TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

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DEC 20 1989

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of) Docket Nos. 50-390
Tennessee Valley Authority) 50-391

WATTS BAR NUCLEAR PLANT (WBN) UNITS 1 AND 2 - ELECTRICAL CABLE DAMAGE - ASSESSMENT AND RESOLUTION PLAN

Reference 1. Cable Issues Corrective Action Program (CAP) Plan, submitted to to NRC by TVA's letter dated June 27, 1989

Reference 2. WBN Units 1 and 2 - Damaged Electrical Cable in Conduit - Condition Adverse to Quality Report, WBRD-50-390/89-10 and WBRD-50-391/89-07 - 10 CFR 50.55(e) Final Report, submitted by TVA's letter dated December 20, 1989

During a November 17, 1989 meeting with NRC, TVA presented the resolution plan for the WBN cable damage issue. Enclosure 1 provides formal documentation of TVA's resolution plan for this issue. Implementation of this resolution plan, in conjunction with implementation of the Cable Issues CAP Plan, will provide reasonable assurance that the WBN safety-related cable systems will perform their intended safety functions. This resolution plan supersedes Section 4.1.6, "Cable Pullby," of the Cable Issues CAP; therefore, TVA is requesting that NRC consider the enclosed information in conjunction with their review of the Cable Issues CAP and address both in their safety evaluation.

Enclosure 2 identifies the commitment made in this submittal.

If there are any questions, please contact R. J. Stevens at (615) 365-8650.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

M. J. Ray

Manager, Nuclear Licensing
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Enclosures
cc: See page 2

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U.S. Nuclear Regulatory Commission

DEC 20 1989

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WATTS BAR NUCLEAR PLANT UNITS 1 AND 2

ELECTRICAL CABLE DAMAGE ASSESSMENT AND RESOLUTION PLAN

CONTENTS

ENCLOSURE 1

EXECUTIVE SUMMARY

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 and the potential for heat damage to cables. No heat damage was found; however, installation damage was noted. This damage resulted in the exposure of the conductors of five instrumentation cables in the Unit 2 Reactor Protection System. Laboratory analysis confirmed TVA's initial assessment that the damage occurred as a result of pullbys.

As stated above, TVA initially found damage to 5 instrumentation cables. During the scope assessment, TVA removed 358 cables comprising of approximately 45,000 feet in 37 conduits. Subsequently, an evaluation methodology was developed and implemented to categorize the potential for pullby damage into low, moderate, and high-risk categories. This methodology considers key parameters such as raceway size, fill, length, cable type, and an assumed configuration. Also, this methodology will ensure that worst-case pullby configurations are considered in selection of conduits for cable replacement.

Cables in the low-risk category are accepted "as is" based on the fact that installation forces would not have exceeded the allowable values during a pullby operation. Cables categorized as moderate-risk will be further evaluated based on consideration of as-built parameters. If installation forces experienced during a pullby are less than allowable forces, the cables are accepted "as is." Otherwise, they will be replaced. Cables categorized as high-risk will be replaced if a pullby is confirmed to have occurred.

Nonpullby jacket damage to coaxial cables was identified during the scope assessment effort. Corrective actions have been identified which will result in the replacement of safety-related, single-jacketed, coaxial cable in a harsh environment, consistent with WBN's commitments to Regulatory Guide (RG) 1.97 and 10 CFR 50.49 requirements, where the coaxial cable (coax) jacket is required to function as a moisture barrier.

For both pullby damage and coaxial cable damage, recurrence control measures have been identified and will be implemented to ensure the adequacy of future installations. Cable replacements will be performed consistent with these recurrence control measures, as well as other applicable design requirements (e.g., cable splicing, cable bend radius, etc).

TVA will implement a comprehensive program to ensure the adequacy of the safety-related cable systems. This program will be completed by fuel load for Units 1 and 2, respectively. These actions, when coupled with the Corrective Action Program (CAP) Plan for Cable Issues and other cable system evaluations and modifications (ampacity, voltage drop, Appendix R, environmental qualifications, etc.), will ensure that the WBN safety-related cable systems will perform their intended safety functions.

