TU ELECTRIC

William J. Cahill, Jr.
Group Vice President

Log # TXX-94085
File # 10010
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March 25, 1994

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION
FOR CPSES AMPACITY DERATING TEST (TAC NO. M85999)

Ref.: U. S. Nuclear Regulatory Commission letter from
Thomas A. Bergman to William J. Cahill, Jr.,
dated February 14, 1994.

Gentlemen:

TU Electric has reviewed the above referenced letter which included a list of questions. TU Electric is hereby responding to the questions. Additionally, the letter requested that TU Electric incorporate these responses into an engineering report regarding Thermo-Lag. As discussed with Thomas A. Bergman of your staff, TU Electric believes that these responses are best addressed separately from the engineering report.

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400 N. Olive Street L.B. 81 Dallas, Texas 75201

The responses to your questions are provided in the attachments to this letter. Should you need additional information regarding these questions please contact John White, CPSES Electrical Engineering, at (817)897-6674 or Obaid Bhatty at (817)897-5839 to coordinate your responses.

Sincerely,

William J. Cahill, Jr.

By:
J. J. Kelley, Jr.
Vice President of Nuclear
Engineering and Support

OB:bm
ATTACHMENTS

cc: Mr. T. A. Bergman, NRR
Mr. L. J. Callan, Region IV
Mr. L. A. Yandell, Region IV
Resident Inspectors, CPSES
NEI (NUMARC)

ATTACHMENT 1 TO TXX-94085

RESPONSE TO QUESTIONS
REGARDING
AMPACITY DERATING TEST

RESPONSE TO QUESTIONS
REGARDING AMPACITY DERATING TEST

QUESTION ONE

The subject test report does not describe how the acceptance criteria as detailed in the IEEE Standard Procedure P848, "Procedure for the Determination of the Ampacity Derating of Fire Protected Cables, " Draft 11, dated April 6, 1992, are met or not met by the test data. In accordance with IEEE-P848, the following criteria must be met in order to utilize the current data in the determination of the ampacity derating factor:

(1) In order to statistically assure thermal equilibrium, the conductor temperatures should be averaged at each sampling period and a linear regression analysis performed on the data obtained in units of °C/hour. As soon as the absolute value of the slope of these data becomes less than 0.55 (conduit) or 0.35 (tray), equilibrium has been reached.

(2) The current in each test circuit shall be adjusted so as to give an equilibrium temperature of 90°C ± 1.1°C at the hottest point monitored within location #2 (those located at the center of the system).

(3) The average temperature of thermocouple locations #1 and #3 shall be within ± 4°C of the average thermocouple location #2.

Contrary to the above criteria the following items were noted:

(1) There were several instances in which the temperature measured failed to stay within the equilibrium temperature range of 90°C ± 1.1°C based on the hottest point monitored within location #2. The test report did not explain these anomalies.

(2) The test report did not provide sufficient data to establish that the average temperature of thermocouple locations #1 and #3 remained within ± 4°C of the average thermocouple location #2 during the equilibrium period.

(3) The test report failed to provide a continuous three hour period of data where the absolute value of the slope of the conductor temperature was less than the required value (0.55 for conduit, 0.35 for tray) thereby establishing that the equilibrium temperature had been reached for all tests except the 3C/#6 in Air Drop (Baseline), 3C/#6 in 24" Cable Tray (Baseline and Clad), 3-1/C 750 kcmil in Air Drop (Clad) and 4-1/C 750 kcmil in 5" Conduit (clad) tests. The licensee should describe in the summary engineering report how all the data fit together to support the ampacity derating conclusions as well as addressing test data anomalies

RESPONSE TO QUESTION ONE

In March of 1993, TU Electric conducted a series of ampacity derating tests utilizing Thermo-Lag as the fire barrier material. The results of these test were documented in a test report titled "Ampacity Derating of Fire Protected Cables", dated March 19, 1993.

The tests were performed in accordance with P848 draft (D) 11, "Procedure for the Determination of the Ampacity Derating of Fire Protected Cables". The draft standard establishes the test methodology, the necessary parameters to determine system equilibrium, and the ampacity derating associated with the tested configuration. The establishment of the equilibrium conditions are the basic foundation of a successful test, and are stated in P848 D11 section 5.4.3. In order for a system to be in equilibrium three basic conditions must be satisfied:

1. The average temperature of the thermocouples at locations one and three must be within four degrees Celsius (plus or minus) of the average temperature of the thermocouple at location two.

