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Docket Number 50-346

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United States Nuclear Regulatory Commission
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Subject: Evaluation of Ampacity Issues Related to Thermo-Lag 330-1 Fire Barriers

Ladies and Gentlemen:

On June 26, 1996, Toledo Edison (TE) submitted a letter to the Nuclear Regulatory Commission (NRC) addressing the ampacity derating issue with respect to Thermo-Lag 330-1 fire barriers installed at the Davis-Besse Nuclear Power Station (DBNPS). This letter (TE Serial Number 2381) was in response to the NRC's requests for additional information dated October 11, 1995 (TE Log Number 4627) and June 20, 1996 (TE Log Number 4864) regarding Generic Letter (GL) 92-08, "Thermo-Lag 330-1 Fire Barr.ers." On October 9, 1996 (TE Log Number 4927), the NRC provided TE with a request for additional information relative to the June 26, 1996 submittal. Toledo Edison submitted a response on November 5, 1996 (TE Serial Number 2410). Additional discussions were held during a conference call with the NRC Staff on January 14, 1997, and during a meeting with the NRC Staff on April 3, 1997.

During the April 3, 1997 meeting, TE stated that there is adequate ampacity margin for the Thermo-Lag installations, even considering the need to incorporate additional conservatisms as a result of the discussions with the NRC Staff. Toledo Edison indicated that the associated calculations would be revised to include the load factor for different types of equipment, and to account for conduit grouping factors. The revisions to these calculations have been completed.

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Enclosed is an update of the evaluation of ampacity issues related to Thermo-Lag 330-1 fire barriers for the DBNPS, which was previously provided in the June 26, 1996 letter. This updated evaluation is based on the aforementioned revised calculations and completely supersedes the previous evaluation. However, the previous conclusion remains unchanged: there is adequate margin to accommodate the ampacity derating due to application of Thermo-Lag 330-1, from the time it was installed to the time it is eventually removed, such that the insulation properties of the protected cables are not adversely impacted.

Toledo Edison considers its activities regarding the ampacity derating issue with respect to installed Thermo-Lag 330-1 fire barriers to be complete. The associated calculations are available on-site for NRC review.

As stated in previous correspondence, TE has awarded a contract to Peak Seals Incorporated to perform Thermo-Lag replacement using 3M Company Interam materials for one-hour and three-hour rated fire barriers and for radiant energy shields. Toledo Edison will use test data for the alternate material to confirm that there is adequate margin to accommodate the ampacity derating due to application of the alternate material, and will revise the applicable plant-specific calculations. These activities will be conducted in conjunction with the plant modification process for the fire barrier replacement activities.

Should you have any questions or require additional infonnation, please contact Mr. James L. Freels, Manager - Regulatory Affairs, at (419) 321-8466.

Very truly yours,

John K Wood

MKL/laj

Enclosure

cc: A. B. Beach, Regional Administrator, NRC Region III
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S. Stasek, DB-1 NRC Senior Resident Inspector
Utility Radiological Safety Board

Docket Number 50-346
License Number NPF-3
Serial Number 2474
Enclosure

UPDATED EVALUATION

OF

AMPACITY ISSUES RELATED TO THERMO-LAG 330-1
FIRE BARRIERS

FOR

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NUMBER 1

This letter is submitted pursuant to 10 CFR 50.54(f). The attachment updates and completely supersedes the Toledo Edison June 26, 1996 response to the October 11, 1995 and June 20, 1996 NRC requests for additional information regarding ampacity derating parameters for the installed Thermo-Lag fire barriers.

By: John K. Wood
J. K. Wood, Vice President, Nuclear

Sworn and Subscribed before me this 10th day of September, 1997.

Nora Lynn Flood
Notary Public, State of Ohio
Nora Lynn Flood, My Commission expires
September 4, 2002.

UPDATED EVALUATION

OF

AMPACITY ISSUES RELATED TO THERMO-LAG 330-1 FIRE BARRIERS

FOR

DAVIS-BESSE NUCLEAR POWER STATION UNIT NUMBER 1

I. Background

The operating temperature of an electrical conductor is proportional to the electric current carried by the conductor. The maximum allowable current that an electrical conductor can carry without exceeding the maximum rated continuous temperature of the cable is termed the cable ampacity. Increased cable insulation temperature could lead to premature insulation failure.

Cable ampacity is a function of cable type, raceway construction, extent of cable fill in the raceway, the presence of an insulating material such as a fire barrier, ambient temperature, and proximity to other raceways.

A Toledo Edison (TE) letter dated June 13, 1995 (TE Serial Number 2298) listed the raceway applications at the Davis-Besse Nuclear Power Station (DBNPS) which utilize Thermo-Lag 330-1 fire wrap material, including one-hour-rated fire barrier applications for conduit, three-hour-rated fire barrier applications for conduit, and one-half-hour-rated radiant energy shield applications. Thermo-Lag 330-1 is not utilized in cable tray applications at the DBNPS.

