October 16, 1996

Mr. Lee Liu
Chairman of the Board, President
and Chief Executive Officer
IES Utilities Inc.
Post Office Box 351
Cedar Rapids, IA 52406-0351

SUBJECT: DUANE ARNOLD ENERGY CENTER - REQUEST FOR ADDITIONAL INFORMATION (RAI) ON THE DUANE ARNOLD ENERGY CENTER THERMO-LAG RELATED AMPACITY DERATING ISSUES (TAC NO. M85547)

Dear Mr. Liu:

On June 2, 1995, IES Utilities Inc., submitted a response to the Generic Letter (GL) 92-08, "Thermo-Lag 330-1 Fire Barriers," for the Duane Arnold Energy Center (DAEC). The staff requires additional information in order to complete its review. The staff requires sufficient information to support a complete review of the ampacity of each cable evaluated by DAEC (i.e., all affected power cables), including cable physical characteristics. The staff also has concerns about the methodology used to evaluate the total heat rejection capacity of cables and the single fire barrier test on which the DAEC analysis of cable trays is based. The staff also has enclosed its contractor's report on DAEC's submittal as Attachment A. The staff requests that you provide a response to the enclosed questions within 60 days.

Sincerely,

Original signed by:
Glenn B. Kelly, Project Manager
Project Directorate III-3
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Docket No. 50-331

Enclosure: Request for Additional Information

cc w/encl: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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REQUEST FOR ADDITIONAL INFORMATION

DUANE ARNOLD ENERGY CENTER

AMPACITY DERATING ISSUES

1.0 GENERAL MODELING CONCERNS

The Duane Arnold Energy Center (DAEC) total heat rejection capacity analysis methodology, as documented in the licensee submittal dated June 2, 1995, provides an assessment of the overall behavior of the protected system only, and provides no assessment of the behavior of individual cables within that system. The DAEC methodology is similar to a "Watts/ft" analysis methodology that had been utilized by the Bechtel Power Corporation to serve as a general design tool to assess the general limits of allowable cable loading within a given cable routing system. Bechtel ("Cable Derating Practice," sheet 21, Bechtel TPO Design Guide E2.6.4, revision 2, October 29, 1984) recognized the limits of this methodology as stated in the following statement:

> CAUTION: Since "watts per foot" or "watts per foot per unit width" correlates with AVERAGE temperatures, each such case should be analyzed to ensure against hot-spots. If many of the cables are lightly loaded, one or a few small cables can be overloaded to the point of damage without the "watts per (square) foot" limitation being exceeded.

The above statement also implies that the analysis methodology provides an overall assessment of the average cable behavior assuming certain geometric and cable loading conditions apply. That is, the statement that the heat rejection capacity correlates to "average" cable temperatures can be somewhat misleading. The experimental data used to establish the heat rejection capacity of cable trays is based on the testing of heavily loaded cable trays, and the measurement of hot-spot temperatures within the cable mass. Hence, the correlation is actually between the overall heat generation rate and a hot-spot temperature rise as measured within a tightly packed cable mass. Therefore, this correlation is not strictly between average temperature and the heat rejection capacity. In addition, the extrapolation of these results to other, less densely packed cable installations has not been demonstrated by the licensee.

Overall, the licensee's analyses do not address potential hot spot temperatures that could arise due to the use of the fire barrier material and do not provide any assessment of the anticipated heat transfer behavior for the individual cables. Therefore, the licensee's analyses have not demonstrated that the ampacity values associated with an individual cable protected by the fire barrier material, Thermo-Lag 330-1, will remain within acceptable limits.

The staff requests the licensee to provide supplemental analyses to demonstrate that individual cable ampacities remain within acceptable limits when enclosed by the fire barrier material.

2.0 CABLE LOADING EFFECTS (DEPTH OF FILL)

In general, the "Watts/ft" method assumes that cable loading effects are largely irrelevant to the overall heat rejection capacity of the cable tray or conduit system. The DAEC analysis methodology does not consider the impact of cable loading on the allowable heat loads except to the extent that the original work performed by Stolpe addresses different depths of cable fill. It is expected that the total tray heat rejection capacity would be dependent on various factors, especially the power density within the cable mass. The basis for the correction by the licensee for the overloaded trays appears unclear. Details of the factors that need to be considered are discussed in Attachment A (Steve Nowlen, Sandia National Laboratories, "A Review of the Duane Arnold Energy Center Analysis of Fire Barrier Ampacity Derating Factors," Letter Report to U.S. NRC, Revision 0, April 5, 1996.)

The staff requests that the licensee either account for these factors in the methodology it uses or demonstrate that these factors are not important to the analysis.

