CENTERIOR ENERGY

PERRY NUCLEAR POWER PLANT
10 CENTER ROAD
PERRY, OHIO 44081
(216) 259-3737

Mail Address:
P.O. BOX 97
PERRY, OHIO 44081

Donald C. Shelton
SENIOR VICE PRESIDENT
NUCLEAR

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Perry Nuclear Power Plant
Docket No. 50-440
Response to the Follow-up to the Request for Additional Information Regarding Generic Letter 92-08, "Thermo-Lag 330-1 Fire Barriers" - Ampacity Derating, Chemical Composition, and Radiant Energy Heat Shield

Gentlemen:

In a letter dated October 4, 1995, the Nuclear Regulatory Commission (NRC) staff stated that additional information was necessary to complete review of the ampacity derating issue at the Perry Nuclear Power Plant (PNPP). Previous information on this issue had been submitted to the NRC by letters dated December 15, 1994 (PY-CEI/NRR-1886L), and June 28, 1995 (PY-CEI/NRR-1966L). A November 20, 1995, response letter to the NRC (PY-CEI/NRR-2003L) stated that the analytical methodology, including typical calculations, used to determine the ampacity derating parameters would be submitted by June 30, 1996. Attachment 1 provides this information for PNPP. The evaluation concludes that there is adequate margin to accommodate the ampacity derating due to application of Thermo-Lag 330-1 such that the insulation properties of the protected cables are not adversely impacted.

Attachment 2 provides a response to an NRC letter dated December 23, 1994, which requested information regarding the chemical composition of Thermo-Lag 330-1 fire barrier materials installed at PNPP. This was to ensure that the fire barrier materials installed at PNPP were representative of the materials that were used by the industry to address technical issues. Attachment 2 provides the results of the chemical analysis, which concludes that the materials used at PNPP are equivalent to the materials tested in the industry fire endurance tests.

Attachment 3 provides a response to a question from the NRC Project Manager for PNPP regarding the location of the Thermo-Lag radiant energy heat shield discussed in a letter to the NRC dated February 11, 1994 (PY-CEI/NRR-1750L). Attachment 3 documents the location of the radiant energy heat shield.

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If you have questions or require additional information, please contact Mr. James D. Kloosterman, Manager - Regulatory Affairs at (216) 280-5833.

Very truly yours,

Neal L. Bonner
for
Donald C. Shelton

KMN:sc

Attachments

cc: NRC Project Manager
NRC Resident Inspector's Office
NRC Region III

Ampacity Derating Evaluation for Cables Protected With Thermo-Lag 330-1 Fire Barrier Material

References

1. NRC Generic Letter (GL) 92-08, "Thermo-Lag 330-1 Fire Barriers."
2. National Fire Protection Association (NFPA) 70-1996, National Electric Code.
3. Insulated Cable Engineers Association (ICEA) (IPCEA) Standard P-46-426 (IEEE S-135), 1984, Power Cable Ampacities, Volume 1 -- Copper Conductors.
4. ICEA (IPCEA) Standard P-54-440 (NEMA WC 51), 1986, Ampacities of Cables in Open-Top Cable Trays.
5. NRC Letter to D. Shelton (Centerior) dated 10/04/95, Response to the Followup Request for Additional Information Regarding Generic Letter 92-08 (PY-NRR/CEI-0781L).
6. NRC Letter to Texas Utilities Electric Company (TUEC) dated 06/14/95, Safety Evaluation of Ampacity Issues Related to Thermo-Lag Fire Barriers at Comanche Peak Steam Electric Station, Unit 2.
7. TUEC test results contained in Omega Point Laboratories Report No. 12340-94583, 95165-95168, 95246, Ampacity Derating of Fire Protected Cables.
8. TUEC Letter to NRC dated 08/08/94, Response to Request for Additional Information Regarding Thermo-Lag Cable Functionality Issues.
9. Gilbert Associates Incorporated (GAI), Perry Project Design Criteria, Cleveland Electric Illuminating (CEI) File #DCC-002, Rev. 3, dated July 30, 1982.

Purpose

Provide the methodology and results of applying a Perry Nuclear Power Plant (PNPP) specific ampacity derating analysis for 600 V and 5 kV rated cables routed in cable trays and conduits protected by Thermal Science Incorporated (TSI) Thermo-Lag fire barriers. The results of this analysis are required to provide a final determination of ampacity derating parameters for Thermo-Lag fire barriers at PNPP.

