A Technical Evaluation of the Clinton Power Station Fire Barrier Ampacity Assessments

A Letter Report to the USNRC

Revision 0

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Prepared by:
Steve Nowlen
Sandia National Laboratories
Albuquerque, New Mexico 87185-0747
(505)845-9850

Prepared for:
Ronaldo Jenkins
Electrical Engineering Branch
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555
USNRC JCN J-2503

ATTACHMENT 1(a)

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The United States Nuclear Regulatory Commission (USNRC) has solicited the support of Sandia National Laboratories (SNL) in the review of utility submittals associated with fire protection and electrical engineering. This letter report documents the results of a SNL review of a set of submittals from the Clinton Power Station (CPS) nuclear plant. These submittals deal with the assessment of ampacity loads for cable trays and conduits protected by Thermo-Lag 330-1 fire barriers. This report represents the second in a series of reports for the CPS ampacity assessments. The original documents reviewed by SNL were submitted by the utility in response to USNRC Generic Letter 92-08. An initial review report was prepared by SNL May 16, 1996, and in August 1996 an RAI was forwarded by the USNRC to the licensee requesting resolution of the review findings. The current report focuses on an assessment of the licensee's RAI response, and on an overall assessment of the adequacy of the licensee's ampacity treatment. This work was performed as Task Order 2, Subtask 5 of USNRC JCN J-2503.

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1.0 INTRODUCTION

1.1 Background

In response to USNRC Generic Letter 92-08, the Clinton Power Station (CPS) nuclear plant provided documentation of the utility position regarding ampacity derating factors associated with its installed Thermo-Lag 330-1 fire barrier systems. This information was contained in a letter dated November 3, 1995 from J. G. Cook, Illinois Power/CPS, to the USNRC Document Control Desk, item U-602512 and included six attachments. SNL was requested to review the ampacity derating aspects of these submittals under the terms of the general technical support contract JCN J-2017, Task Order 8, Subtask 5.

A letter report documenting the results of SNL's review was submitted to the USNRC on May 16, 1996. Largely on the basis of the SNL review findings, an RAI was forwarded by the USNRC to the licensee on August 16, 1996. The licensee response to this RAI was provided on March 31, 1997.

1.2 Objectives

This letter report documents SNL's findings and recommendations resulting from a review of the licensee RAI response. The report also provides an overall assessment of the adequacy of the licensees treatment of ampacity loads for fire barrier clad cables.

It is important to note that, consistent with the statement of work for this effort, the SNL review has been limited to those portions of the utility submittals directly related to the issue of ampacity derating only. The utility submittals include documentation of other aspects of the Thermo-Lag issue including quality control and fire performance issues. SNL has not reviewed these portions of the documents.

1.3 Organization of Report

This review has focused on a review of the licensee's specific RAI responses, and on an overall assessment of the adequacy of the licensee's treatment. Section 2 provides a summary overview of the licensee's ampacity derating process and results. Section 3 of this report provides a point-by-point review of the licensee's RAI responses. Section 4 provides SNL's findings regarding the acceptability of the individual fire area ampacity assessments cited in the licensee study. Section 5 provides for a review of the licensee calculation of fire barrier ADF, Calculation 19-AI-08, and also discusses in more detail the licensee response to RAI item 4 and those aspects of the licensee "heat intensity" analysis method that have not been adequately resolved by the RAI process. Section 6 summarizes the SNL findings and recommendations.

2.0 OVERVIEW OF THE UTILITY AMPACITY APPROACH

2.1 Overview

The utility ampacity analysis is performed in two parts using two different methods of analysis. As was noted by SNL in its earlier review, the first part of the analysis is based on a fairly straight-forward ampacity margins assessment:

> Part 1 / Method 1: The utility assesses the baseline ampacity limits of its installed cables using tabulated ampacity values. These values are then compared to the actual in-plant ampacity loads, and an available ampacity margin is determined. If this margin is sufficient to bound the ampacity derating impact of the fire barriers, then the utility appropriately concludes that the in-plant ampacity loads are acceptable.

The second part of the licensee analysis was the focus of much discussion in the earlier SNL review. This part of the analysis was based on a comparison of cable heat intensity values under various conditions. SNL had identified a number of concerns related to this part of the licensee assessments, and these concerns were also raised in the USNRC RAI. The licensee's response to these concerns is discussed in Section 4 below. SNL's position and recommendations regarding this calculation have not changed substantially, and are summarized in Sections 2.4 and 5.2 below.