3.0 CABLE LOAD DIVERSITY EFFECTS

The "Watts/ft" analysis method does not appear to be capable of providing significant treatment of cable load diversity effects on the total allowable heat loads. All of the ampacity tests cited by the licensee are based on cable trays in which all of the cables are powered uniformly. In actual applications, many cable trays may contain a mixture of loaded and unloaded cables. In general, where there are unloaded cables present in a cable tray, there will be more margin to cable failure. This assumption is true as long as one is considering the heat transfer behavior of individual cables. However, since the "Watts/ft" method provides an assessment of the overall behavior of the cable system only, this methodology may lead to erroneous results for cases involving diverse loads.

For example, consider two cases involving a cable tray loaded with 50 power cables. In the first case, we assume that all 50 of the cables are powered uniformly. In the second case, we assume that a single cable out of the 50 is powered. The "Watts/ft" methodology would assume that the overall heat rejection capacity in these two cases would be identical. Hence, the "Watts/ft" methodology would indicate that it would be acceptable for the heat load generated by the one cable in the second case to be increased by a factor of 50 (assuming that the other 49 cables are deenergized) since, by the "Watts/ft" methodology the cable would still remain within its original heat load capacity. This result would imply a 7-fold increase (since heating load is proportional to the square of current) in the allowable ampacity value based upon the above example. This conclusion is clearly unrealistic. Yet, the "Watts/ft" methodology would conclude that the ampacity values determined in each of the two above cases were equally acceptable.

The total overall heat rejection capacity of the cable tray system may be reduced in those cases involving diverse cable loads, even though the ampacity of the individual cables which are powered could be increased as a result of a

diversity analysis. However, it is not clear how the "Watts/ft" methodology would determine the allowable capacity increase for individual cables in a cable tray due to diverse cable loads.

The staff requests that the licensee clarify how the "Watts/ft" methodology, as employed by DAEC, incorporates cable tray diversity effects.

4.0 EXTRAPOLATION OF EXPERIMENTAL RESULTS

Another concern regarding the licensee's methodology is the extrapolation from a very limited database to all of the licensee's plant applications. In particular, it would appear that the extrapolation of the experimental results has been performed without adequate technical justification or validation.

The use of the experimental values of the total heat load associated with referenced ampacity tests appears to miss the intent of the ampacity derating test approach for the draft IEEE Standard P848, "Procedure for the Determination of Ampacity Derating of Fire Protected Cables." The intent is to provide a relative measure of the impact of the fire barrier system on the performance of the cables. In this relative assessment, many factors "wash out."

That is, the ampacity correction factor, the ratio of two currents (cladded and baseline currents), causes many physical parameters to become secondary in importance. These parameters become "self-cancelling" in nature so long as the parameters remain consistent between the baseline and cladded test specimen. In contrast, the licensee's methodology is based on use of the absolute thermal load measured during the ampacity test of a cladded test specimen. Parameters that may have only secondary importance when considered based upon relative performance can be of primary importance when the absolute thermal loads are used to determine ampacity limits. This includes factors such as cable size, cable loading density, diversity, insulation thickness, jacketed versus nonjacketed cables, conductor type, and insulation material. Each of these factors would be expected to have an impact on the measured absolute thermal loads, but would not be expected to significantly impact the relative cladded versus baseline ampacity performance.

The use of the absolute measured values of cable tray heat rejection capacity would appear to raise significant concerns regarding many of the factors which had been minimally addressed under the IEEE P848 procedure. The intent of the IEEE P848 procedure, a relative performance test, is to isolate the insulating effect due to the fire barrier material. Therefore, test data referenced by the licensee must be carefully evaluated to ensure that consistent, conservative, and technically defensible results are obtained which compensate for the site specific difference in cable parameters. The staff has reviewed approaches by other utilities that are similar to that used by DAEC. The staff has not found any that provide adequate justification due to the inherent limitations of the particular methodology.

In addition to the above concern the licensee should address following related concerns as discussed in Attachment A: (1) the use of cable tray experiment to

characterize the thermal behavior effects for conduits; (2) the potential for surrounding unpowered cables to act as thermal insulation causing an increase in the temperature of the energized cables as compared to the case of a cable in open air or alone in a cable tray.

5.0 VALIDATION OF THE "WATTS/FT" METHOD

The licensee's submittal references the paper by O. Esteves entitled "Derating Cables in Trays Traversing Firestops or Wrapped in Fireproofing" as the basis for the validation of the total heat load (or "Watts/ft") methodology, and presumably for the extrapolation of the test results. However, the Esteves paper only refers to the extrapolation of the test results to other similarly heavily loaded cable trays - trays with full layer, no gaps coverage, and uniform heating of the cables. This reference does not address the more complex issues associated with variations in cable loading density and cable diversity issues as discussed above. This paper does not provide adequate support to justify the extrapolation of the subject data to sparsely loaded trays and conduits such as are installed at DAEC.

The staff requests the licensee to provide additional technical basis for the subject extrapolation of data results to sparsely loaded cable trays and conduits.