Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381

DEC 06 1994

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 - USE OF DOW CORNING RTV-3140 AS A REPAIR METHOD FOR KAPTON INSULATION DAMAGE

The purpose of this letter is to provide NRC with TVA's technical basis for use of Dow Corning RTV-3140 in the repair of Kapton insulation damage. This basis is provided in Enclosure 1 and was discussed with NRC staff during the NRC/TVA meeting held on November 3, 1994, in Rockville, Maryland. Enclosure 2 provides the list of commitments made in this letter.

Although TVA has deemed the use of Dow Corning 3140 RTV as acceptable, TVA will perform testing at their Central Laboratory facility to confirm the capability of this material to perform as a viable repair method for non 10 CFR 50.49 pigails. These tests will include wet electical testing after exposure to thermal cycling, thermal aging, and radiation. TVA will provide the results of these tests to the NRC by mid - February 1995.

If you should have any questions, contact P. L. Pace at (615)-365-1824.

Sincerely,

Dwight E. Nunn
Vice President
New Plant Completion
Watts Bar Nuclear Plant

Enclosure
cc: See page 2

IE01

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ENCLOSURE 1

BACKGROUND - CONAX PIGTAIL DESIGN

The Watts Bar containment electrical penetrations are of a modular design supplied by the Conax Buffalo Corporation of Buffalo, New York. The modules are comprised of polyimide film insulated solid copper conductors which are encapsulated with a polysulfone seal. The polyimide film is commonly known by its DuPont trade name "Kapton." The material is flame resistant and radiation resistant and is suitable for use in high temperature environments. Unlike many other organic insulations, Kapton does not relax appreciably under compression, making it useful for penetration seals using a swaged mechanical seal system.

Since Kapton cannot be extruded, it is produced as a film and applied to the solid pigtail conductors in opposing spiral wraps, each having a 50% overlap. A fluorinated ethylene propylene (FEP) Teflon bonding agent is applied between the layers of Kapton and the composite is then sintered at elevated temperature to provide a continuous dielectric. Conductors smaller than #2 AWG are insulated with two layers of a Kapton tape (designated by Conax as the "A" tape). That tape is 1 mil thick with 0.5 mils of FEP Teflon on either side. Larger conductors have a single layer of a "B" tape (2 mils of Kapton with 0.5 mils of FEP Teflon on either side) covered with a single layer of the "A" tape. (Reference 7)

The pigtails, 3 to 6 feet long, are spliced to the TVA field cables in troughs or trays at the outboard end of the feedthroughs and in a box on the inboard side. As a result of numerous reports of damage to the Kapton in the field during the 1980s, Conax added a protective oversleeve of polyolefin as a recurrence control measure. The protective polyolefin oversleeve was not installed at WBN.

SIGNIFICANCE OF DAMAGE

The extent of the damage at WBN consists of nicks, cuts, scratches, abrasions, tool marks, and localized discoloration. In some cases, the underlying copper conductor has been exposed. The majority of the damage found to date is on the outboard side which is believed to be the result of the high degree of traffic associated with the outboard side of the penetrations and the use of the split socket wrench on the outboard side only to tighten the feedthrough seal. The relatively low number of damaged areas identified on the inboard side is attributed to the location, which is not in a high traffic area, and installation of the feedthrough module with the split socket wrench is performed from the outboard side.

Table 1 and the subsequent sections identify the environments in which the subject damages are located, the failure mechanisms of the Kapton system, and the significance of the damages within the subject environments considering those mechanisms.

TABLE 1 ENVIRONMENTS AT THE DAMAGE LOCATIONS		
ATTRIBUTE	INSIDE CONTAINMENT (IC)	OUTSIDE CONTAINMENT (OC)
Normal Temperature	120°F	111°F
Accident Temperature	327°F HELB, 235°F LOCA	136.2°F
Accident Spray	borated	none
40 Year Radiation	2.0E7 Rads	1.0E6 Rads
Accident Radiation	2.4E7 Rads (Gamma), 3.3E8 Rads (Beta)	9.1E6 Rads
Maximum Relative Humidity (IC)/Maximum Abnormal Relative Humidity (OC)	100%	90%

FAILURE MECHANISMS OF THE KAPTON INSULATION SYSTEM

A review of the literature regarding the performance of Kapton insulation indicates that the potential causes of failure may be divided into two broad categories: mechanical and environmental.