2. The maximum temperature associated with any thermocouple at location two must be ninety degrees Celsius (plus or minus 1.1 degrees Celsius).

3. A minimum of three hours must have passed since the last perturbation of the system occurred, and the system must have reached thermal equilibrium.

In order to statistically assure thermal equilibrium, the conductor temperatures are averaged at each sampling period and a linear regression analysis performed on the data obtained in units of degrees Celsius per hour. As soon as the absolute value of the slope of this data becomes less than .55 (conduit) or .35 (tray), equilibrium has been reached. It should be noted that as soon as the required data values have been obtained equilibrium has been achieved, provided all other system requirements have been met. There is no requirement that the slope of the data remain below the required values for any period of time.

Based on the above and additional review of the submitted questions (as we understand them); 1) Once the equilibrium was achieved, the maximum temperature associated with any thermocouple at location #2 did not exceed 90°C ± 1.1°C. It should be noted that where criterion 2 above was not met, it occurred before achieving the equilibrium and was not considered as an anomaly; 2) The average temperature of the thermocouples at locations #1 and #3 remained within ± 4°C of the average temperatures at location #2 and sufficient data is provided within the calculation to establish this; and 3) For all tests, equilibrium was reached as described above. No anomalies in the test data could be identified.

QUESTION TWO

The second photograph in Appendix F of the Omega Point Report indicates that a flexible blanket (Sil-Temp) was placed on top of the cables in the cable tray prior to installation of the fire barrier system. However, no further documentation of either this material or the installation procedure was provided in the body of any of the TU Electric documents. The licensee should document this aspect of the procedure. Further, the impact of this blanketing material on the ampacity derating results should be addressed by the licensee. The licensee should provide an analysis that justifies the use of these test results for CPSES tray configurations that did not contain the blanket.

RESPONSE TO QUESTION TWO

The Sil-temp blanket was included because it represents possible configurations at CPSES. A Sil-temp blanket is utilized in some trays with a high fill content, in order to provide physical protection to the cables. Since the Sil-temp is an insulating material it will increase the thermal resistivity of the enclosure. CPSES's ampacity testing correctly included this worst case configuration, and is therefore reflected in the ampacity derating factor. This derating factor has been applied to all thermo-lagged tray, even if Sil-temp was not utilized. The use of our tested derating factor conservatively bounds CPSES configurations and will have no adverse affect on trays which do not include the Sil-temp blanket.

QUESTION THREE

The licensee should definitively state (1) that a plastic sheet covering the bottom of the tray during the baseline test and (2) the option to default to tabulated ampacity derating values instead of the experimental values in the base line test case, were not used in the ampacity derating test procedure. Although these changes were implied by the deletion of references present in previous version of the test procedure, there should be a specific statement verifying these facts.

RESPONSE TO QUESTION THREE

The use of a plastic sheet on the bottom of the tray, and of ICEA ampacity values for the baseline current were proposed changes to IEEE P848, and these items were included in an early revision of TU Electric's test plan. These items were subsequently removed from our test plan and were never part of our tested configurations. Therefore, (1) A plastic sheet was not used to cover the bottom of the tray during the baseline test; and (2) TU Electric did not default to tabulated ampacity derating values.

QUESTION FOUR

It was noted that the heat distribution of the cable tray had an average temperature for (Thermocouples 27-39) Location #3 higher than the center Location #2 (Thermocouples 14-26). Identify the points in time when the final amperage reading was taken to determine the ampacity derating factors shown in the test results section of the test report. Since IEEE-P848 assumes the center position on the test specimen to be the hottest point during the ampacity test, describe the impact of higher than allowed (> 4°C) temperatures at other thermocouple locations in the determination of the ampacity derating parameter. Should not the hottest temperature measurement be used irrespective of location in order to determine the ampacity derating factor?