Summary

As a result of applying the appropriate ampacity derating factor, power cables routed in cable trays/conduits, and protacted by Thermo-Lag fire barriers at PNPP were found to have positive ampacity margin. The specific Thermo-Lag ampacity derating value selected and applied to each configuration was determined by:

1. reviewing the ampacity derating testing conducted by the Texas Utilities Electric Company (TUEC),

2. confirming by similarity analysis that the TUEC tested configurations bound installed Thermo-Lag configurations at PNPP, and

3. applying the comments discussed in the NRC "Safety Evaluation of Ampacity Issues Related to Thermo-Lag Fire Barriers at Comanche Peak Steam Electric Station, Unit 2," dated June 14, 1995.

Discussion

As described in Reference 5, the NRC staff requested that additional information be provided with respect to the ampacity derating issues for circuits protected by Thermo-Lag 330-1 fire barriers. Responses to the request for additional information (RAI) are provided below.

RAI #1

The licensee is requested to submit its ampacity derating evaluations including any applicable test reports, in order to provide an adequate response to Generic Letter 92-08 Reporting Requirement 2(c).

RAI #1 Response

A complete ampacity derating evaluation was conducted for PNPP power cables routed in cable trays/conduits and protected by Thermo-Lag fire barriers. The evaluation was performed to determine if acceptable margin exists between allowable ampacity and actual full load current for each power cable, or if a need exists for corrective action/resolution of unsatisfactory results.

The methodology for the evaluation consisted of performing a similarity analysis of applicable PNPP power cable installations and barrier construction against the tested configurations detailed in Reference 7 and the NRC evaluation comments noted in Reference 6. The following test results were obtained for the configurations tested by TUEC as described in Reference 6:

RACEWAY TYPE	AMPACITY DERATING TEST VALUES
3/4" Conduit	9.4%
2" Conduit	6.6%
5" Conduit	10.7%
24" × 4" Cable Tray	31.5%
Small Air Drop	21.3%
Large Air Drop	31.7%

However, the NRC indicated in their safety evaluation that the ampacity derating factor of 21% should be used for cables in conduit to ensure an adequate design margin. In addition, the TUEC applied derating factor for cable trays was endorsed by the NRC as 31.5%. Accordingly, these derating factors were applied.

In comparing the Thermo-Lag barriers at PNPP to the configurations tested by TUEC, the following characteristics could affect the ampacity derating factor:

1. configuration of the raceway protected (e.g., tray, conduit, boxes, airdrops)
2. raceway material (e.g., steel, aluminum)
3. raceway size
4. barrier material (i.e., Thermo-Lag 330-1, 330-660 blanket)
5. thickness of the barrier
6. joint assembly (e.g., prebuttered, dry fit)
7. stress skin application (i.e., inside or outside barrier)

Other parameters that are unique to particular barriers, such as interfaces between Thermo-Lag materials and other fire barrier materials or building features (e.g., walls, etc.) and internal supports, were not considered to be factors in determining the ampacity derating factors. These types of variations occur only for a short part of the overall run of the barrier (1-2 feet). As stated in the NRC staff Safety Evaluation (Reference 6), the variations in construction for short distances are not expected to impact the overall ampacity derating given the conservatism applied in the derating factors used.

Perry configurations are consistent with the configurations covered by the TUEC ampacity derating numbers, except for the following items:

- The "large air drops" where several cables are bundled into one barrier occur at two locations, one in the Control Complex and one in the Diesel Generator building. However, these are short sections (1-2 feet) of the overall protected raceway runs and the use of the derating figure for the tray configuration of 31.5% is justified.

- The ampacity derating of 21% was used for both conduit and small air drops (single cable outside of any conduit). However, the small air drops are short sections, open at the end and are limited to MOV power cables and instrumentation cables, where derating is not a factor.

- Only one conduit is protected by a 3-hour barrier. This conduit contains circuits for the MSIV solenoids. The circuits in this conduit have been identified as control type. As described in the Conclusion section of this attachment, control cables are adequately sized at PNPP.

- The 1-hour rated barriers installed on conduits utilizing the "annular pumping" type installation are located on the Control Complex 574' elevation. The circuits in these conduits have been identified as instrumentation and/or control type. As described in the Conclusion section of this attachment, this type of cable is adequately sized at PNPP.