One aspect of the licensee treatment that was not clear in the original submittal but has now been made clear is that for the cable tray cases the licensee has actually imposed the fire barrier ADF in addition to having already applied a 5% ADF for the presence of solid tray covers that were assumed in the base plant design. The basis for the 5% tray cover ADF remains somewhat unclear. It is also in apparent conflict with the ADF thermal model in which a tray cover was apparently assumed to impose a 15% ADF. This is noted as an apparent discrepancy, but is not considered especially important in the context of the discussions which follow. The net effect of the licensee treatment can be most easily be illustrated through the ampacity correction factor (ACF) rather than ADF. Recall that:

$$ADF = (1-ACF)*100\%$$

Because ACF is a direct multiplier on ampacity, the net effect of a 5% ADF supplemented by a 32% ADF is given by the product of the two corresponding ACF values. Therefore the net ACF is given by (ACF_{net}=0.95*0.68=0.646). In effect, the licensee has applied an ADF of 35.4% to the tabulated ampacity limits to allow for both a steel cover plate and a 3-hour fire barrier.

The licensee actually goes on to cite that an additional 10% ADF has been applied to correct for a 50°C ambient as compared to a 40°C ambient, and cites this as an additional source of conservatism. While the assumption of a 50°C ambient may be conservative, SNL prefers to treat this as a separate effect from the derating impact of the fire barrier. Hence, SNL's comments as documented here all assume that an appropriate ambient has been used by the licensee, and focuses just on the fire barrier/tray cover impact.

2.2 Basis for Estimated Fire Barrier Derating Impact

The licensee has assumed a fire barrier derating impact of 32% for all installed fire barriers including both 1-hour and 3-hour and both tray and conduit barriers. As discussed above, in practice for cable trays the licensee has actually applied a 35.4% ADF to tabulated ampacity limits to allow for both a fire barrier and a solid steel tray cover plate. The basis for the 32% fire barrier ADF is a licensee calculation, 19-AI-08, which was provided as Enclosure 4 to Attachment 2 of the licensee RAI response and is reviewed in more detail in Section 5.3 below. The value is cited as an estimate of the ADF impact of a 3-hour cable tray fire barrier system which bounds the impact for the 1-hour tray and the conduit applications.

In summary, SNL finds that the licensee calculation has resulted in a non-conservative estimate of the derating impact of a 3-hour Thermo-Lag cable tray fire barrier system. This finding is based on a comparison of the licensee results to available test data. Based on this comparison SNL makes the following findings:

- The licensee assumption of a 32% ADF is adequate to bound the impact for both 1-hour cable tray installations and all conduit applications. This finding is based on a comparison to available test results. For conduits, a range of test results are available, and all indicate conduit ADF values well below the cited 32%. For a 1-hour tray system the Texas Utilities Electric (TUE) results are cited as indicating an ADF of 31.6%.

- The licensee assumption of a 32% fire barrier ADF is not adequate to bound the impact for a 3-hour cable tray installation. SNL cites two sources for this assessment:
  - Florida Power and Light (FPL)[1] Crystal River tested a nominal single layer 3-hour Thermo-Lag cable tray fire barrier system with no upgrades and no tray cover. The tested ADF was 41.4%.
  - Tennessee Valley Authority (TVA) Watts Bar[2] tested an upgraded 3-hour Thermo-Lag cable tray fire barrier system that included a solid tray cover (the upgrade was installed over a nominal single layer 330-1 installation). The tested ADF was 48%.

The actual ADF appropriate to the CPS 3-hour tray systems will likely lie somewhere between these two values (41.4% and 48%). That is, the FPL result would underestimate the net impact at CPS because it did not include tray covers while the TVA results would be conservative for CPS because it involved both covers and an upgrade to the base installation.

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[1]Aspects of the FPL tests are proprietary, but a non-proprietary version of the test report is available in the USNRC public document room.

[2]See TVA submittal to the USNRC document control desk of April 25, 1995.

While the basis for the 5% derate for solid tray covers remains unclear and may be optimistic for a tray cover impact alone, it is probably a reasonable estimate of the added impact of a solid cover imposed in addition to a fire barrier system. Consider that if the 5% ADF is imposed on top of the 41.4% ADF found by FPL, then the net ADF applied would be 44.3% (ACF_{net}=0.586*0.95=0.557). As expected this does yield an intermediate result between that of TVA and that of FPL. This is considered by SNL to be a reasonable estimate of the ADF for a base Thermo-Lag installation that includes a tray cover.