1.0 BACKGROUND

As a part of the Employee Concerns Special Program at WBN, subcategory report 15100, dealing with damage occurring during construction, was written. Within this report, an allegation of heat damage to electrical cables during welding activities (subsequent to cable installation) on Unit 2 conduit 2PM6474D and its support, was addressed. An inspection of the conduit in question revealed discolorations of the metal, which may have been the result of welding activities. Conduit 2PM6474D contained reactor protection system cables that provide inputs from the main steam, feedwater, turbine controls, safety injection, and reactor coolant systems.

The corrective action plan developed for this concern was to pull back the cables and perform a visual inspection. Approximately 12,000 feet of cable were removed. This activity was performed in accordance with General Construction Specification G-38, "Installing Insulated Cables Rated for Up to 15,000 Volts."

2.0 INSPECTION RESULTS

The above cables were subjected to a hand-over-hand inspection by TVA's Nuclear Engineering (NE), Nuclear Construction (NC), and Quality Control (QC) personnel. No evidence of heat damage was noted.

However, installation damage was observed. Five cables were damaged such that their copper conductors were exposed. A review of the cables and raceways revealed that the damage had occurred in three raceways, 2PM6470D, 2PM6473D, and 2PM6474D.

In addition to the exposed conductors, several other observations were made:

1. In conduit 2PS702D, one abandoned 15-foot segment of cable was found. Close inspection indicated that this cable may have been broken during installation.

2. A segment of braided pull rope was found in conduit 2PM6473D.

3. Woven nylon cord ("parachute cord") was found in conduit 2PM6474D.

4. A one-half inch diameter concrete expansion anchor was found in conduit 2PM6399D.

Condition Adverse to Quality Report (CAQR) WBP 890331 was prepared to document the discovery of the subject damage. Visual inspection of the damaged areas resulted in a consensus that cable "pullbys" had been the initiating damage mechanism. (A pullby occurs when cables are pulled into a conduit which is already occupied.) However, the presence of the raceway "debris" noted above, in conjunction with the fact that this review was initiated by an employee concern, resulted in TVA's determination to perform further detailed analysis prior to assigning a root cause damage mechanism.

3.0 EMPLOYEE CONCERNS REVIEW

In recognition of the numerous allegations related to its cable pulling activities, WBN performed a thorough review of its Employee Concerns Program (ECP) files to ascertain if any installation concerns had been expressed in reference to the conduit discussed in Section 1.0 above. ECP Report ECP-89-WB-441-01 was generated to document this review. Although the ECP review did not identify any allegations relative to these specific conduits, it did note that concerns had been filed related to suspect work practices by certain crews and QC personnel. Pull records revealed that several of those personnel were involved in installation of the subject cables.

4.0 ROOT CAUSE MECHANISM DETERMINATION

Since preliminary analysis showed that the damage could have been the result of either the practice of pullbys or poor workmanship, TVA performed a detailed evaluation of the root cause mechanism.

As a part of this effort, detailed walkdowns of the subject conduits were performed and isometrics were prepared. In addition, a thorough review of the cable pull records was performed to assess how the cables were grouped as they were pulled and the sequence of those pulls. From this, it was determined that as many as 12 pulls (i.e., 11 pullbys) may have occurred in those conduits containing damage. Compilation of the above data permitted calculation of the pull tensions and sidewall bearing pressures which may have been encountered during cable installation.

These calculations revealed that excessive tensions and sidewall bearing pressures were generated in raceways 2PM6470D, 2PM6473D, and 2PM6474D during one of the pullbys. Calculated forces were of sufficient magnitude to cause the pullby damage observed. In addition, review of the pull sequence data showed that the cables that suffered damage were installed prior to the difficult pullby. This is consistent with the way pullby damage is expected to occur, that is, resident cables are cut during subsequent pulls.

In order to further evaluate this data, overlays of the cable damage locations were prepared for each conduit segment isometric. The exposed conductors were found to have been located at bends in the raceway system. This again is consistent with the pullby damage mechanism.

In parallel with this effort, the Electrical Insulation Research Center at the University of Connecticut (UCONN) was utilized to independently identify the likely damage mechanism(s) and to confirm that the damage was not caused by the removal process.

4.0 ROOT CAUSE MECHANISM DETERMINATION (Continued)

UCONN's report concludes that the damage was the result of the cable pullby process and most likely produced by the cutting action of the "parachute cord." A copy of the report is provided as Attachment 1.

These analytical, visual, and laboratory investigations confirm that the root cause mechanism was cable pullbys.