RESPONSE TO QUESTION FOUR

The final amperage reading which were used to determine ampacity were taken for each test at the following times:

	TEST	TIME (MINUTES)
3/c #10	3/4" Baseline	528
3/c #10	3/4" Clad	1002
3/c #6	2" Baseline	500
3/c #6	2" Clad	1002
3/c #6	Airdrop Baseline	1434
3/c #6	Airdrop Clad	1193
24" Tray	Baseline	1434
24" Tray	Clad	2300
3-1/c 750 MCM	Airdrop Baseline	802
3-1/c 750 MCM	Airdrop Clad	990
4-1/c 750 MCM	5" Baseline	1192
4-1/c 750 MCM	5" Clad	1213

Question four raised the concern of higher than allowed average temperatures at locations one and three (greater than four degrees celsius). These conditions are not allowed, and were not experienced, when test samples were in equilibrium. The impact of such conditions which occur prior to the sample achieving equilibrium are not of concern and need not be addressed. The temperature readings referenced, associated with locations two and three, were within the tolerance allowed by the standard (± 4°C). TU Electric considers that the center position, as required by the standard, is the proper temperature measurement to use when determining ampacity, as long as the equilibrium requirements are met.

QUESTION FIVE

The test report did not include the computer program for the data acquisition software used to average temperatures and determine temperature rate of change parameter (i.e., slope). Please provide a listing of the program line instructions and an explanation of any variables or nomenclature associated with the test measurements.

RESPONSE TO QUESTION FIVE

The computer program is the proprietary information of Omega Point Laboratories and was not included in the test report for that reason (the report is being made available to other utilities). The software was part of the Quality Assurance program associated with the ampacity test program and was available for audit when the NRC vendor branch performed an audit during the course of TU Electric ampacity testing. Notwithstanding, TU Electric has arranged with Omega Point Laboratories to have this computer program available for NRC review.

QUESTION SIX

The licensee should perform a one-to-one comparison of any mathematical models to the available experimental results if used in any Comanche Peak Steam Electric Station Unit 2 configuration. If models were not used, please provide an explicit statement to that effect. In addition, the licensee should demonstrate that all tested or analyzed configurations are representative of the full range of applications actually present in CPSES Unit 2.

RESPONSE TO QUESTION SIX

Ampacity deratings for CPSES Unit Two are not determined by mathematical modeling techniques. The ampacity deratings associated with tray, conduit and air-drops are all determined by testing. The configurations tested by TU Electric are representative of or more conservative than the installed configurations at CPSES Unit Two.

QUESTION SEVEN

TU Electric identified in their engineering report multiple conduits/trays in a common enclosure. In addition, the licensee identified approximately 180 cases as noted in CPSES Supplementary Safety Evaluation Report 26 where the application of Thermo-Lag barrier materials used to protect electrical raceways and structural steel deviated from the tested configurations. The tests performed by the licensee do not apply to multiple trays or conduits in a single box. A large percentage of the heat is rejected off of the outer surface of both cables and the enclosure via thermal radiation.

Multiple trays will inhibit radiative transfer since each tray would receive thermal radiation from a neighboring tray. In fact, the same concern would apply to trays which are individually protected, but obtained within larger stacks of trays. Please provide analyses or tests to justify ampacity derating factors for these non-standard configurations.

RESPONSE TO QUESTION SEVEN

In the vast majority of cases, the thermo-lag installations were installed with no deviation from the tested configurations. However, as stated in CPSES's Supplementary Safety Evaluation Report 26, there are some cases where standard designs cannot be utilized. These deviations occur at transition points and to avoid interferences. Transition points and interferences, by their very nature, require modifications that are limited to short distances and cannot not be accurately tested for ampacity derate. The difficulty in developing a test plan for different unique configurations arises when the effects of heat sinks (support steel), thermal masses (concrete walls), and uniqueness of the configuration is required to be accommodated in the sample test.

The deviations fall into one or more of three categories or types: 1) Modifications to the stress skin, 2) modification of the banding configuration, and 3) modifications occurring at transition or interference points. The effects of these deviations (which include the affects of multiple conduits/trays in a common enclosure) will be minimal for the following reasons: 1) All installations utilize the basic commodities tested; flat panels, preformed conduit sections, and wrap material; 2) the modifications occur over short distances, at fittings and transition points; 3) when flat panels are utilized the result is normally an increase in surface area, thus increasing the heat transfer from the system; 4) conduits, support steel and cables act as heat sinks and temperature equalizers, and will tend to normalize temperatures over the short distances that are associated with deviations; 5) concrete walls and floors are tremendous thermal masses, and will remove heat from enclosures; 6) many of the interference problems occur orthogonally,usually in the vertical plane, where heat effects are minimized; and 7) most of the modifications effect instrument and control circuits which are not ampacity concerns.