Mechanically Induced

The excellent electrical and physical properties of the Kapton insulation system have permitted its application at thicknesses substantially below that typically required for extruded organics. The reduced wall thickness results in a potential susceptibility to certain types of mechanical damage (nicks, abrasion, gouges) as has been documented in References 1 and 2.

Environmentally Induced

Environmentally induced damage to the insulation system may result from the following:

Hydrolysis

Deterioration of the Kapton film may occur when the film is subjected to an aqueous media (of any pH). Hydrolysis results in chain scission of the polymer which may lead to cracking and flaking. This in turn could lead to

shorting or low insulation resistance in the presence of water. (Reference 1)

Caustic Spray

DuPont literature also notes that Kapton may be hydrolyzed as the result of the exposure to caustic sprays of particularly high pH. As noted above, the hydrolysis results in degradation by chain scission. (Reference 6)

Radiation

In addition, research has shown that the presence of the Teflon adhesive between the layers of Kapton makes the system susceptible to degradation from exposure to high radiation. Under such exposure, chain scission of the Teflon occurs resulting in possible adhesive failure and thus potential unwrapping of the tape and potentially low insulation resistance if wetted. Reference 1 notes that such unwrapping has not been noted in any of the Conax testing. The Kapton film itself has very high radiation endurance and for the areas of application, no failure mechanism exists.

Like Kapton, Teflon exhibits excellent thermal and flame resistance.

CONCLUSIONS

The Kapton insulated pigtails as supplied by Conax are qualified for their installed environment. Documentation to support qualification is included as part of the Watts Bar Environmental Qualification Program.

Inside Containment:

For those Kapton insulated 10CFR50.49 circuits located inside containment, the environment is considered "harsh" and qualified repairs must be installed in accordance with Conax's approved procedures (using Raychem tubing) or qualified Site Engineering approved repair methods. Prior to implementing, additional repair methods must be evaluated and qualification documented in the appropriate Environmental Qualification Binder. The repair methodology selected for these cables must meet regulatory requirements for tests and documentation.

For Kapton insulated non-10CFR50.49 circuits, given the postulated failure mechanisms and the normal containment environment described above, it is concluded that no potential failure mechanism exists that represents a challenge to the Kapton or Teflon. Thus, conventional "industrial" repairs may be effected provided that the repair 1) can be shown to be suitable for the normal containment environment, 2) provides sufficient adherence to the Kapton/Teflon, 3) provides adequate dielectric strength, and 4) does no harm to the penetration's polysulfone seal.

Outside Containment:

For those circuits located outside containment, given the postulated environment failure mechanisms and the annulus normal and accident environment described above, it is concluded that no potential failure mechanism exists that represents a challenge to the Kapton or Teflon. For Kapton insulated 10CFR50.49 circuits, the annulus environment is considered

"radiation harsh" and qualified repairs must be in accordance with Conax's approved procedures (using Raychem tubing) or with other qualified Site Engineering approved methods. Prior to implementing, additional repair methods must be evaluated and qualification documented in the appropriate Environmental Qualification Binder. Even though conventional "industrial" repairs can be shown to be suitable for the annulus environment, TVA intends to perform repairs on 10CFR50.49 circuits per previously mentioned Conax approved procedures.

However, for the non-10CFR50.49 circuits, conventional "industrial" repairs may be applied, provided that the repair 1) can be shown to be suitable for the annulus environment, 2) provides sufficient adherence to the Kapton/ Teflon, 3) provides adequate dielectric strength, and 4) does no harm to the penetration's polysulfone seal. The repair methodology selected for 10CFR50.49 cables must meet the requirements of that regulation for tests and documentation.