Given these observations, SNL recommends that the margins results for a three-hour cable tray installations at CPS be compared to a net ADF impact of 44.3% for the combined cover plus barrier configuration. In practice, because the licensee has already included the 5% derate for the solid covers in its assessment of the nominal "project ampacity," the cited margins results can be compared directly to the FPL test result of 41.4% for a final assessment of acceptability.

In Section 4 SNL has reviewed the licensee margins calculations in light of this finding. The results are summarized in Section 2.4 immediately below. Only one fire zone, CB-1f, is actually impacted by this question because this is the only area cited as containing a 3-hour cable tray fire barrier system.

2.3 A Summary of the CPS Margins Analysis Results

The licensee's margin analysis (the step 1 analysis) are considered by SNL to be sufficient in an of themselves to address the issues of fire barrier ampacity derating for CPS. The utility ampacity and margins calculations have been performed in an appropriate manner. No major discrepancies were noted by SNL in this portion of the licensee's assessments. The updated assessments also now include consideration of a 1.25 load factor for all non-resistance loads (see discussion of related RAI item 8 discussed in Section 3.8 below), and hence, provides a conservative bound on under-voltage and motor overload operating conditions. (In some few instances this assumption has been relaxed to some extent.)

Section 4 below provides an area-by-area review of the licensee calculations. As a part of this SNL review, the issues raised in Section 2.2 immediately above have also been considered. That is, for those barriers involving 3-hour tray configurations, SNL has considered the adequacy of the licensee margin including consideration of the higher potential derating impact of 41.4% as compared to the screening value of 32% used by the licensee. In summary, SNL finds that the licensee margins analysis has demonstrated an adequate margin for all of its cables and that the licensee submittals provide a reasonable assurance that the subject cables are, in fact, operating under acceptable ampacity conditions.

2.4 The Licensee Heat Intensity Analyses

The licensee's heat intensity based analyses were the focus of considerable discussion in SNLs original review efforts, and in the USNRC RAI of 8/16/96. The licensee has gone to significant lengths to further justify this aspect of the analysis in its RAI response.

However, as discussed further in Section 5.2 below, SNL remains unconvinced that this is an appropriate basis for analysis. SNL must continue to recommend that this aspect of the licensee analysis not be credited by the USNRC, and that this approach to analysis be viewed with significant scepticism.

However, SNL also finds that this part of the analysis is not needed to support an assessment of the licensee's cable ampacity. Rather, the margins analysis is sufficient in and of itself to support the conclusion that cables at CPS are operating within acceptable limits. It is SNL's recommendation that further interactions to resolve our concerns related to this analysis method are not warranted. SNL has concluded on the basis of the margins analysis that the licensee has demonstrated adequate margin for all of its fire barrier clad cables. SNL recommends that our concerns simply be noted for the record.

3.0 REVIEW OF THE LICENSEE RAI RESPONSES

The USNRC RAI of 8/16/96 requested clarification related to eight specific points of concern. The following subsections provide a point-by-point review and assessment of the licensee responses to these eight RAI items.

3.1 RAI Item 1: Ambient Temperature

Synopsis of Concern: RAI item 1 requested that the licensee identify the assumed ambient temperatures used in the analyses, and clarify how the ICEA ampacity limits were adjusted to account for this value.

Synopsis of Licensee Response: The licensee cites that all of the licensee assessments have been based on an assumed ambient temperature of 50°C, with the exception of Area D-8 in which a 40°C ambient was assumed.

Findings and Recommendations: This response is adequate to resolve the identified concern. It is clear from the licensee response that the actual conditions prevailing in each area have been considered, and that a bounding ambient temperature limit has been assumed. No further actions on this RAI item are recommended.

3.2 RAI Item 2: Cable Characterization

Synopsis of Concern: The licensee was requested to provide additional information on the characteristics and assumed ampacity limits of its cables. The licensee was also asked to identify the ADF assumed for each barrier analyzed.

Synopsis of Licensee Response: The licensee has included Calculations 19-G-01 and 19-G-02 as the basis for its base line ampacity assessments. These calculations include information on the cable types and characteristics. The licensee also provided Calculation 19-AI-08 as the basis for its assumed fire barrier derating factors. The licensee cites that all barriers were assessed using a 32% screening value which was considered to bound the impact for all of the installed fire barrier systems at CPS.

Findings and Recommendations: This response is adequate to resolve the identified concern. SNL has provided a specific review of the ADF calculation as documented in 5.3 below. Based on this review, SNL finds that the licensee assessment of 32% ADF is non-conservative for the 3-hour cable tray fire barriers. However, a further review of the licensee margins analysis did reveal that the 3-hour tray clad cables do have sufficient margin to allow for a more realistic 41.4% ADF (see further discussion in Sections 5.3 and 4.6 below). Hence, no further actions on this RAI item are recommended.