A TE letter dated February 20, 1996 (TE Serial Number 2358) discussed plans to remove all existing Thermo-Lag and replace it with an alternate material. For some circuits, reanalysis has eliminated the requirement for fire barrier protection, such that the Thermo-Lag can be either removed or abandoned in place, without the need for replacement with an alternate material. Thermo-Lag fire barriers on conduits with power circuits which no longer require fire barrier protection will be removed.

Where an alternate material is applied, TE will confirm via test data that there is adequate margin to accommodate the ampacity derating due to application of the alternate material.

Since the application of an alternate material will be shown to be acceptable from an ampacity standpoint, this evaluation focuses on verification that the application of

Thermo-Lag is acceptable from an ampacity standpoint, such that the insulation properties of the protected cables have not been adversely impacted.

Ampacity is an important consideration for power circuits. Instrumentation and control circuits typically carry low current in relation to cable size, such that ampacity is not a concern. The attached Table 1 lists the power circuit cables which are routed in conduits protected by a Thermo-Lag fire barrier or routed through a radiant energy shield constructed of Thermo-Lag. Portions of these circuits are also protected by 3M Company fire barrier material.

Many of the cables listed in Table 1 are not required to be enclosed in a fire barrier, but were enclosed because they are in the vicinity of cables that are required to be enclosed per 10 CFR 50 Appendix R.

II. Initial Cable Ampacity Derating Calculations

For each of the cables listed in Table 1, an ampacity derating calculation was performed to support the initial Thermo-Lag installation. These calculations determined that the cable ampacity was acceptable. The general approach utilized in these calculations was as follows:

1. Obtain the "base" ampacity value from the appropriate industry standard.

2. Correct the base ampacity value to account for the difference between the ambient temperature for which the base ampacity value is valid (typically 30°C or 40°C) and the normal design temperature for the plant area in which the cable is located, utilizing the appropriate factor provided in the industry standard.

3. Apply an additional derating factor to account for multiple conductors within the raceway, if applicable, utilizing the appropriate factor provided in the industry standard.

4. Apply as additional derating factor to account for the conduit grouping factor, as applicable for groups of closely spaced conduits, utilizing the appropriate factor provided in the industry standard.

5. Apply an additional derating factor to account for the presence of the fire barrier, utilizing data provided by the fire barrier manufacturer.

6. Confirm that the resulting (derated) ampacity exceeds the load the cable carries. Load currents for motors are based on 125% of nameplate ratings.

The ampacity derating factors for the Thermo-Lag fire barrier material were originally obtained from test data provided by Thermal Science Incorporated (TSI), the Thermo-Lag manufacturer. The ampacity derating factors for conduits provided by TSI for one-hour-rated and three-hour-rated thicknesses of fire wrap were 7.68% (Reference 5) and 9.72% (Reference 6), respectively. However, a December 23, 1994 NRC letter (TE Log Number 4464) raised concerns on the reliability of information and data supplied by TSI. Accordingly, as will be discussed in the following sections, this evaluation does not rely on these TSI-provided ampacity derating factors, and instead utilizes recent industry test data.

The ampacity derating factor for the 3M fire barrier material was obtained from test data supplied by the manufacturer, 3M Company. The ampacity derating factor for conduits provided by 3M for a one-half-hour-rated thickness of fire wrap was 19.5% (Reference 8).

III. Applicability of Industry Test Data to DDNPS

A. One-Half-Hour and One-Hour-Rated Applications

Texas Utilities Electric Company (TUE) initiated an ampacity derating test program to demonstrate the acceptability of the use of Thermo-Lag material at the Comanche Peak Steam Electric Station (CPSES), Unit 2. The test results are contained in a report from Omega Point Laboratories, San Antonio, Texas (Reference 9). The TUE ampacity test program and results were reviewed by the NRC and a Safety Evaluation Report (SER) was issued on June 14, 1995 (Reference 10).

The TUE testing included cabling in 3/4", 2", and 5" conduit sizes. The DBNPS one-half-hour and one-hour-rated configurations compare favorably with these tested configurations, as summarized in Table 2. The 3" conduit size is enveloped by the sizes tested. The tested configurations have an equal or slightly greater thickness of Thermo-Lag material than the DBNPS configurations, which is conservative. The use of the 350 topcoat on the tested configurations would most likely be slightly conservative. As indicated in Table 2, the DBNPS configurations use the 350 topcoat only on applications located in the containment and the containment annulus. As also indicated in Table 2, the tested configurations were an "upgrade" design, with additional material applied at joints and seams. This should also be conservative.

The Omega Point Laboratories test report provided the following test results:

conduit size (inches)	ampacity derating factor (%)
3/4	9.34
2	6.67
5	10.7

The NRC SER required CPSES Unit 2 to apply an additional 10% factor to the bounding 11% ampacity derating factor, resulting in a total 21% ampacity derating factor, to bound test protocol uncertainties identified after the tests were completed. In addition, the NRC SER required application of a total 30% ampacity derating factor for a conduit/cable tray configuration which was not tested.