Based on the comparison of the Thermo-Lag installations tested by TUEC to obtain the derating factors described in Reference 6 and those installed at PNPP, the use of the TUEC ampacity derating factors at PNPP is justified.

In comparing the cables/trays at PNPP to the cables/trays tested by TUEC, the following characteristics could affect the ampacity derating factor:

1. type of cable insulation
2. conductor material
3. temperature rating of the cable
4. percentage fill of the cable tray

As stated in Reference 7, the cables utilized at TUEC, for the tray ampacity test, were 3/C #6 AWG 600 V copper with a thermosetting XLP insulation and a PVC jacket. The test specimen was built to earlier drafts of IEEE Standard P848 "Procedure for the Determination of the Ampacity Derating of Fire Protected Cables." The previous revision of the standard allowed for the use of several different types of material in the construction of the cables utilized in the ampacity test. In order to provide consistency between ampacity derating tests, the standard was revised to recommend the use of a 3/C #6 AWG copper cable, with an XLPE insulation and a Hypalon jacket. The specifications for the cables at PNPP are consistent with those of the revised IEEE standard.

In Reference 7, TUEC concluded that the test specimen constructed for the ampacity test satisfies the technical requirements for an acceptable ampacity derating test, and the derating factor is representative of any facility utilizing ICEA P-54-440 for its cable tray design. The use of the TUEC ampacity derating factors at PNPP is justified because PNPP utilizes ICEA P-54-440 for its cable tray design.

For comparable cable trays, the percentage fill of the worst case PNPP trays are well below the percentage fill of the tested tray.

Based on the comparison of cables/trays tested by TUEC to obtain the derating factors described in Reference 6 and those installed at PNPP, the use of the TUEC ampacity derating factors at PNPP is justified.

For PNPP configurations, Thermo-Lag one-hour fire barriers were found to be applicable. The results from the PNPP specific evaluation were found to have positive ampacity margins. Specific results from the evaluation are detailed in the Conclusions section of this attachment.

RAI #2a

In its submittal of December 15, 1994, the licensee referred to a site specific evaluation. If this evaluation represents the licensee's final determination of ampacity derating parameters for Thermo-Lag fire barriers, please forward a copy of the subject evaluation for staff review.

RAI #2a Response

PNPP's site-specific evaluation on ampacity derating parameters is discussed in the RAI #1 response.

RAI #2b

Given that there are no unresolved technical issues, the licensee is requested to provide its site-specific schedule and plans for the resolution of the ampacity derating issue for Thermo-Lag fire barriers.

RAI #2b Response

With respect to cable ampacity derating due to Thermo-Lag barriers, the evaluation results revealed no ampacity derating issues requiring resolution.

RAI #2c

Finally, the staff expects that the licensee will submit, in conjunction with the resolution of the fire endurance issues, the test procedures or alternatively, a description of the analytical methodology including typical calculations which will be used to determine the ampacity derating parameters for the Thermo-Lag fire barriers that are installed at the Perry Nuclear Power Plant.

RAI #2c Response

As discussed in the RAI #1 response, the methodology used to evaluate and apply PNPP ampacity derating factors to Thermo-Lag installations on power cables was the performance of a PNPP similarity evaluation against the Reference 7 TUEC test configurations, and the development of a comprehensive calculation using the appropriate derating factors reflected in Reference 7 and Reference 8. The same derating factors for conduit and cable tray installations were applied for PNPP power cable configurations (worst case bounding).

Specific calculations used for applying overall power cable derating factors were performed consistent with References 2, 3, and 4 to address aspects of required power cable derating, the type/method of raceway installation, and the additional derating required due to Thermo-Lag installations. A typical calculation for a conduit is shown at the end of this attachment. The complete calculation which addresses each cable configuration utilized at PNPP is available onsite for NRC review.

Conclusion

The ampacity margins for PNPP 600 V and 5 kV rated power cables were found to be positive. This indicates that power cables routed in cable trays and conduits protected by Thermo-Lag fire barriers are adequately sized at PNPP.

Control cables were excluded from the calculation. Control cables were reviewed and a sample was selected, based on worst case conditions, for calculations of their ampacity margins. These control cables are used for intermittent or continuous operation to indicate or change the operating status of equipment. The positive margins indicate that the control cables routed in cable trays and conduits protected by Thermo-Lag fire barriers are adequately sized at PNPP.