Additionally, TU Electric in response to an NRC request, reviewed "Unique Configurations" identified within Engineering report ER-ME-082 Rev. 1 to determine the worst case Unit Two configuration. The evaluation consisted of a review of applicable design changes and field walkdowns of selected commodities. Engineering found no multiple power tray runs within a common enclosure. There were a few instances of a control and power tray within the same enclosure. However, in these instances the power trays are routed above the control trays, as required by Design Basis Document (DBD) DBD-EE-052. The control tray does not add a significant amount of heat to the enclosure and acts as an additional heat sink for the power tray.

Temperature differentials inside the enclosure cause air circulation within the sealed enclosure. The circulated, heated air is forced into contact with all Thermo-Lag surfaces, as well as the control cables and the steel of the tray and supports. The net effect is improved heat conduction to these components from the circulating air, and a larger heat transfer rate provided by the greater radiating surface of the larger Thermo-Lag enclosure. Therefore, the overall heat transfer associated with the system will not be adversely affected.

TU Electric believes that the worst case configuration is identified in Design Change Authorization (DCA) 102679 R. 1 and involves a level 2 (power) 24" tray, and two level 2 conduits which are routed above the tray for a distance of approximately 17 feet. One conduit is unprotected and occasionally touches the top of the envelope. The second conduit is similarly located and protected with Thermo-Lag pre-shaped sections which merge with the tray envelope at the bottom of the conduit. Attachment 2 provides a pictorial view of the configuration. The configuration is acceptable based on the following; the surface of the tray is relatively large with respect to the adjacent protected conduit, the merged length of the conduit is relatively short with respect to the tray, and the tray envelope surface available to radiate heat is not materially affected. Additionally, the available margin associated with cables within the affected raceways are sufficient to allow for the decrease in surface area.

TU Electric Engineering's evaluation confirms that unique configurations have been limited, and the design requirements have ensured that ampacity of affected cables have not been adversely effected.

QUESTION EIGHT

The licensee stated that ampacity derating based on ambient test environment of 40°C versus the normal plant ambient environment of 50°C provides a more conservative parameter. The licensee provided the following explanation in their January 19, 1993 letter to the staff:

> "As the temperature of an insulating material increases the thermal conductivity increases. Therefore, since the resistivity is inversely proportional to the conductivity as the thermal conductivity of Thermo-Lag increases its thermal resistance will decrease. The thermal resistance of Thermo-Lag will be greater at 40°C than at CPSES's plant ambient of 50°C. With a higher thermal resistance, the cable derate factors will be higher. Therefore, the CPSES utilization of cable derate factors derived from tests conducted at 40°C ambient instead of 50°C is conservative."

The staff agrees that if properly applied, the ampacity correction factors (ACF) determined for Thermo-Lag at a 40°C ambient will be a conservative estimate of ACFs at a 50°C ambient because the thermal conductivity of Thermo-Lag will be somewhat higher at the higher ambient. The degree of conservatism introduced would, however, be small because conduction through the insulating barrier is not a dominant factor in the overall heat transfer process. The heat flux will obviously be higher between 90 and 40 degrees, for all reasonable resistivity variations.

The fact that the conductivity of one of the materials decreases with temperature will not counteract the increased driving potential. The licensee is requested to explain how the test results will be utilized with a 50°C ambient cable rating at CPSES Unit 2.

RESPONSE TO QUESTION EIGHT

Cables located in a fifty degree celsius ambient receive a derating associated with this above normal ambient temperature. This derating is applied in addition to any derating associated with Thermo-Lag, and is in accordance with ICEA 54-440.

QUESTION NINE

The licensee's analysis described in Attachment 3 of the letter from William J. Cahill to the U.S. NRC dated February 26, 1993, had several problems. For example:

The first equation in the subject attachment is a comparison of two ampacity correction factors (ACF) found numerically (number in parentheses refers to cable fill depth).

$$\frac{ACF(3) - ACF(1)}{ACF(3)} = \frac{78 - 75}{78} = 0.038 \qquad (1)$$

Attachment 3 states that the ACF for a 3-inch fill is 3.8 percent greater than that found for a 1-inch fill. However, the ampacities (actual current carrying capacity) for the various depths are significantly different.

Equation 1 can be rewritten where the ACF values are replaced by current ratios. Then it is seen that Equation 1 is the percent difference between ratios that do not have the same denominator:

$$\frac{\dfrac{I_{3,i}}{I_{3,b}} - \dfrac{I_{1,i}}{I_{1,b}}}{\dfrac{I_{3,i}}{I_{3,b}}} = 0.038$$

where $I_{x,y}$ is the current. The first subscript indicates the depth of cables, and the second subscript indicates if the cable tray is insulated or bare. It is difficult to see how the above result can be multiplicatively applied to anything with dimensions of amperes (as is done later in Attachment 3). The result should only be multiplicatively applied to an ACF.