3.3 RAI Item 3: Cable Designations

Synopsis of Concern: The licensee was asked to clarify certain cable designations in which cables were identified as either "#19/22 AWG" or "#19/25 AWG".

Synopsis of Licensee Response: The licensee has clarified that these two designations are equivalent to #9 AWG and #12 AWG cables respectively.

Findings and Recommendations: This response is adequate to resolve the identified concern. No further actions on this RAI item are recommended.

3.4 RAI Item 4: The Heat Intensity Method

Synopsis of Concern: The licensee was asked to further clarify and justify its heat intensity based cable ampacity analysis method and results. Five specific points of concern were identified:

a) inadequate treatment of depth of fill,
b) removal of conservatism from tabulated ampacity limits,
c) inadequate justification for an assumed 32% ADF as a bounding limit,
d) deviation from a testing based approach without adequate justification, and
e) inadequate justification for applicability of the heat intensity analysis method.

Synopsis of Licensee Response: The licensee has provided an extensive response to the identified concerns (over eight pages of additional discussion). Hence, providing a concise synopsis of this response is rather difficult. A detailed discussion of the licensee response will be deferred to Section 5.2 below.

Findings and Recommendations: A detailed review of the licensee response to this RAI item is provided in Section 5.2 below. In summary, while SNL finds that the licensee response has not adequately resolved certain of the most critical concerns, SNL also recommends that no further actions to resolve these concerns is warranted at the current time. In particular, a review of the licensee margins analysis has shown that all of the cables considered are operating within acceptable ampacity limits. The licensee heat intensity analysis is not needed to reach this conclusion, and hence, resolution of the identified concerns will not significantly contribute to an assessment of the ultimate acceptability of the licensee's ampacity loads.

3.5 RAI Item 5: Appropriateness of Barrier ADF Values

Synopsis of Concern: The licensee was requested to further justify the applicability of the cited ADF factors for the fire barrier installations at CPS.

Synopsis of Licensee Response: The licensee response again cites the supporting calculation for ADF 19-AI-08, and provides limited discussion explaining that this value was considered to bound all of the CPS conduit and tray installations.

Findings and Recommendations: This response is adequate to resolve the identified concern as expressed in this RAI item. That is, the licensee has made clear that its intent was to apply a single ADF value that would bound all of the fire barrier installations including both trays and conduits. While SNL does not consider the cited value of 32% to adequately bound the 3-hour tray systems, the value will bound both 1-hour trays and all conduit installations. No further actions on this RAI item are recommended.

3.6 RAI Item 6: Cables 1DG29A and 1DG30A

Synopsis of Concern: The licensee was asked to provide additional documentation to support the assessments for these two cables.

Synopsis of Licensee Response: The licensee response does provide additional information on the operating conditions for these two cables. In particular, the licensee cites that these cables are operated for approximately five minutes on a daily basis and concluded that the time period of operation is too short to allow for significant heating to occur.

Findings and Recommendations: This response is adequate to resolve the identified concern. SNL concurs with the licensee assessment that the operating period for these cables is so short that the cables will not have an opportunity to reach anywhere near the steady state condition. For this case, the limited nominal margin will be sufficient to assure that the cables are acceptable, regardless of the barrier condition. No further actions on this RAI item are recommended.

3.7 RAI Item 7: Fire Breaks Versus Protective Barriers

Synopsis of Concern: The licensee was asked to discuss the physical characteristics of barriers installed as fire breaks as compared to those installed as protective barriers.

Synopsis of Licensee Response: The licensee response indicates that all barrier were installed in the same manner, and that there are no significant differences.

Findings and Recommendations: This response is adequate to resolve the identified concern. No further actions on this RAI item are recommended.

3.8 RAI Item 8: Under-Voltage and Motor Overloads

Synopsis of Concern: The licensee was asked to reassess its ampacity margins including consideration of a 1.25 load factor to allow for potential under-voltage and motor overload conditions of operation.

Synopsis of Licensee Response: The licensee has provided the requested reassessments. An initial assessment was made based on the increase in total heat generation rate for each tray and conduit. Supplemental analyses are also provided for any cable that was found to be loaded to over 40% of the nominal "project ampacity" which is really the nominal base line ampacity of the cable in an un-clad conditions.