A sample of cables supplying loads with operating duration less than 120 seconds, (e.g., MOVs), was selected for calculation of their ampacity margins. Several equipment items with less than 120 seconds operating time were evaluated to examine the impact on the steady state operating temperature of the cables protected by Thermo-Lag fire barriers. The positive margins indicate that the cables supplying loads of short operating duration are adequately sized at PNPP.

Instrumentation cables are excluded from this calculation. They are not sized on the basis of ampacity. They carry very low current in the milli-amp range. Therefore, the Thermo-Lag fire barriers have no impact on the ampacity of these cables.

The design criteria for selection of cable size at PNPP is conservative because selection of cables considers other factors such as allowable overloads, voltage drops, short circuit considerations, and worst case route ampacity.

Typical Ampacity Derating Calculation for a Conduit

The general approach utilized in these calculations was as follows:

1. Obtain the ampacity value from the appropriate industry standard, accounting for environmental conditions, such as equipment temperature, ambient temperature, cable type, and raceway construction.

2. If applicable, ampacities of cables routed in conduit are derated, based on NFPA 70 Table 310-16 Note 8 "Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway."

3. Apply an additional derating factor to account for the presence of Thermo Lag, utilizing data provided in Reference 6 and Reference 7. This factor is 31.5% for cables in a tray and 21% for cables in conduit.

4. Calculate the ampacity margin.

The following is a sample calculation for conduit number 1R33F0103B, which contains seven cables.

Type of Cable in this Conduit	Number of Cables	B/M Number	Cable Class	Circuit Number
A	1	EKA-72	3/C #6	1M39F6B
B	1	EKA-75	3/C #12	1E12F8B
C	2	EKB-12	2/C #14	
D	2	EKB-16	9/C #14	
E	1	EKC-11	STP #16	

As previously stated, a random sampling of cables supplying loads with operating duration less than 120 seconds (types C and D) was selected for calculation of their ampacity margins. Their positive margins indicated that the cables supplying loads of short operating duration are adequately sized at PNPP, and therefore, are excluded from this calculation. In addition, instrumentation cables (type E) are excluded from this calculation because they are not sized on the basis of ampacity. They carry low current in the milli-amp range and the Thermo-Lag fire barriers have no impact on the ampacity of these cables. Therefore, the only cables included in the derating calculation for this conduit were types A and B.

For circuit 1M39F6B, from standard ICEA P-46-426, Page 313 (Reference 3), for #6 AWG, 90°C conductor, 40°C ambient temperature, the cable ampacity rating is 69 amps. From standard National Electric Code (NEC) Table 70-196-8, the adjustment factor is 0.8 for 6 energized/current carrying conductors in conduit.

Using methodology provided in Reference 2, the cable ampacity adjusted for multiple conductors within the conduit is:

$$\text{Cable Ampacity} \times \text{Adjustment Factor} = \text{Corrected Cable Ampacity}$$

$$69 \text{ amps} \times 0.8 = 55.2 \text{ amps}$$

The percent margin between cable ampacity and full load current rating is determined for the cable with and without a Thermo-Lag fire barrier in place. For this cable, the actual conductor load based on equipment FULL LOAD AMPERE (FLA) ratings is 25 amps. The load factor is 1.0 for resistive loads and 1.1 for other loads.

$$\%\text{ Margin Without Thermo-Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\%\text{ Margin Without Thermo-Lag} = \frac{55.2 - (25 \times 1.1)}{55.2} = 50\%$$

Applying the additional derating factor (0.21 for cables in conduit, as stated in step 3 to account for the presence of Thermo-Lag, the ampacity with Thermo-Lag is:

$$\text{Ampacity With Thermo-Lag} = (\text{Cable Ampacity}) \times (1 - \text{Derating Factor})$$

$$\text{Ampacity With Thermo-Lag} = 55.2 \text{ amps} \times (1 - 0.21) = 43.6 \text{ amps}$$

$$\%\text{ Margin With Thermo-Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\%\text{ Margin With Thermo-Lag} = \frac{43.6 - (25 \times 1.1)}{43.6} = 37\%$$

Similarly, for circuit 1E12F8B, from Gilbert Associates Incorporated (GAI) Design Criteria Table 2.7-2 and 2.7-6, the ampacity for #12 AWG, 90°C conductor, 40°C ambient temperature is 20 amps. (Note: ICEA P-46-426 does not cover #12 AWG conductor.) The adjustment factor from NEC Table 70-196-8 is 0.8 for 6 energized/current carrying conductors in conduit