B. Three-Hour-Rated Applications

The Tennessee Valley Authority (TVA) also initiated ampacity derating testing with Omega Point Laboratories (Reference 11).

The TVA testing included cabling in 1" and 4" conduit sizes. The DBNPS three-hour-rated configurations compare favorably with these tested configurations, as summarized in Table 3. The 4" conduit size is enveloped by the sizes tested. The tested configuration includes an overlay of Thermo-Lag 770-1 mat material, however, this upgrade configuration should be conservative. As noted in Table 3, a 350 topcoat is applied to a small length of Thermo-Lag in Room 114, however no topcoat was utilized in the tested configurations. This difference would likely be slightly less conservative, but should have only a minimal affect on results. The tested configurations utilized post-caulking of the joints and seams rather than pre-caulking. This would not be expected to have an appreciable effect on results since all gaps were filled in. The overlay applied should also serve to prevent any vent paths.

The Omega Point Laboratories test report provided the following test results:

conduit size (inches)	ampacity derating factor (%)
1	10
4	13

Based on discussions with the TVA Staff, in order to support licensing of their Watts Bar Station, TVA applied an additional 5% factor to the bounding 13% ampacity derating factor, resulting in a total 18% ampacity derating factor, to bound various test uncertainties.

C. Screening Criteria

Utilizing the TUE and TVA test data, a set of screening criteria was developed for ampacity derating for DBNPS Thermo-Lag applications, as described below.

As noted in Section III.A, the ampacity derating factor applicable for one-hour-rated applications is 21%. This value is also considered conservatively applicable for box configurations such as the one-half-hour rated radiant energy shields located in the containment annulus, since the larger surface area of the boxes would improve heat transfer. For a stacked conduit configuration, it would be appropriate to use a 30% ampacity derating factor, corresponding to the value utilized by TUE for conduit/cable tray configurations. These values include at least 10% margin to account for uncertainties including test protocol, and should serve as adequate screening criteria for the DBNPS one-half-hour and one-hour-rated conduit applications.

As noted in Section III.B, the ampacity derating factor applicable for three-hour-rated applications is 18%, which includes a 5% margin to account for test uncertainties. For additional conservatism, this value was increased by an additional 10%, for a total ampacity derating factor of 28%. This value will serve as the screening criteria for the DBNPS three-hour-rated conduit applications. For a stacked conduit configuration an additional 9% margin is added, similar to the margin added for one-hour-rated stacked conduit configurations, resulting in a screening criteria of 37% for three-hour-rated stacked conduit applications.

The screening criteria applicable for each DBNPS cable application is provided in the "Barrier Derate %" column of Table 1. As will be described in Section IV, these screening criteria are used to determine applications which require further evaluation.

IV. Updated Cable Ampacity Derating Calculations

The ampacity calculations were revised based on the use of the new screening criteria derived from the TUE and TVA test data. The results are shown in Table 1.

The asterisked footnote in Table 1 indicates that certain listed power cables are actually electrical penetration "pigtails" installed between certain cable numbers in the containment annulus (Room 127). These "pigtails" are single conductors of the same size, or larger, as the cables that they join. All other power cables listed in Table 1 are triplexed cable with ground, installed in conduit.

The "base" ampacity values and applicable equations and factors were obtained from IPCEA P-46-426, "Power Cable Ampacities, Volume 1 - Copper Conductors." For the triplexed cable in conduit, the table on page 264 of the IPCEA Standard is appropriate. This table provides baseline ampacity values for triplexed coppe. conductor concentric stranded rubber insulated cable in conduit for 40° ambient air. For the single conductor pigtails in the containment annulus, different tables are utilized, depending on whether the radiant energy shield enclosing the penetration pigtails is a four-sided box configuration (i.e., completely enclosed) or a three-sided box configuration (i.e., open at the top). For the three-sided box configuration application, the table on page 215 of the IPCEA Standard is appropriate. This table provides baseline ampacity values for single copper conductor concentric stranded rubber insulated cable in 40°C ambient air (no conduit). For the four-sided box configuration, a single conductor in conduit ampacity value would be appropriate, however the IPCEA Standard does not include a table for this configuration. Therefore the table on page 264 is utilized. As described above, this table is for triplexed cable in conduit. However the ampacity value of the triplexed cable should be conservative compared to single conductor cable.

IPCEA P-46-426, Section II.B, Equation 5a was used to correct the base ampacity value to account for the difference between the ambient temperature for which the base ampacity value is valid and the normal design temperature for the plant area where the cable is located.

The baseline ampacity values prov...d in the IPCEA ampacity tables also require adjustment to account for the difference between the number of conductors for which the base ampacity value is valid and the number of conductors present in the particular application. Table B-310-11 of the National Electric Code (NEC) or IPCEA Table VIII, which provide similar derating valves, were used. Load diversity was credited, as appropriate. For triplex cable with ground, the ground is not a current-carrying conductor. Hence an adjustment to account for an extra conductor is not required.