5.0 SCOPE ASSESSMENT

Having determined that the root cause mechanism for the damage observed on Unit 2 was pullbys and knowing that pullbys did occur, TVA concluded that the potential for cable damage existed wherever a difficult pullby occurred. Furthermore, if suspect work practices contributed to the cable installation damage, the impact of these suspect work practices would have been greater during pullbys, in that pullbys are typically more difficult to perform than the original cable installation.

In order to determine the scope of the cable damage, TVA selected a number of other conduits in which pullbys were known to have occurred and removed the cables for inspection. In this manner, it could be determined if such damage was widespread where pullbys occurred or isolated to the Unit 2 conduit. Conduits selected for this assessment were chosen from those voltage levels in which pullbys occurred with some frequency (WBN voltage levels V1-V4*), with the following considerations:

1. Unit 1 conduits equivalent to the Unit 2 conduits in which the original damage was found were included. This run was comprised of 14 conduit segments.

2. There were 4 conduits selected from the WBN calculation used as a part of the Cable Issues Corrective Action Program to identify the worst-case pullby installations.

3. Conduit configurations may become more complex with length, and the difficulty of performing a successful pullby increases significantly with fill. Therefore, 10 conduits were selected following a sort of the WBN Computerized Cable Routing System (CCRS) for high fill, long length, and subsequent confirmation that significant pullby activity had occurred.

A total of 28 conduits was selected. The cables were carefully removed in accordance with plant procedures, with close participation by NE, NC, and QC personnel. A total of 358 cables were removed, comprising approximately 33,500 feet.

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*Voltage levels are defined in the Section 13.0. Medium voltage cables (V5) are discussed separately in Section 7.0.

5.0 SCOPE ASSESSMENT (Continued)

Significant damage was identified only in conduit MC400B. The damage consisted of the exposure of the conductors of 1M2451B and a reduced insulation wall thickness on 1M2450B. CAQR WBP 890492 was issued to document this finding.

While onsite inspection of 1M2451B and 1M2450B indicated that the pullby process was the root cause damage mechanism, it was again decided to confirm this hypothesis at UCONN. The cables from MC400B were sent to UCONN and subjected to the same tests as were performed on the Unit 2 cables. The damage mechanism was determined to be pullbys.

Aside from the damage described above and the jacket damage to two coaxial cables (as described below), all other findings were regarded as nonsignificant. Specific nonsignificant observations are shown in Table I.

6.0 INSPECTION RESULTS - COAXIAL CABLE

Two of the conduits selected for removal as a part of the scope assessment process contained a total of nine coaxial cables in Class 1E service. Nicks and scrapes to their jackets were observed; however, no evidence of pullby damage was noted. The jackets of certain coaxial cables provide a moisture barrier function; therefore, those with nicks and scrapes were submitted to UCONN for analysis.

This analysis confirmed that the nicks and scrapes were not related to pullbys but rather were typical of the normal rigors of installation. Two of the cables, 1RM448B and 1RM450B, had nicks that reduced the remaining intact jacket wall to less than the required 80 percent of nominal thickness. The damage was also addressed in CAQR WBP 890492.

WBN's corrective action plan for these cables is provided in Section 10.0.

7.0 MEDIUM VOLTAGE (V5) CABLE ANALYSIS

A review of installation records was performed for all medium voltage cables routed in safety-related raceways and required for Unit 1 operation. The purpose of this review was to confirm the absence of pullbys or the performance of satisfactory post-pullby high potential tests on all active cables, such that these large critical cables could be decoupled from the pullby analysis described in Section 8.0.

The results of this review and a description of the actions to be implemented by WBN are given in Section 11.0.

8.0 RESOLUTION PLAN - PULLBYS

The results of the scope assessment investigations, coupled with the initial (Unit 2) analysis, revealed that pullby damage, while not widespread, was also not isolated to that first group of conduits (i.e., 2PM6470D, 2PM6473D, and 2PM6474D).

Though suspect crews were involved in a number of the conduits examined, no systematic evidence of damage as the result of poor workmanship was noted. In the conduit containing the additional damage (MC400B), only one cable, out of a total of 29, was installed by a suspect crew. There were 21 cables installed subsequent to those that were damaged and before the one installed by the suspect crew. As a result, TVA concluded that suspect work practices did not contribute to the pullby damage.

