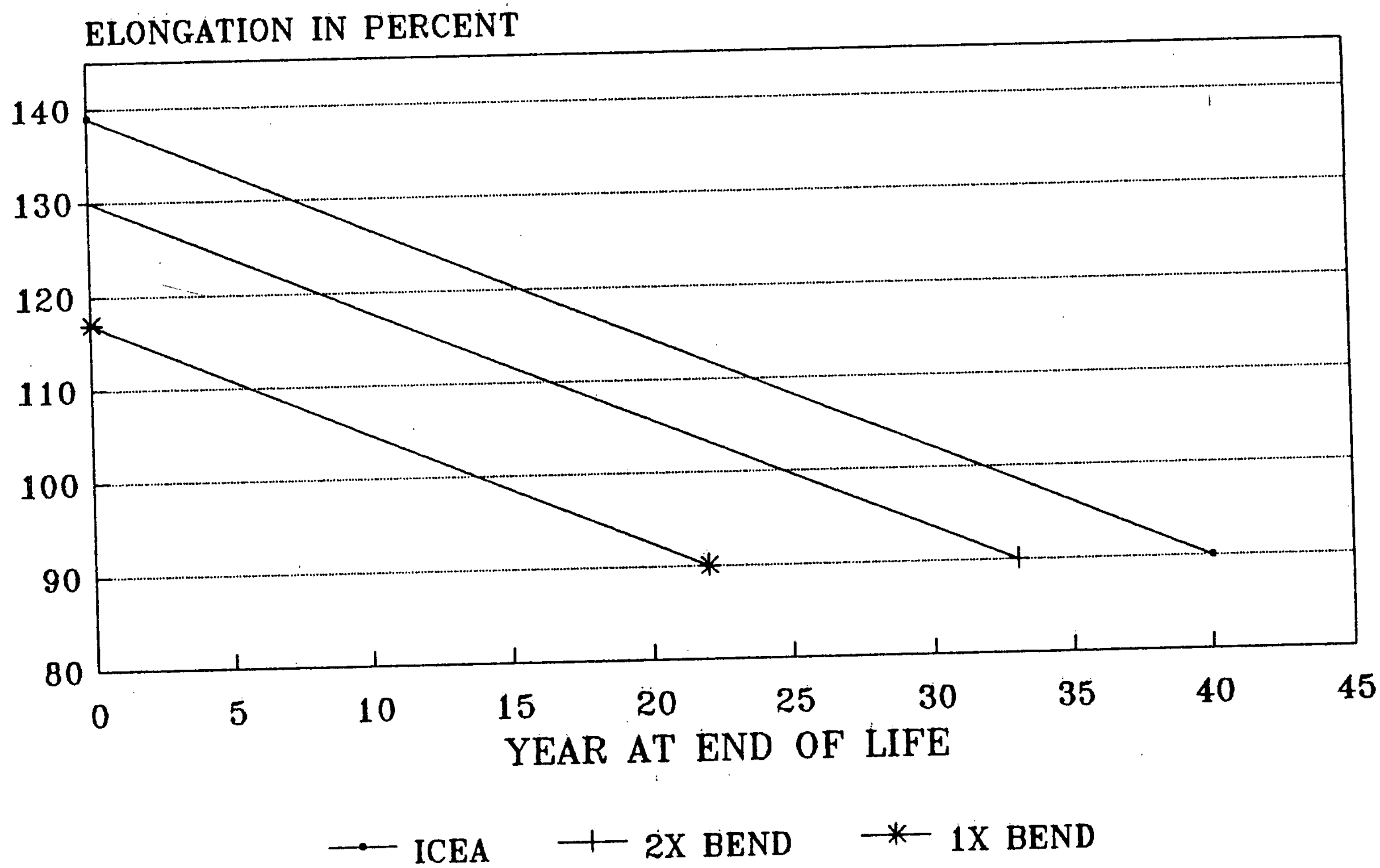
Concerns have been expressed and documented in CAQRs, Employee Concerns, and an NRC Inspection Report on SQN about the adequacy of the CCRS.

The planned approach to resolve similar CCRS concerns at WBN is to (1) qualify the computer software, (2) verify the existing data, (3) revise procedures for controlling data entry, revision, and utilization, (4) expand the data base to support other activities, and (5) validate the system.