As applicable for groups of closely spaced conduits, where the spacing between conduit surfaces is not greater than the conduit diameter or less than 1/4 of the conduit diameter, an additional derating factor was applied to the baseline ampacity values, utilizing the appropriate grouping factor provided in IPCEA Table IX.

The resulting derated ampacities were compared to the load currents. As previously noted, load currents for motors are based on 125% of nameplate ratings. As a result of this review, several cables were identified which had load currents in excess of their derated ampacities calculated using the screening criteri.. The acceptability of these applications were further evaluated, as summarized below.

A. <u>Electrical Penetration Pigtail Between Cable Numbers 1PBE1401B and 1PBE1401D in Room 127 (Containment Annulus)</u>

Cables 1PBE1401B and 1PBE1401D are part of the circuit which supplies power for high speed operation of the Containment Air Cooler (CAC) 1-1 fan. There are three installed CAC fans, however, during normal operation, only two CAC fans are operated in high speed to cool the containment atmosphere by circulating air through cooling coils. The CAC fans selected to be running are chosen so as to even out the running time of each. During accident conditions, the fans are automatically switched to low speed operation. The low speed circuit utilizes a separate set of cables.

Cable 1PBE1401B is routed through Rooms 314 and 429 of the auxiliary building. Cable 1PBE1401D is routed through Rooms 217 and 317 of the containment building. A pigtail connects these cables at electrical penetration P1P3B, which is enclosed by a one-half-hour rated radiant energy shield, in a four-sided box arrangement. Cable 1PBE1401B is not required to be protected by a fire barrier in Room 429.

As noted in Table 1, the pigtail is a 3-1 conductor 250 Kcmil power cable. This cable is rated at 90°C. The baseline ampacity for this application, 317.0 amps, is for triplex cable in conduit in 40°C ambient air, taken from page 264 of the IPCEA Standard (Reference 3). No temperature derate is required since the design temperature of the annulus is also 40°C.

There are several additional power cable pigtails routed through electrical penetration P1P3B and included within the radiant energy shield enclosure. Including the CAC 1-1 fan high speed power cable pigtail, there are a total of 18 power conductors routed through the penetration. The pigtails exit the annulus through short lengths of pipe and conduit, however, in the middle, they are routed in free air and are unsupported. The pigtails are not wrapped or bundled together, therefore for the most part, there is free air space between them. Based on Table B-310-11 of the NEC (Reference 4), the baseline ampacity must be reduced to 70% (derated by 30%) when there is between 10 and 24 conductors present. This results in a derated ampacity of 221.9 amps (317.0 amps x 70%).

A 21% screening criteria is applied to account for derating due to the one-half-hour rated radiant energy shield. This results in a final derated ampacity of 175.3 amps (221.9 amps x 79%), which is approximately 23% lower than the 226.2 amp load current for the CAC 1-1 fan motor. The final derated ampacity is approximately 3% lower than the nameplate load current for the motor of 181.0 amps.

The calculated ampacity for this power circuit is most limiting for the short portion of the circuit in the containment annulus, due to the required derate due to the multiple conductors. The multiple conductor derate is not applicable for this power circuit outside the annulus, hence the ampacity for the remainder of the circuit is higher. Article 310-15 (c) of the NEC (Reference 4) permits the use of a higher ampacity for the circuit, where two different ampacities apply to adjacent portions of the circuit, provided that the distance involved is equal to 10 feet or 10% of the circuit length figured at the higher ampacity, whichever is less. This exception would apply to this application, allowing the use of a higher ampacity for this circuit, calculated for the portions of the circuit routed in conduits in the auxiliary building and the containment. As noted in Table 1, the derated ampacity values for cable 1PBE1401D in Rooms 217 and 317 of the containment building are 250.4 and 247.9 amps, respectively, and the derated ampacity value for cable 1PBE1401B in Room 314 of the auxiliary building is 250.4 amps. Each of these values compare favorably with the 226.2 amp load current.

There are numerous conservatisms in the ampacity calculation for this circuit. The IPCEA ampacity table value includes built-in conservatism. In addition, the fire barrier screening criteria includes at least 10% margin. Also, the actual ambient temperature for the annulus would be somewhat less than the continuous 40°C value assumed in the calculation. Finally, the normal running current for the fan motor would be somewhat less than the nameplate value of 181.0 amps assumed in the calculation. The running current for the CAC 1-1 fan motor was recently measured to be approximately 154 amps (Reference 19). It is also important to note that since there are three CAC fans but only two are normally operated, the CAC 1-1 fan motor circuit will not be continuously energized.

Based on the above factors, it is concluded that the long-term effect of cable insulation degradation due to ampacity heating is not present.