Results of the investigations showed that where configurations involving pullbys became severe (i.e., high fill, long length) and where multiple pullbys or large pullbys occurred, likelihood for damage significantly increased. TVA evaluated the available data to develop an appropriate corrective action program. TVA obtained assistance in assessing this data from the consulting engineering firm of Pickard, Lowe, and Garrick (PL&G).

In order to determine which additional conduits had the potential for containing damage as a result of pullbys, TVA considered the following significant parameters:

1. Length - As conduit length increases, the likelihood for configuration complexity increases.

2. Percent fill - TVA and the industry have recognized that both pullby difficulty and likelihood for damage during the pullby operation increase significantly with fill. In addition, highly filled conduits are more likely to have experienced large pullbys than are raceways with fewer cables.

3. Raceway size - Conduit bend radius values directly impact both pull tension and sidewall bearing pressure.

4. Cable construction - Each voltage level consists of cables with somewhat unique materials, construction, and limitations.

In order to evaluate the influence of each of these parameters, TVA developed pullcharts, with conservative assumptions, to solve for sidewall bearing pressure (SWBP). Separate pullcharts were developed for voltage levels V1/V2, V3, V4, and for various ranges of fill.

8.0 RESOLUTION PLAN - PULLBYS (Continued)

Pullcharts, expressed in terms of allowable length, are commonly used throughout the industry as a guide for the cable installation process. Efforts are currently underway within the Institute of Electrical and Electronic Engineers (IEEE) to develop such charts for industry-wide usage. In addition, such charts served as the basis for resolution of the silicone rubber cable issue at WBN.

By solving the equations for sidewall bearing pressure during pullbys, the relative forces experienced by the subject cables became more readily apparent. Table II presents an example of such a chart prepared for voltage level 3 cables at a 40 percent fill.

These charts have been developed with the following conservative assumptions:

1. Pullbys have always occurred.

2. Those pullbys have been substantial in size; as much as half of the final fill weight is assumed to have been involved in a pullby in small conduits with the proportion decreasing to 20 percent for 5-inch raceways.

3. For each voltage level, a "typical" cable construction has been utilized in assessing the total weight under maximum permissible fill conditions. For example in voltage level 2, a TVA mark letter WVA has been used (2/C 16 AWG, twisted shielded pair, 0.345" OD and 0.07 pounds per foot [lbs/ft]).

4. A total of 366 degrees of bends distributed between pullpoints.*

5. The expected sidewall bearing pressures have been calculated for various ranges of conduit lengths. Within each range, the maximum footage has been utilized in the calculation. Conduit segment lengths have been determined using data from the CCRS. These footages have been shown by experience to be conservative.

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* Conduit 2PS702D was the only one of the 37 conduits examined that exceeded the assumed degrees of bend, having a total of 504 degrees of bend. A detailed evaluation of this 30 percent filled, 26-foot, 1.5-inch diameter, V2 conduit reveals that the methodology herein would have accurately categorized the conduit in spite of the excessive degrees of bend. This is reflective of the conservatism in the process as a whole. For this size and length conduit, the process employed would predict a sidewall bearing pressure of less than 500 lbs/ft. Calculations based on the actual configuration and pull sequence estimated the sidewall bearing pressure to have been 266 lbs/ft for the worst-case direction pull. Both values are at or below the maximum allowable 500 lbs/ft. As expected, no pullby damage was observed in this conduit.

8.0 RESOLUTION PLAN - PULLBYS (Continued)

6. A coefficient of friction of 0.75 was utilized in evaluating all 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 overfilled conduits or pulling into conduits where the pullby results in a substantial overfill.

Use of this methodology (i.e., solving for sidewall bearing pressure) allows the forces encountered during installation to be mapped across the various combinations of raceway size, fill, raceway length, and cable type. Following development of these charts, a review was performed of available data to assess a cable's response to these various forces. This data was obtained from a variety of sources such as standards, specifications, and tests. (See Section 12.0 for a list of the pertinent references.)

This review led to the identification of three levels of potential for pullby damage categorized as low, moderate, and high-risk.

The low-risk category consisted of those combinations of parameters which yielded expected sidewall bearing pressures which were less than or equal to values currently specified by TVA's General Construction Specification G-38, "Installing Insulated Cables Rated Up to 15,000 Volts." Cables removed during the pullby investigations from conduits in this classification displayed no evidence of pullby damage.