The cable ampacity adjusted for multiple conductors within the conduit is:

$$\text{Cable Ampacity} \times \text{Adjustment Factor} = \text{Corrected Cable Ampacity}$$

$$20 \text{ amps} \times {}' = 16.0 \text{ amps}$$

The percent margin between cable ampacity and full load current rating is determined for the cable with and without a Thermo-Lag fire barrier in place. For this cable, the actual conductor load based on equipment FLA ratings is 6.6 amps. The load factor is 1.0 for resistive loads and 1.1 for other loads.

$$\%\ \text{Margin Without Thermo-Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\%\ \text{Margin Without Thermo-Lag} = \frac{16.0 - (6.6 \times 1.1)}{16.0} = 54\%$$

Applying the additional derating factor to account for the presence of Thermo Lag, the ampacity with Thermo-Lag is:

$$\text{Ampacity With Thermo-Lag} = (\text{Cable Ampacity}) \times (1 - \text{Derating Factor})$$

$$\text{Ampacity With Thermo-Lag} = 16.0\ \text{amps} \times (1 - 0.21) = 12.6\ \text{amps}$$

$$\%\ \text{Margin With Thermo-Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\%\ \text{Margin With Thermo-Lag} = \frac{12.6 - (6.6 \times 1.1)}{12.6} = 42\%$$

Chemical Composition of Thermo-Lag 330-1

References

1. NRC Generic Letter (GL) 92-08, Thermo-Lag 330-1 Fire Barriers.
2. Letter from D. Shelton (Centerior) to NRC dated 02/11/94, Response to 10CFR50.54(f) Request for Additional Information Regarding Generic Letter 92-08, Thermo-Lag 330-1 Fire Barriers (PY-CEI/NRR-1750L).
3. NRC Letter to D. Shelton (Centerior) dated 12/23/94, Follow-up to the Request for Additional Information Regarding Generic Letter 92-08, Issued Pursuant to 10 CFR 50.54(f), Perry Nuclear Power Plant, Unit No. 1 (PY-NRR/CEI-0754L).
4. Letter from D. Shelton (Centerior) to NRC dated 03/22/95, Response to the Follow-up to the Request for Additional Information Regarding Generic Letter 92-08, Issued Pursuant to 10 CFR 50.54(f), Thermo-Lag 330-1 Fire Barriers (PY-CEI/NRR-1926L).
5. NRC Information Notice (IN) 95-27, NRC Review of Nuclear Energy Institute "Thermo-Lag 330 1 Combustibility Evaluation Methodology Plant Screening Guide."

Summary

In Reference 3, the NRC requested information regarding the chemical composition of the Thermo-Lag 330-1 fire barrier materials installed at the Perry Nuclear Power Plant (PNPP). As stated in the response to this NRC request (Reference 4), representative samples of both trowelable grade and preformed Thermo-Lag 330-1 used at Perry were contributed to a chemical testing program coordinated by the Nuclear Energy Institute (NEI). This was to ensure that the fire barrier materials installed at PNPP are representative of the materials that were used by the industry to address technical issues.

Details

The chemical testing program consisted of a pyrolysis gas chromatography analysis of 169 samples from participating utilities to assess organic composition, and an energy dispersive x-ray spectroscopy of 33 samples to assess inorganic chemical composition. The sample population consisted of materials manufactured between 1982 and 1995. On the basis of these tests, NUCON International, Inc., the testing laboratory, concluded that the samples contained the constituents identified by Thermal Science Inc., as essential to fire barrier performance. NUCON also determined that the composition of the sample population was consistent. A copy of the summary report has been provided to the NRC by NEI.

The submitted PNPP samples were found to be consistent in terms of chemical composition with the other utility samples. Selected summary pages of the NUCON report for the submitted samples is contained at the end of this attachment, however the Figures and Tables referenced by NUCON that contain technical details are not included. The complete report is available at PNPP for review. The high degree of chemical consistency adequately demonstrates that the materials used at PNPP are equivalent to the materials tested in the industry fire endurance tests. The consistent chemical test results from the broad population of Thermo-Lag samples also validates the position that five samples from PNPP is adequate.

Regarding the combustibility and flame spread characteristics of Thermo-Lag materials, the appropriate information has been incorporated into the combustible loading analysis for PNPP.