REPAIR OPTIONS

Repairs to 10CFR50.49 circuits, in both inboard and outboard locations, will be performed in accordance with approved Conax procedures (Raychem tubing) or other qualified Site Engineering approved repair methods. Prior to implementing, additional repair methods must be evaluated and qualification documented in the appropriate Environmental Qualification Binder. Damage to non-10CFR50.49 circuits that are away from the polysulfone seals may be repaired using techniques that are suitable for the environment and application. These repair techniques include Raychem tubing and tape. Repairs to non-10CFR50.49 circuits that are within two inches of the polysulfone seal may be accomplished using Dow Corning 3140 RTV as described in the section below.

Dow Corning 3140 RTV

Description:

The conformal coating is Dow Corning 3140 RTV. This product is a clear, flowable, silicone elastomer protective coating. The manufacturer states the useful temperature range is -65°C to 250°C. The manufacturer rates the coating material as having a dielectric strength of 500 volts/mil. The manufacturer states that the material is still useful after exposure to 1.0 E 8 megarads. (Reference 5)

Material Qualification:

The coating has been tested by Wyle Laboratories (Report 17733-1, as documented in Reference 3) to simulated LOCA conditions including pretest conditioning to 2.432 E 8 rads (Gamma) radiation and thermal aging equivalent to forty years at 49°C followed by exposure to 342°F steam temperature. The test specimens were GE CR151B terminal blocks connected via terminal lugs to Tefzel insulated wire. The terminal blocks, lugs, and Tefzel wire were coated with Dow Corning 3140 protective coating.

Dielectric Strength:

The temperature and voltage rating of materials used in non-10CFR50.49 applications is governed by the manufacturer's rating. The viscosity and self-leveling properties of the material ensures that greater than 1 mil of cured thickness is achieved. The cured thickness ensures the dielectric strength and temperature rating envelopes the 90°C temperature requirement for 480 Volt power applications.

Limitations:

The application is limited to non-10CFR50.49 applications of 480 volt and below. The material can only be used within two inches of the feedthrough module where access is limited. Installation of the material in this area precludes external disturbances. The limited flexibility of the pigtails at this point ensures the material's capability to adhere. This product is classified as USE CODE III as defined by the Watts Bar Chemical Traffic Control Procedure and must be handled accordingly.

Application Method:

The product is a flowable self-leveling liquid that may be applied by brush or other suitable means. The product cures at room temperature, which precludes the use of heat or other type of activators. The Dow Corning 3140 RTV must be applied as one liberal coating 360° around the conductor which extends one inch beyond the damaged area onto the non-damaged Kapton or up to the polysulfone seal if the damage is closer than one inch. The process of applying Dow Corning 3140 is governed by General Engineering Specification G-38, "Installation, Modification, Maintenance of Insulated Cables Rated up to 15,000 Volts," and Modification and Addition Instruction (MAI)-3.3, "Terminating, Splicing, and Testing of Insulated Cables Rated up to 15,000 Volts."

Accessibility:

Due to viscosity of the product it can be applied in areas of limited access.

Adhesion:

Although specific data is not available to address the coating's compatibility with Kapton or FEP Teflon, it is recognized that 3M Kapton and Teflon pressure sensitive tapes use silicone based adhesives. Dow Corning 3140 RTV is also a silicone based adhesive giving credibility to material's capability to adhere to Kapton and Teflon. The referenced Wyle qualification tests also demonstrated the material's compatibility with the fluoropolymer Tefzel, which is similar in molecular structure to Teflon. Additionally, the Wyle report demonstrated the material's ability to adhere to metallic components. Based on the similarity of the Teflon and Tefzel materials, the use of silicone based adhesives by other manufacturers on Kapton and Teflon products, the demonstrated ability to adhere to metallic materials, and the requirement to encapsulate the area (360°), it is concluded that adequate adhesion will be accomplished.