The moderate-risk category was defined as that grouping which contained raceways in which the projected sidewall bearing pressures under the assumed conditions may have exceeded TVA's permissible values.

The high-risk category was defined as that family in which damage could be expected to be found with considerable frequency as a result of the severity of the assumed configuration and installation.

The validity of such groupings was further supported by the analysis performed by PL&G.* The results of their analysis are provided as Attachment 2.

Finally, Table III provides an overview of the results of evaluating each of the 37 conduits from which cables were removed. As was noted earlier, four conduits (2PM6470D, 2PM6473D, 2PM6474D, and MC400B) contained pullby damage. All four of these conduits were in the moderate- or high-risk category. No pullby damage was observed to cables in the low-risk group.

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*The PL&G evaluation categorized as low-risk, subgroup I in voltage level 4 (1000-1500 lbs/ft sidewall bearing pressure). TVA's specification allowable is 1000 lbs/ft. Therefore, TVA is conservatively assessing the subgroup with the moderate-risk category.

8.0 RESOLUTION PLAN - PULLBYS (Continued)

Objective evidence has been provided to demonstrate that the root cause mechanism is clearly understood, that a means exists to establish broad groupings in which the potential for pullby damage may reasonably be said not to exist (low), and that the potential for such damage exists under the assumed conditions (moderate or high).

9.0 CORRECTIVE ACTION PLAN - PULLBYS

Conduits containing class 1E cables required for Unit 1 operation have been categorized utilizing the methodology described above. In the low-risk category, no action is required. The cables are accepted "as is" based on the fact that no excessive installation forces would have been encountered during a pullby operation. The categorization process ensures that the conduits in this category are "benign" as a result of their relatively short length or are of such a low fill that any pullbys which may have occurred were made into essentially empty conduits. The evidence accumulated during the pullback process supports this decision (i.e., no pullby damage was observed in conduits which were classified as low-risk).

In the moderate category, pull records will be reviewed to confirm the presence of pullby activity. If no pullbys occurred, the subject cables will be accepted "as is." If a pullby occurred and the conduit is overfilled, then the subject cables will be replaced. If the conduit is not overfilled and a pullby occurred, a walkdown will be performed to determine the presence and location of midrun pullpoints. (As was noted earlier, the initial classification process assumes the absence of any intermediate pullpoints.) If intermediate pullpoints do exist, the length of the individual segments will be determined and those segments will be recategorized. If any one of those segments remains in the moderate category, then the cables will be replaced. Pull records for recategorized conduit will be reviewed to confirm that the largest pullby did not exceed sidewall bearing pressure limitations. If sidewall bearing pressure limitations were exceeded, the cables will be replaced. If not exceeded, that conduit (and its cables) will be accepted "as is."

In the high-risk category, pull records will be reviewed. If no pullby occurred, then the subject cables will be accepted "as is." If a pullby occurred, then the cables will be replaced.

Since the root cause mechanism has been confirmed to be pullbys, the root cause has been determined to be the lack of guidance in engineering procedures for pullbys, which allowed cables to be installed with excessive pull tension and cable sidewall bearing pressure. Recurrence control has been implemented in the form of an Electrical Engineering Procedure Method. This document requires the consideration of pullby effects in design activities. A revision has been made to the General Construction Specification G-38 to detail requirements for performing pullbys. The corresponding construction procedures will also be revised.

10.0 CORRECTIVE ACTION PLAN - COAX

As a result of the discovery of nonpullby jacket damage to coaxial cables, which reduced the intact wall thickness to less than that required by the manufacturer, WBN will undertake a replacement program.

The scope of this effort will include single-jacketed coax in a harsh environment, consistent with WBN's commitments to RG 1.97 and 10 CFR 50.49 requirements, for which the outer jacket of the cable serves as the jacket of the coax (and therefore is a moisture barrier). Other coaxial cables which are constructed such that the outer jacket is distinct from the coax jacket will be accepted "as-is."

A total of 24 cables required for the operation of Unit 1 will be replaced according to this criteria. The replacement cables will be of double-jacketed construction, permitting the outer sheath to absorb the normal rigors of installation and the inner jacket to provide the necessary moisture barrier function.

Recurrence control procedures are being implemented to ensure that future installations that are dependent upon the coax jacket functioning as a moisture barrier will be double-jacketed.