The second equation in the subject Attachment is a standard correction to be applied to cables when the ones in use are of slightly different dimensions than the cables that are tabulated:

$$I_x = \frac{d_x}{d_o} I_o \qquad (2)$$

Equation 2 is a valid expression endorsed by the industry ampacity tables.

The third equation in the subject attachment applies the second equation to a specific example. It corrects a tabulated ampacity for a 0.72 inch cable packed to a one inch depth to the 0.75 inch cable at a one inch depth:

$$I_x = \frac{0.75}{0.72} \quad 44A + 45.8A \qquad (3)$$

The fourth equation in the subject attachment appears invalid since it seems inappropriate to apply the result from Equation 1 to the ampacity of a 0.75 inch diameter cable packed to a 1 inch depth. The units of the percentage change term do not equal amperes over amperes. Therefore, it is inappropriate to modify actual ampacity ratings in this manner.

$$45.8A \times 0.038 = 1.74A \qquad (4)$$

Finally, the conclusion as stated in Attachment 3 does not appear to be logically derived from the analysis presented and is unclear. The 9.5 percent is the conservatism found built into a single case in the IPCA ampacity tables (which reports currents in amperes) and the 3.8 percent is the difference between two calculated ACFs. The licensee is requested to review, clarify and justify the analysis in Attachment 3.

RESPONSE TO QUESTION NINE

The analysis in the referenced letter was in response to an NRC question asking if there would be any difference in the ampacity derating of cable tray if different cable percent fill levels were tested. The answer to this question was yes, and a copy of "Fire Protection Wrapped Cable Tray ampacity" by P. Save and G. Engmann was provided to the NRC. In this paper the TSI one hour fire barrier is tested. A cable tray with a one inch depth of fill has an ampacity correction factor of .75. A cable tray with a three inch depth of fill has an ampacity correction factor of .78. This means that if TU Electric had tested a cable tray with a one inch depth of fill, as opposed to the three inch depth of fill utilized in our test, we could have experienced an ampacity correction factor of 3.8 percent lower. As shown below equation one simply calculates the additional derating.

$$(1) \qquad \frac{ACF(3) - ACF(1)}{ACF(3)} = \frac{78 - 75}{78} = 0.038$$

By converting the additional derate to an ampacity correction factor, the additional ACF can be applied to any base ampacity.

20Amps .78 x .962 = 15Amps   77Amps x .78 x .962 = 57.8Amps

20Amps x .75 = 15Amps   77Amps x .75 = 57.8Amps

Equation three calculated the baseline ampacity for the cable tested at Omega Point. It then demonstrated that if the lower correction factor numbers had been utilized the maximum difference (the largest ampacity associated with the cable occur at the one inch depth of fill) would have been 1.74Amps. The ampacity difference can also be demonstrated in the following manner:

a) Utilizing the ampacity correction factor, from the paper by Save and Engmann, for a 1 inch depth of fill

   45.8Amps x .75 = 34.35Amps

b) Utilizing the ampacity correction factor, from the paper by Save and Engmann, for a 3 inch depth of fill

   45.8Apms x .78 = 35.72Amps

c) The percentage difference in these two ampacities is

(35.72Amps - 34.35Amps)/35.72Amps = .038

d) The equation to determine the maximum ampacity difference in the referenced memo was incorrect. Equation four applied the additional .038 derating to the 45.8Amps, it should have been applied to 35.72Amps. This will result in an additional derating of 1.36Amps.

