UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

ENCLOSURE

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

WATTS BAR NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-390

CORRECTIVE ACTION PROGRAM FOR CABLE ISSUES

METHODOLOGY FOR ELECTRICAL CABLE - HOT PIPE SEPARATION

INTRODUCTION

In the safety evaluation on the cable issues corrective action program of April 25, 1991, the staff mentioned the issue of cable proximity to hot pipes. At that time, the staff had not yet evaluated the applicant's mathematical model used for this issue.

Ebasco Services Incorporated, under contract to TVA, is performing calculations and analyses to establish acceptable clearances between electrical cables and hot pipes. Overheating of the cables could lead to premature aging which could cause eventual failure of the cable insulation. Electrical cables within proximity to heated pipes may be affected by convection plumes of heated air, as well as by thermal radiation. Internal electric resistance heating must also be considered. The calculational methods involve a number of computer codes developed by Ebasco to calculate radiation and convection heat transfer from component surfaces and simple conduction within a cable tray. For complex conduction analyses in three dimensions, Ebasco uses the HEATING5 computer code developed by the Oak Ridge National Laboratory (ORNL).

EVALUATION OF SPECIFIC METHODS

This issue was discussed in a site audit during the week of March 2, 1992. Among other things, the staff reviewed Watts Bar site calculation WBN-OSG4-138, "Class 1E Electrical Cable/Hot Pipe Clearance Requirements". The staff has reviewed the more significant computer codes and subroutines used by the applicant. Findings are described below:

CTRHT - The heat conduction equation is solved to find the maximum temperature within a bundle of cables within a cable tray. Internal electric heating within the cable bundle is considered. Heat transfer is assumed only from the top and bottom bundle surfaces of the cable tray which is conservative and makes the problem one-dimensional. Heat transfer boundary conditions at the top and bottom surfaces are determined elsewhere.

HTCNC - Natural convection heat transfer coefficients are determined for vertical and horizontal plates and cylinders. Correlations of experimental data are used as they appear in standard texts. The resulting coefficients are functions of the product of the Grashof and Prandtl numbers. The staff made audit checks of the correlations programmed into the computer code and found the results to be acceptable.

QRAD - Radiation heat transfer between a surface exposed to one hot surface and background is calculated. The geometrical shape factors and emissivities are used as input. The Stefan-Boltzmann equation modified for gray body radiations used according to standard engineering practice.

CONDHT - The surface temperature of conduits containing cables is calculated. The calculations consider radiation heat transfer from an adjacent hot pipe (QRAD), natural convection heat transfer (HTCNC), the effect of a heated plume from a hot pipe below the conduit (THPLUM) and internal heating from up to 24 electric load bearing cables. The program iterates on conduit/pipe spacing until an acceptable conduit surface temperature is obtained. Internal cable temperatures are not calculated directly but are accounted for by using electrical design standards. The calculation is made conservative by using the heat flux for the smallest conduit that can hold the specified number of cables in accordance with the design standard.

PTEMP80 - This program calculates the surface temperature of Mirror insulation covering hot pipes within the containment building. The calculation is based on a design commitment by the manufacturer to limit surface heat loss to 80 BTU/hour/square foot. Surface heat transfer is calculated by the HTCNC computer program for convective heat transfer and QRAD for radiative heat loss. The method should be accurate provided that the Mirror insulation is installed in accordance to the manufacturer's commitment to limit heat flow to 80 BTU/hour/square foot.

Radiation shape factors - These refer to the fraction of thermal radiation leaving one heated object which then strikes another body. The shape factors were derived by digital integration of the conduit and hot pipe surfaces using standard formulas.

Convection heating - Temperatures of cables inside conduits or cable trays will increase when located within thermal plumes that rise from hot pipes. The temperature, velocity and width of rising thermal plumes are calculated by the THPLUM, VPTLA and HORIZN computer programs. The effect of heated plumes is considered in determining the heat transfer and bulk temperature boundary conditions.

HEATING5 - This is a three-dimensional heat conduction computer program developed by the Oak Ridge National Laboratory which is described in ORNL/CSD/TM-15 dated March 1977. HEATING5 has been successfully used by the NRC staff and its contractors to calculate temperature distributions that might occur in the long-term storage of high level nuclear waste. With proper input, the code would accurately calculate temperature distributions within electrical conduits and cable trays.

Calculational results - Based on computer analyses, Ebasco arrived at the following general guideline for parallel runs of insulated pipes and cables, while other guidelines are being developed for asymmetric configurations and uninsulated pipes: (1) Conduits and cable trays must maintain a clearance of

6 inches from an insulated hot pipe when run in parallel to the pipe but not above it. (2) Conduits run parallel, and above an insulated hot pipe must maintain a clearance of 1.5 times the outer diameter of the pipe insulation; cable trays in this configuration must maintain a clearance of 0.5 times the outer diameter of the pipe.

CONCLUSION

The staff reviewed the models and assumptions used at Watts Bar to determine electrical cable temperatures, and has determined that the models and assumptions are reasonable for calculations of this type. All relevant physical phenomena appear to have been considered. The detailed temperature results from the computer analyses were not submitted and were therefore not reviewed. The staff understands that TVA plans to verify these calculations during hot functional testing by performing temperature surveys of locations that might be subject to overheating.

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Dated: April 1992