11.0 MEDIUM VOLTAGE CABLE ANALYSIS RESULTS

Installation records were reviewed for 77 medium voltage cables routed in safety-related raceways and required to support Unit 1 operation.

There were 17 conduits identified as having experienced pullbys. Of the 17, 16 involved a pullby of an active cable over an abandoned cable which it was replacing. In accordance with plant procedures, these active cables were subjected to high-potential (hi-pot) withstand tests following installation to confirm their integrity. The stationary cables during the pullby were confirmed to be abandoned, and therefore, of no concern.

In the case of the final conduit, records indicate that the 2 cables were pulled five days apart. Hi-pot withstand tests were not performed on either cable until after the final pull. Therefore, the integrity of both cables has been demonstrated subsequent to the pullby.

In the course of this review, it was determined that 7 post-installation hi-pot records could not be retrieved. Though these cables were not involved in pullby operations, WBN has decided to repeat the tests at IEEE 400 maintenance levels in order to complete these records. These tests will be performed prior to Unit 1 fuel load.

12.0 SIDEWALL BEARING PRESSURE DATA REFERENCES

1. EPRI Report EL-3333, Maximum Safe Pulling Lengths for Solid Dielectric Insulated Cables, Research Project 1519-1, February 1984.

2. "Committee Report - Recommended Practice on Specific Aspects of Cable Installation in Power-Generating Stations," prepared by Task Force 14-1, "Station Cable Installation," Insulated Conductors Committee.

3. Cable Sidewall Bearing Pressure Tests - Tennessee Valley Authority, Division of Operations Support, Central Laboratories Services Branch, May 1986.

4. Brand-Rex Company Final Test Report No. 684, Instrumentation Cables, Maximum Sidewall Bearing Pressure, May 1985.

5. TVA Division of Nuclear Engineering, "General Construction Specification, G-38, Installing Insulated Cables Rated Up To 15,000 Volts," Revision 8, including SRNs through October 1989.

6. IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations, IEEE 690-1984.

13.0 VOLTAGE LEVEL DEFINITIONS

At Watts Bar, cable systems are divided into five categories dependent upon the voltage level of the electrical system and the nature of the service provided by the end device. Cable systems are designated as V1, V2, V3, V4 and V5. The following is a brief description of these cable designations:

V5 - This category consists of shielded cables rated 8kVAC that provide power at 6900 VAC to boards and large motors.

V4 - This category consists of cables rated at 600 VAC that provide low voltage power at service voltages from 277 to 480 VAC. In addition, heavily loaded control power and direct current power cables are designated as V4 regardless of their service voltage. These cables are not shielded.

V3 - This category consists of cables rated 600 VAC in control or control power applications with service voltages of 277 VAC/VDC or less. These cables are not shielded.

V2 - This category is comprised predominantly 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 VAC.

V1 - This category is comprised of shielded cables predominantly rated 300 VAC in low-level instrumentation applications such as thermocouples, strain gauges, thermal converters, and RTDs that are 100 mV and less.

TABLE I

CABLE INSPECTION RESULTS
(EXCLUDING SIGNIFICANT PULLBY DAMAGE)

Results	Unit 2	Unit 1 Assessment
° Shield/Assembly Wrap	5	3
° Cut/Scrape to Jacket	30	19*
° Bulge/Kink, etc.	13	2

A cable may appear in multiple categories.

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*Jacket damage to two coax cables was determined to be significant.

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TABLE II

TYPICAL EXAMPLE OF PULLCHART FOR
SIDEWALL BEARING PRESSURE DURING PULLBY
(lbs/ft)

Voltage Level 3 40 Percent Fill

Conduit Length (ft)

CONDUIT SIZE (inches)	0 - 10	11 - 25	26 - 50	51 - 75	76 - 100	> 100
0.75	88	221	442	664	885	1327
1.00	104	259	519	778	1038	1557
1.50	113	283	566	849	1132	1698
2.00	128	320	641	961	1282	1923
2.50	166	415	830	1244	1659	2489
3.00	213	532	1065	1597	2130	3194
4.00	238	595	1190	1785	2380	3570
5.00	243	606	1213	1819	2426	3639