35.72Amps x .038 = 1.36Amps

or

35.72Amps - 34.35Amps = 1.37Amps

Another objective of the paper was to demonstrate that CPSES's utilization of a cable tray with a percent fill approaching three inches would not have a negative impact on the final tested ampacity value. In order to do this TU Electric discussed an area of conservatism inherent in the standard. The standard only applies to cables that are sized in accordance with ICEA P-54-440 or P-46-426. The tray utilized in our test would have an ICEA baseline ampacity of 21.875Amps. However, previous testing performed by Omega Point, on the same cable tray, resulted in a baseline ampacity of 23.96Amps. Assuming a clad ampacity value of 15.8Amps the following deratings would be obtained:

(23.96Amps - 15.8Amps)/23.96Amps = .034 or 34% derating

Utilizing the ICEA values:

(21.875Amps - 15.8Amps)/21.875Amps = .028 or 28% derating

At the time the original memo was written the actual clad ampacities associated with TU Electric's Thermo-Lag configurations were not known so the 9.5 percent increase in ampacity derating was a conservative estimate. The actual values from the TU Electric test are as follows:

(23.1Amps - 15.8Amps)/23.1Amps = .0316 or 31.6% derating

Utilizing the ICEA values:

(21.875Amps - 15.8Amps)/21.875Amps = .028 or 28% derating

The use of actual baseline ampacity values results in an increase in ampacity derating of 12.9 percent.

When the increase in ampacity derating that results from using actual baseline ampacities (+ 12.9 percent) is compared to the decrease in ampacity derating that results form the use of high percentage fill trays (- 3.8 percent) it is apparent that there is no adverse affect associated with ampacity derating values obtained from testing.

QUESTION TEN

The licensee's submittal failed to address the effects of inductive currents evident in the test on the 3/C 750 kcmil in 5" conduit specimen. The staff has noted that for similar tests performed by Tennessee Valley Authority using the IEEE-P848 procedure, those test specimens using 3 conductor configurations resulted in higher phase angles and voltages with lower current levels than the 4 conductor test configurations. The inductive currents result from unbalanced current flows associated with the odd number of conductors traveling through the conduits. The licensee should indicate how those conduit tests conducted using a three conductor configuration provide conservative results.

RESPONSE TO QUESTION TEN

There are no ampacity derating values associated with three conductor 750 MCM cables in conduit in the TU Electric test report. The single phasing associated with the three conductor 750 MCM cables, fed in series by a single phase source, was first identified by TU Electric. The single phasing problem was corrected at Omega Point by running four conductors in conduit, thus eliminating the inductive heating of conduit. The 3/4" and 2" conduits tests were not re-run because the inductive heating produced a conservative derating (higher). The conservative derating value is due to the additional heat added by the inductive heating which in turn reduces the ampacity of cables. The additional heating had the greatest impact on the clad configurations and when cables carrying large currents are utilized. Since the 5" conduit has the greatest derating and the derating values of 3/4" and 2" conduits were conservative, TU Electric found no technical basis which would have required the tests to be re-run.

ATTACHMENT 2 TO TXX-94085

FIGURE - 1

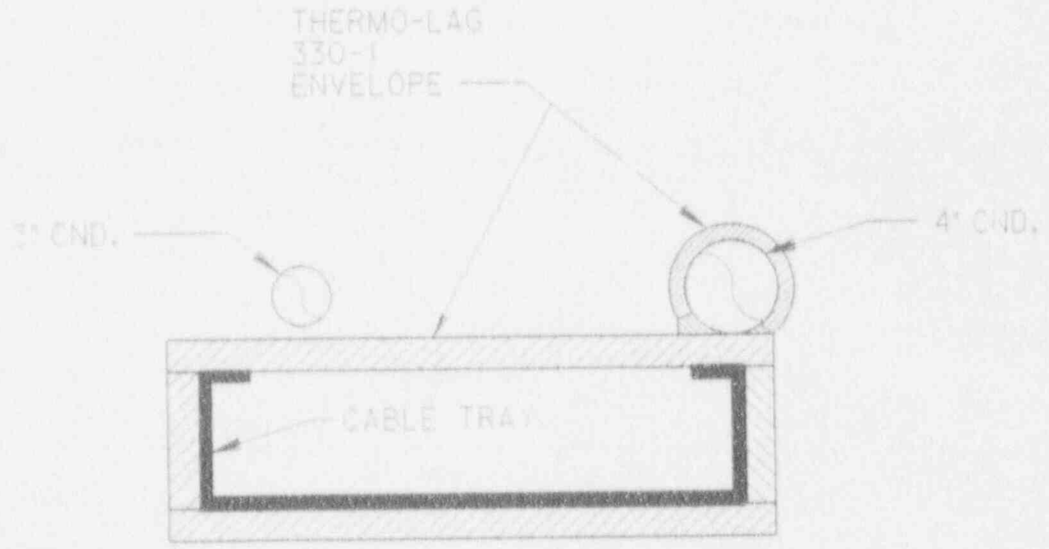

FIGURE - 1