Effects on Polysulfone:

There is no known component in the Dow Corning 3140 RTV coating that will adversely affect the polysulfone sealant. (Reference 4)

Flammability:

Dow Corning 3140 RTV does not have a specific UL rating. The quantity of the material applied to the Kapton insulated conductor is minimal. The entire repair encapsulates the damage for a distance of approximately one inch on both sides of the damaged area and is a few mils thick. The repaired areas are covered by a split unshrunk polyolefin tubing supplied by Conax which is secured by tie wraps. The Class 1E penetration pigtails (including repairs) are then either enclosed in a junction box or covered on the top and two sides by sheet metal. The automatic suppression and detection system in the annulus prevents a single fire from damaging both redundant fire safe shutdown paths (10CFR50 Appendix R, Section III.G.2.e). Inside containment repairs of Class 1E pigtails are enclosed in metal boxes which are considered radiant energy shields. Only one safe shutdown path is allowed per penetration.

It is concluded that the small amount of Dow Corning material will not contribute significantly to the fire. The Kapton insulated conductors on either side of the repairs are qualified to the flame test requirements of IEEE 383 - 1974.

Conclusion:

The installed normal (non-accident) environments for inside and outside containment will not exceed 2.0E7 Rads and 120°F. The maximum voltage for any application is 480 volts AC. All these parameters are within the use range as defined by the manufacturer. The use of Dow Corning 3140 RTV in non-10CFR50.49 circuits both inside and outside containment is acceptable. However, as discussed in the cover letter, TVA will conduct additional testing.

Summary:

Damage to 10CFR50.49 circuits both inside and outside containment will be repaired in accordance with Conax's approved procedures (using Raychem tubing) or other qualified Site Engineering approved repair method. Prior to implementing, additional repair methods must be evaluated and qualification documented in the appropriate Environmental Qualification Binder. If the damage is such that these methods cannot be implemented, then a spare conductor will be utilized or the feedthrough will be replaced.

Damage to non-10CFR50.49 Class 1E or non-Class 1E circuits that are equal to or greater than two inches away from the polysulfone seal will be repaired in accordance with Conax's approved procedures (using Raychem tubing), or NJRT tape, or 3-M Scotch tape, or a spare conductor will be utilized, or the feedthrough will be replaced.

Damage to non-10CFR50.49 Class 1E or non-Class 1E circuits that are less than two inches away from the polysulfone seal will be repaired with Dow Corning 3140 RTV, Raychem tubing, NJRT tape, 3-M Scotch tape or a spare conductor will be utilized or the feedthrough will be replaced.

These repair methods have been incorporated into General Engineering Specification G-38.

REFERENCES

1. EPRI NP-7189, "Review of Polyimide Insulated Wire in Nuclear Power Plants," February 1991.
2. NRC Information Notice No. 88-89, "Degradation of Kapton Electrical Insulation," November 21, 1988.
3. Watts Bar Nuclear Plant Environmental Qualification Binder JB-001.
4. Conax letter to TVA dated October 12, 1994 (RIMS T41941021817).
5. Selection guide to electrical/electronic materials from Dow Corning (RIMS T41941026871)
6. Excerpt from Dupont's Kapton Polyimide Film, Summary of Properties (RIMS T41941026870)
7. Conax letter to TVA dated October 26, 1994 (RIMS T41941026872)
8. Watts Bar Calculation WBNAPS4-006 R1 (RIMS B269305270219)

ENCLOSURE 2

LIST OF COMMITMENTS

1. Although TVA has deemed the use of Dow Corning 3140 RTV as acceptable, TVA will perform testing at their Central Laboratory facility to confirm the capability of this material to perform as a viable repair method for non 10 CFR 50.49 pigtails. These tests will include wet electrical testing after exposure to thermal cycling, thermal aging, and radiation. TVA will provide the results of these tests to the NRC by mid - February 1995.