B. <u>Electrical Penetration Pigtail Between Cable Numbers 2PBF1401B and 2PBF1401D in Room 127 (Containment Annulus)</u>

Cables 2PBF1401B and 2PBF1401D are part of the circuit which supplies power for the Containment Air Cooler (CAC) 1-2 fan high speed circuit. Operation of the CAC fans is described above.

Cable 2PBF1401B is routed through Rooms 427 and 428 of the auxiliary building. Cable 2PBF1401D is routed through Rooms 217, 317, and 410 of the containment building. A pigtail connects these cables at electrical penetration P2P5F, which is enclosed by a one-half-hour rated radiant energy shield on three sides of a box arrangement. The box is open at the top. The only portion of the circuit required to be protected by a fire barrier is the electrical penetration pigtail in the containment annulus.

As noted in Table 1, the pigtail is a 3-1 conductor 250 Kcmil power cable. This cable is rated at 90°C. The baseline ampacity for this application, 445.0 amps, is for single conductor cable in 40°C ambient air, taken from page 215 of the IPCEA Standard (Reference 3). No temperature derate is required since the design temperature of the annulus is also 40°C.

There are several additional power cable pigtails routed through electrical penetration P2P5F and included within the radiant energy shield enclosure. Including the CAC 1-2 fan high speed power cable pigtail, there are a total of 62 power conductors routed through the penetration. The pigtails exit the annulus through short lengths of pipe and conduit, however, in the middle, they are routed in free air and are unsupported.

The pigtails are not wrapped or bundled together, therefore for the most part, there is free air space between them. Based on Table B-310-11 of the NEC (Reference 4), the baseline ampacity must be reduced to 50% (derated by 50%) when there is more than 43 conductors present. This results in a further derated ampacity of 222.5 amps (445.0 amps x 50%).

A 21% screening criteria is applied to account for derating due to the one-half-hour rated radiant energy shield. This results in a final derated ampacity of 175.8 amps (222.5 x 79%), which is approximately 22% lower than the 226.3 amp load current for the CAC 1-2 fan motor. The final derated ampacity is approximately 3% lower than the nameplate load current for the motor of 181.0 amps.

As noted above, the radiant energy shield enclosure is open at the top. This provides a pathway for removal of heat generated within the enclosure, via natural convection. Hence the application of the 21% fire barrier screening criteria is very conservative. In addition, the IPCEA ampacity table value includes built-in conservatism. Also, the actual ambient temperature for the annulus would be somewhat less than the continuous 40°C value assumed in the calculation.

The NEC exception discussed above for the CAC 1-1 fan circuit also applies to this application, allowing the use of a higher ampacity for the CAC 1-2 circuit, calculated for the portions of the circuit routed in the auxiliary building and the containment. The most limiting ampacity for this circuit, outside the annulus, is 334.6 amps (Reference 17). This value compares favorably with the 226.3 amp load current.

In addition to the above mentioned conservatisms, it is also important to note that the normal running current for the fan motor would be somewhat less than the nameplate value of 181.0 amps assumed in the calculation. The running current for the CAC 1-2 fan motor could be reasonably expected to be similar to the measured current of 154 amps for the CAC 1-1 fan motor, since the motors are of similar design. It is also important to note that since there are three CAC fans but only two are normally operated, the CAC 1-2 fan motor circuit will not be continuously energized.

Based on the above factors, it is concluded that the long-term effect of cable insulation degradation due to ampacity heating is not present.

C. <u>Cable Number 3PBEF15D in Room 410 (Containment Building)</u>

Cable 3PBEF15D is part of the circuit which supplies power for the Containment Air Cooler (CAC) 1-3 fan high speed circuit. Operation of the CAC fans is described above. Cable 3PBEF15D is routed through Rooms 217, 317, and 410 of the containment building.

As noted in Table 1, the cable is a 3-1 conductor 250 Kcmil power cable with one #2 ground. This cable is rated at 90°C. The baseline ampacity for this application, 317.0 amps, is taken from page 264 of the IPCEA Standard (Reference 3). This baseline ampacity is for triplexed cable routed in conduit in 40°C ambient air. Since the design ambient temperature in Room 410 is 143°F (61.7°C), a correction factor of 0.752 (calculated using equation 5a on page III of the IPCEA Standard) is applied to the baseline ampacity, resulting in a derated ampacity of 238.4 amps (317.0 amps x 0.752).

A 21% screening criteria is applied to account for derating due to the one hour rated fire barrier. This results in a final derated ampacity of 188.3 amps (238.4 x 79%), which is approximately 20% lower than the 235.0 amp load current for the CAC 1-3 fan motor. The final derated ampacity is slightly greater than the nameplate load current for the motor of 188.0 amps.

The NEC exception discussed above for the CAC 1-1 fan circuit also applies to this application, allowing the use of a higher ampacity for the CAC 1-3 circuit, 247.9 amps, calculated for the portion of the circuit routed in adjacent Room 317 of the containment (Reference 15). This value compares favorably with the 235.0 amp load current.