TABLE III

CONDUIT REMOVAL RESULTS

Category			Removed	Failures
LOW	V1/V2	(A)	5	0
		(B)	3	0
	V3/V4	(G)	0	0
		(H)	1	0
MODERATE	V1/V2	(C)	9	1
		(D)	7	1
	V3	(I)	2	0
	V4	(I)	1	0
		(J)	0	0
HIGH	V1/V2	(E)	1	0
		(F)	2	1
	V3	(J)	0	0
		(K)	6	1
	V4	(K)	0	0

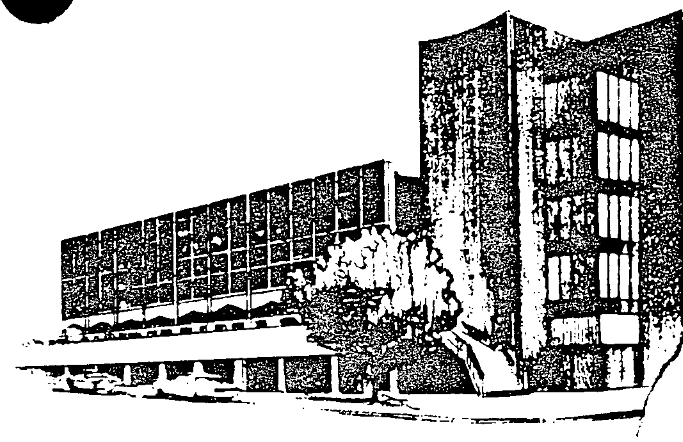
ATTACHMENT 1

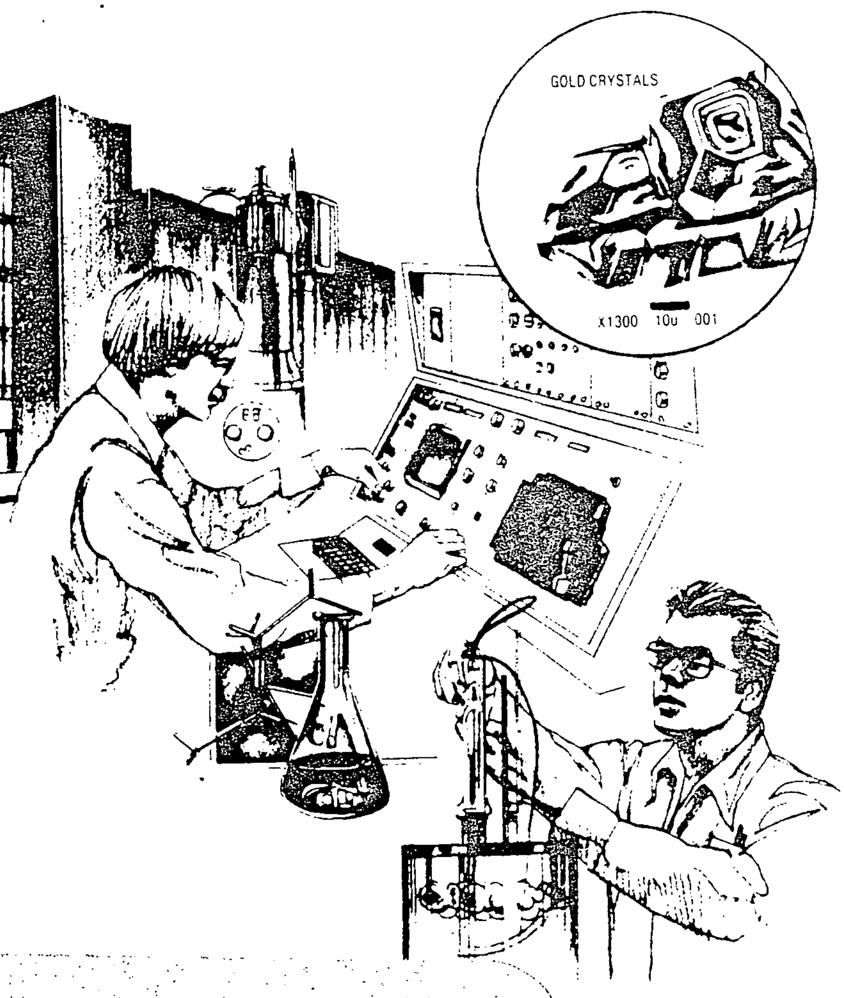
University of Connecticut

Analysis of Damage to Instrumentation Cables

Removed from

Watts Bar Nuclear Plant





IMS

Institute of Materials Science

University of Connecticut