# ENCLOSURE 3

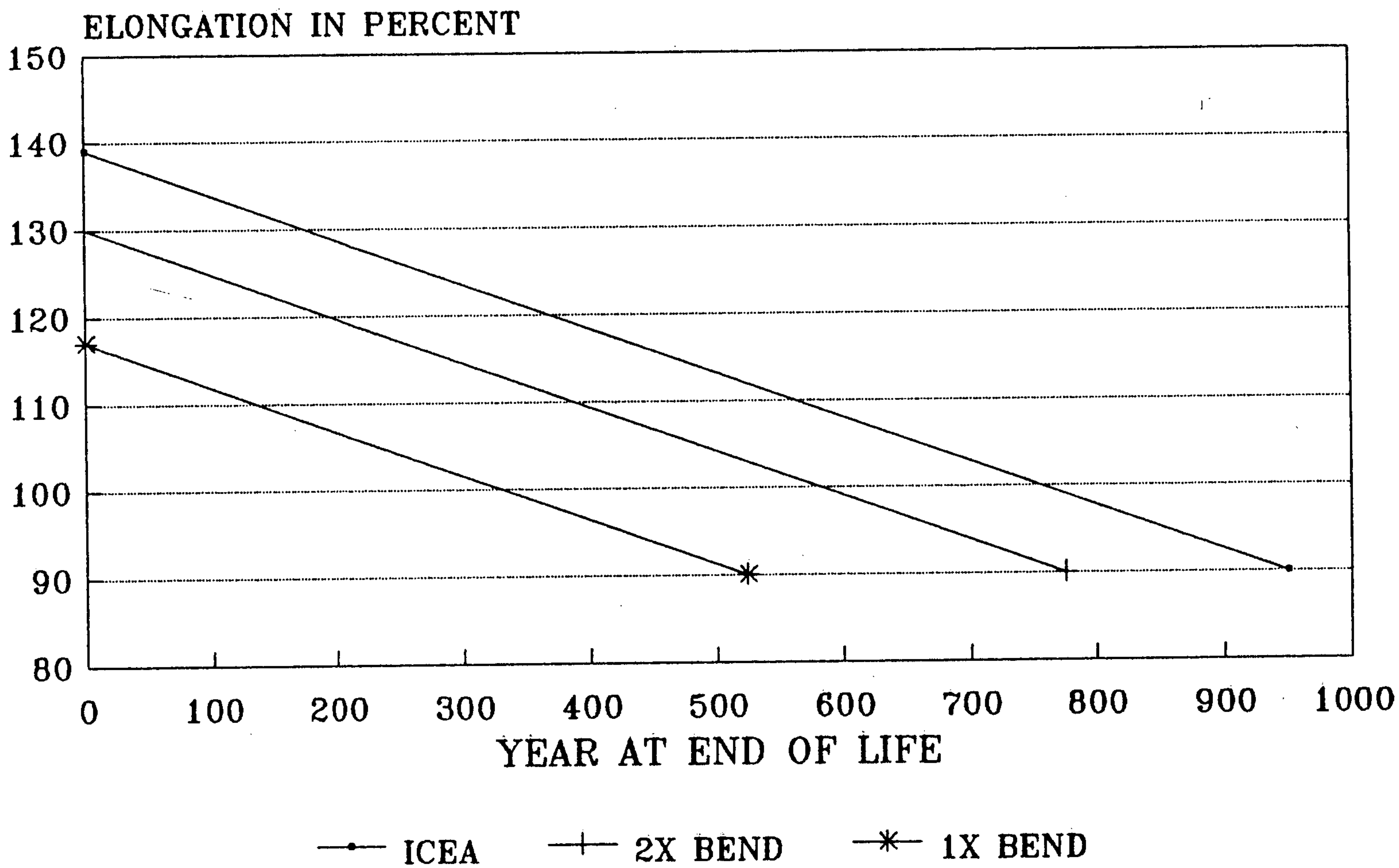
## CABLE BEND RADIUS GRAPHS

# FIGURE I
## TYPE II EPR POWER CABLE




150% x 60% RETAINED = 90% ELONGATION

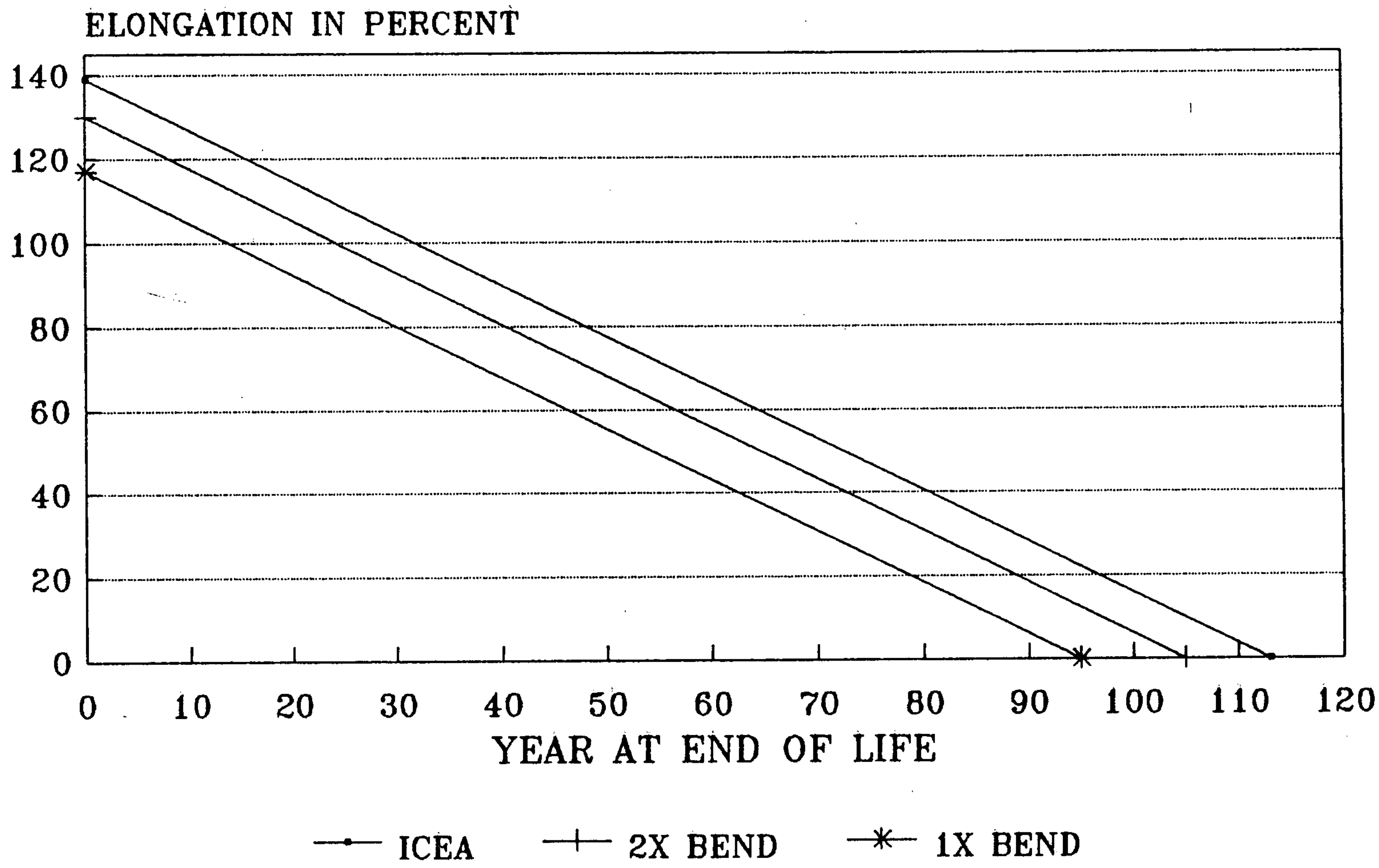
# FIGURE II
## EPR CONTROL CABLE




150% X 60% RETAINED = 90% ELONGATION

FIGURE III

TYPE II EPR POWER CABLE (NON-50.49)



ENCLOSURE 4

LIST OF COMMITMENTS

1. CABLE JAMMING

   - TVA will identify the population of cables most likely to have experienced jamming damage and rank according to SWBPs.

   - Perform examinations of the sample of cables in conduits selected to bound the issue. If these cables do not bound the worst-case-ranked conduits for jamming, then subsequent cables will be analyzed, inspected, reworked, or tested.

2. CABLE SUPPORT IN VERTICAL CONDUIT

   - TVA will revise the subject calculation to disallow credit for the horizontal contribution for cable support for power cables (V4/V5). Cables will be reanalyzed and/or reworked, as required.

3. CABLE PROXIMITY TO HOT PIPES

   - TVA will revise implementing documents to address pipes less than 2 inches in diameter.

4. CABLE TESTING

   - TVA will incorporate the requirement for using DC negative for high-potential testing into the test instruction.

5. CABLE BEND RADIUS

   - TVA will perform the corona and load cycle test on medium voltage cables.

   - TVA will perform the test described in Section 5 (Enclosure 1) on low-voltage multiconductor cables to verify lower bound.

   - TVA will present bend radius program to several cable manufacturers and document their technical comments.

6. SIDEWALL BEARING PRESSURE

   - TVA will calculate SWBPs for the additional sample identified and compare with the allowable limits.

   - TVA will provide a response to the issues in the WBN TER relative to the applicability of TVA's cable SWBP testing program to actual plant installation conditions.

   - TVA will revise Construction Specification G-38 to require closer engineering participation as expected SWBP approaches allowable limits.

ENCLOSURE 4

LIST OF COMMITMENTS

7. MIDROUTE FLEXIBLE CONDUIT

   ° TVA will document results of the cable test in addition to results of the U.C. inspection test to bound the program.

8. AMPACITY

   ° TVA will address this issue by implementing the appropriate recommendation as outlined in Enclosure 1 (Section 8).

9. CABLE INSTALLATION

   ° TVA to revise G-38 to include megger requirements for all future cable installations and more definitive requirements for cable lubricants.