It is important to note that the IPCEA ampacity table value includes built-in conservatism. Also, the actual ambient temperature for Room 410 would be expected to be somewhat less than the continuous 61.7°C value assumed in the calculation.

It is also important to note that the normal running current for the fan motor would be somewhat less than the nameplate value of 188.0 amps assumed in the calculation. The running current for the CAC 1-3 fan motor could be reasonably expected to be similar to the measured current of 154 amps for the CAC 1-1 fan motor, since the motors are of similar design. It is also important to note that since there are three CAC fans but only two are normally operated, the CAC 1-3 fan motor circuit will not be continuously energized.

Based on the above factors, it is concluded that the long-term effect of cable insulation degradation due to ampacity heating is not present.

D. Electrical Penetration Pigtail Between Cable Numbers BPBF1113A and BPBF1113B in Room 127 (Containment Annulus)

Cables BPBF1113A and BPBF1113B are part of the circuit which supplies power for Containment Recirculation Fan 1-2. This fan is one of two redundant fans that provide mixing of the containment air during normal plant operation by circulating the hot upper containment air. These fans are non-Q and [illegible] not needed for 10 CFR 50 Appendix R purposes, therefore the circ[illegible] [illegible]ed to be enclosed in a fire barrier. The portion of the circuit consisting of the pigtail in the containment annulus is enclosed in a fire barrier only because it is routed through an electrical penetration through which other cables that are required to be enclosed in a fire barrier are routed.

Cable BPBF1113A is routed through Room 427 of the auxiliary building. Cable BPBF1113B is routed through Rooms 410, 407, and 701 of the containment building. A pigtail connects these cables at electrical penetration P2P5F, which is enclosed by a one-half-hour rated radiant energy shield on three sides of a box arrangement. The box is open at the top. The only portion of the circuit which is protected by a fire barrier is the electrical penetration pigtail in the containment annulus, and as noted above, this portion of the circuit is not required to be protected.

As noted in Table 1, the pigtail is a 3-1 conductor #2 power cable. This cable is rated at 90°C. The baseline ampacity for this application, 192.0 amps, is for single conductor cable in 40°C ambient air, taken from page 215 of the IPCEA Standard (Reference 3). No temperature derate is required since the design temperature of the annulus is also 40°C.

There are several additional power cable pigtails routed through electrical penetration P2P5F and included within the radiant energy shield enclosure. Including the Containment Recirculation Fan 1-2 power cable pigtail, there are a total of 62 power conductors routed through the penetration. The pigtails exit the annulus through short lengths of pipe and conduit, however, in the middle, they are routed in free air and are unsupported. The pigtails are not wrapped or bundled together, therefore for the most part, there is free air space between them. Based on Table B-310-11 of the NEC (Reference 4), the baseline ampacity must be reduced to 50% (derated by 50%) when there is more than 43 conductors present. This results in a further derated ampacity of 96.0 amps (192.0 amps x 50%).

A 21% screening criteria is applied to account for derating due to the one-half-hour rated radiant energy shield. This results in a final derated ampacity of 75.8 amps (96.0 x 79%), which is only slightly lower than the 76.3 amp load current for the fan motor. The final derated ampacity is approximately 24% greater than the nameplate load current for the motor of 61.0 amps.

As noted above, the radiant energy shield enclosure is open at the top. This provides a pathway for removal of heat generated within the enclosure, via natural convection. Hence the application of the 21% fire barrier screening criteria is very conservative. In addition, the IPCEA ampacity table value includes built-in conservatism. Also, the actual ambient temperature for the annulus would be somewhat less than the continuous 40°C value assumed in the calculation.

The NEC exception discussed above for the CAC 1-1 fan circuit also applies to this application, allowing the use of a higher ampacity for the Containment Recirculation Fan 1-2 circuit, calculated for the portions of the circuit routed in the auxiliary building and the containment. The most limiting ampacity for this circuit, outside the annulus, is 113.3 amps (Reference 17). This value compares favorably with the 76.3 amp load current.

Based on the above factors, it is concluded that the long-term effect of cable insulation degradation due to ampacity heating is not present.

V. Conclusions

The conclusion of this evaluation is that there is adequate margin to accommodate the ampacity derating due to application of Thermo-Lag 330-1, from the time it was installed to the time it is eventually removed, such that insulation properties of the protected cables are not adversely impacted.

Calculations performed in support of this evaluation are available on-site for NRC review.

VI. References

1. Toledo Edison (TE) letter to NRC dated June 13, 1995 (TE Serial Number 2298).

2. TE letter to NRC dated February 20, 1996 (TE Serial Number 2358).

3. IEEE Standard S-135-1-62, IPCEA (now ICEA) Standard P-46-426, "Power Cable Ampacities, Volume 1 - Copper Conductors, Third Printing."

4. National Electric Code (NEC), NFPA 70, 1996.

5. Thermal Science Incorporated (TSI) Technical Note 111781, "Engineering Report on Ampacity Test for 600 Volt Power Cables Installed in a Five Foot Length of Two Inch Conduit Protected With Thermo-Lag 330-1 Subliming Coating Envelope System," 5th Revision, February, 1985.

6. Industrial Testing Laboratories (ITL) Report Number 84-10-5, "Engineering Report on an Ampacity Test for 600 Volt Power Cables Installed in a Five Foot Length of Two Inch Conduit Protected with a Three Hour Fire Rated Design of the Thermo-Lag 330 Fire Barrier System," October, 1984.

7. NRC letter to TE dated December 23, 1994 (TE Log Number 4464).

8. 3M Company letter to TE dated March 9, 1989, "3M Ampacity Test Results on Conduit Protected with 3M Interam E-50A Mat."

9. Omega Point Laboratories Report No. 12340 - 94583, 95165 - 95168, 95246, "Ampacity Derating of Fire Protected Cables," March 19, 1993.

10. NRC letter to Texas Utilities Electric dated June 14, 1995, "Safety Evaluation of Ampacity Issues Related to Thermo-Lag Fire Barriers at Comanche Peak Steam Electric Station, Unit 2 (TAC No. M85999)," (TE Log Number 4560).

11. Omega Point Laboratories Report No. 11960 - 97337 & 97338, "Ampacity Derating of Cables Enclosed in Conduits with Thermo-Lag 330-1/770-1 Upgrade Electrical Raceway Fire Barrier System (ERFBS)," August 21, 1995.

12. DBNPS Calculation Number C-EE-013.06-001, Revision 2.

13. DBNPS Calculation Number C-EE-013.06-004, Revision 2.

14. DBNPS Calculation Number C-EE-013.06-005, Revision 2.

15. DBNPS Calculation Number C-EE-013.06-008, Revision 5.

16. DBNPS Calculation Number C-EE-013.06-010, Revision 2.

17. DBNPS Calculation Number C-EE-013.06-011, Revision 2.

18. DBNPS Calculation Number C-EE-013.06-012, Revision 1.

19. Potential Condition Adverse to Quality (PCAQ) Report Number 95-0617.

Table 1

Ampacity Derating due to Thermo-Lag

Cable Number	Cable Size	Conduit Size (in.)	Room	Fire Rating (hr.)	Cable Baseline (amps)	Temperature Derate (amps)	Number of Conductors Derate (amps)	Conduit Grouping Derate (amps)	Barrier Derate %	Fire Barrier Derate (amps)	Load current (amps)
1PAC107A	3-1/C #2/0 power cable w/1 #4 ground	4.0	53	3.0	204	N/A	N/A	N/A	28.0	146.9	100.0
1PAC111A	3-1/C #2/0 power cable w/1 #4 ground	4.0	114	3.0	204	N/A	N/A	173.4	37.0	109.2	96.3
1PAC112A	3-1/C #2/0 power cable w/1 #4 ground	4.0	114	3.0	204	N/A	N/A	173.4	37.0	109.2	62.5
1PBE107B	3-1/C 500 kcmil power cable w/1 #1/0 ground	4.0	323	3.0	477	N/A	N/A	N/A	28.0	343.4	308.8
1PBE1123A & B *	3-1/C #8 power cable	Box	127	0.5	55	N/A	38.5	N/A	21.0	30.4	3.5
1PBE1202A	3-1/C 500 kcmil power cable w/1 #1/0 ground	4.0	53	3.0	477	N/A	N/A	434.1	28.0	312.5	79.8
1PBE1213A & B *	3-1/C #2 power cable	Box	127	0.5	130	N/A	91.0	N/A	21.0	71.9	50.6
1PBE1214A & B *	3-1/C #2 power cable	Box	127	0.5	130	N/A	91.0	N/A	21.0	71.9	50.6
1PBE1215A & B *	3-1/C #2 power cable	Box	127	0.5	130	N/A	91.0	N/A	21.0	71.9	50.6
1PBE1234A	3-1/C #4/0 power cable w/1 #2 ground	3.0	314	1.0	278	N/A	N/A	261.3	21.0	206.4	38.6
1PBE1401A	3-1/C #4/0 power cable w/1 #2 ground	3.0	314	1.0	278	N/A	N/A	N/A	21.0	219.6	95.0
1PBE1401B	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	314	1.0	317	N/A	N/A	N/A	21.0	250.4	226.2
1PBE1401A & C *	3-1/C 250 kcmil power cable	Box	127	0.5	317	N/A	221.9	N/A	21.0	175.3	95.0
1PBE1401C	3-1/C #4/0 power cable w/1 #2 ground	3.0	217	0.5	278	N/A	N/A	N/A	21.0	219.6	95.0
1PBE1401C	3-1/C #4/0 power cable w/1 #2 ground	3.0	317	0.5	278	275.2	N/A	N/A	21.0	217.4	95.0
1PBE1401B & D *	3-1/C 250 kcmil power cable	Box	127	0.5	317	N/A	221.9	N/A	21.0	175.3	226.2
1PBE1401D	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	217	0.5	317	N/A	N/A	N/A	21.0	250.4	226.2
1PBE1401D	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	317	0.5	317	313.8	N/A	N/A	21.0	247.9	226.2
2PBF1120A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	17.3
2PBF1121A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	1.2
2PBF1123A & B *	3-1/C #6 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	1.2
2PBF1126A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	0.5
2PBF1127A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	0.5
2PBF1130A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	18.8
2PBF1213A & B *	3-1/C #2 power cable	Box	127	0.5	192	N/A	96.0	N/A	21.0	75.8	50.5
2PBF1214A & B *	3-1/C #2 power cable	Box	127	0.5	192	N/A	96.0	N/A	21.0	75.8	50.5
2PBF1215A & B *	3-1/C #2 power cable	Box	127	0.5	192	N/A	96.[illegible]	N/A	21.0	75.8	50.5
2PBF1227A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	1.2
2PBF1228A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	1.2
2PBF1237A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	2.9
2PBF1238A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	2.9
2PBF1260A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	3.5
2PBF1285J & M *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	0.5
2PBF1401A & C *	3-1/C 250 kcmil power cable	Box	127	0.5	445	N/A	222.5	N/A	21.0	175.8	95.0
2PBF1401B & D *	3-1/C 250 kcmil power cable	Box	127	0.5	445	N/A	222.5	N/A	21.0	175.8	226.3
2PVRC21A & J *	2-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	0.4
2PVF201A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	2.4
2PVF203A & B *	3-1/C #8 power cable	Box	127	0.5	83	N/A	41.5	N/A	21.0	32.8	2.4
3PACD06A	3-1/C #2/0 power cable w/1 #4 ground	4.0	53	3.0	204	N/A	N/A	N/A	28.0	146.9	100.0
3PBEF15A	3-1/C #4/0 power cable w/1 #2 ground	3.0	427	1.0	278	N/A	N/A	N/A	21.0	219.6	106.3
3PBEF15B	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	427	1.0	317	N/A	N/A	N/A	21.0	250.4	235.0
3PBEF15C	3-1/C #4/0 power cable w/1 #2 ground	3.0	217	0.5	278	N/A	N/A	N/A	21.0	219.6	106.3
3PBEF15C	3-1/C #4/0 power cable w/1 #2 ground	3.0	317	0.5	278	275.2	N/A	N/A	21.0	217.4	106.3
3PBEF15C	3-1/C #4/0 power cable w/1 #2 ground	3.0	410	0.5	278	209.1	N/A	N/A	21.0	165.2	106.3
3PBEF15D	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	217	0.5	317	N/A	N/A	N/A	21.0	250.4	235.0
3PBEF15D	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	317	0.5	317	313.8	N/A	N/A	21.0	247.9	235.0
3PBEF15D	3-1/C 250 kcmil power cable w/1 #2 ground	3.0	410	0.5	317	238.4	N/A	N/A	21.0	188.3	235.0
8PBF1113A & B *	3-1/C #2 power cable	Box	127	0.5	192	N/A	96.0	N/A	21.0	75.8	76.3

* Electrical penetration seal installed between these cables

Table 2

Comparison of One-Hour-Rated Tested vs. Site Specific Configurations

	Tested Configuration	Davis-Besse Configuration
Conduit Sizes:	3/4", 2" & 5"	3"
Raceway material:	Galvanized steel	Galvanized steel
Thermo-Lag thickness:	1/2" nominal plus 1/4" overlay on 3/4" and 2", 1/2" nominal on 5"	0.625 +/- 0.125"
Pre-formed conduit:	Yes	Yes
Stress skin facing conduit:	Yes	Yes
350 Topcoat:	Yes	Yes, inside cntmt & annulus
Upgrade:	Yes	No
Air gaps:	Yes	Yes
Steel bands:	Yes, max 12" spacing	Yes, max 12" spacing
Pre-caulk joints and seams:	Yes	Yes

Table 3

Comparison of Three-Hour Rated Tested vs. Site Specific Configurations

	Tested Configuration	Davis-Besse Configuration
Conduit Sizes:	1" & 4"	4"
Raceway material:	Galvanized steel	Galvanized steel
Thermo-Lag thickness:	1.25" nominal Plus 3/8" overlay of Thermo-Lag 770-1 mat	1.25 +/- 0.25"
Pre-formed conduit.	Yes	Yes
Stress skin on both faces:	Yes	Yes
350 Topcoat:	No	Yes, only a small length in Room 114
Upgrade:	Yes	No
Air gaps:	Yes	Yes
Steel bands:	Yes, max 12" spacing	Yes, max 12" spacing
Pre-caulk joints and seams:	No	Yes