Findings and Recommendations: SNL discounts the initial assessment of the total heat load on the trays and conduits because the cited "Watts per foot" approach is fundamentally unable to assess the performance of individual cables, and hence, provides essentially no useful information for cases such as those at CPS which involve significant load diversity. However, the licensee's supplemental assessments for individual cables have shown that all cables do have adequate margin to allow for under-voltage and motor overload condition. On the basis of the supplemental cable assessments, SNL finds that

this response is adequate to resolve the identified concern. No further actions on this RAI item are recommended.

3.9 Summary of Findings on RAI Responses

SNL finds that with the exception of RAI item 4, the licensee has provided responses that adequately resolve all of the identified concerns. With regard to RAI item 4, this item dealt exclusively with the licensee heat intensity analysis methodology. As is discussed in Sections 2.3, 2.4, 4, and 5.2, SNL finds that the heat intensity analyses are not needed to support the conclusion that all of the cables considered are, in fact, operating at acceptable ampacity levels. Hence, SNL recommends that further actions to resolve the open items with respect to this methodology are not warranted. No further actions on any of the RAI items have been recommended.

4.0 A REVIEW OF THE LICENSEE MARGINS ASSESSMENTS

4.1 Overview and Objective

The objective of the following subsections is to review each of the fire area margins results and to assess the ultimate acceptability of the licensee ampacity loads. Included in this discussion is consideration of the issue identified in Section 2.2 above. That is, SNL considers the licensee assessment that 32% will bound the impact of a three-hour cable tray fire barrier system to be unrealistic and optimistic. For cases involving such barriers, SNL has compared the licensee cited margins results to a 41.4% fire barrier ADF. This impacts only those cables located in zone CB-1f (see section 4.5 below).

4.2 Fire Zone A-1a

All fire barriers in this area are 1-hour installations, hence, screening based on a 32% margin is acceptable for this area. All but three of the cables have been demonstrated to have a 50% or more margin available. The remaining three cables were examined in detail in the licensee's most recent RAI response.

- Of these three cables, two were found to have adequate margin (in excess of 32%) on the basis of relaxing certain conservative assumptions made in the base analysis. This included the consideration of 1.25 load factor for under-voltage and motor overload operation. SNL concurs with these two assessments.

- The third cable, Cable 1VD02A, is associated with a Diesel Generator (DG) ventilation fan and is only active during DG operation. The cable was found to have a margin of 31.4% in the base analysis. This margin is only nominally below the TUE test result of an ADF of 31.6% and would normally be judged acceptable on this basis. However, when a 1.25 load factor is considered the margin is considerably smaller, and would not encompass the ADF impact of the fire barrier.

  The licensee assessment includes a thorough discussion of the operating conditions of this cable. Based on the information provided SNL concurs with the licensee assessment that the only potential time when an overheating of the cable might normally occur is during the periodic diesel generator surveillance tests performed at 18 month intervals when the cable would be in operation for 24 hours. (Similar conditions might also occur during a Loss of Off-Site Power event in which a prolonged demand for DG operation might be observed. This situation would be bounded by emergency overload ratings and limits. SNL would not expect such conditions to be considered in the licensee analysis.) Under these conditions a nominal overload could occur. The licensee judges this to be an acceptable condition based on the limited time associated with overload operation.

  In general, SNL concurs with this assessment. In particular, SNL notes that for an actual overload to occur would require that the cable be operating with under-voltage and/or motor overload conditions. Given that this load is a ventilation fan, a motor overload condition is considered by SNL to be highly unlikely. (Ventilation fans are typically designed with a significant motor load margin and in any case a motor overload is unlikely given the nature of fan

operation and construction. Fan motors are sized to handle the maximum rated flow rate under unrestricted operation. Unlike pumps, when the air flow rate of a fan is restricted, the motor load actually decreases because the fan itself will tend to "free wheel" and will actually move less air and hence do less work.) Given this, SNL finds that only the under-voltage condition is considered probable. This might result in a minor overload for a limited time period, but given the times and intervals involved as well as the demonstrated tray load diversity, SNL recommends that the cited margin of 31.4% is acceptable.

Hence, for this fire area, SNL finds that the licensee had demonstrated an adequate margin for the installed cables.

4.3 Fire Area C-2

Fire Area C-2 contains several cables in both trays and conduits, all wrapped with 1-hour fire barriers. Hence, screening based on a 32% ADF is appropriate for all clad cables in this area.

All but one of the cables in this area were identified as having an available margin in excess of 50% based on the nominal current loads with one exception. The licensee has also considered a re-assessment that includes a 1.25 load factor for all non-resistance type loads. The one exception is considered by the licensee as follows:

- Cable 1SC02B is a pump motor feed cable for the Standby Liquid Control system. The cited nominal margin for this cable was 23.75%. This is significantly reduced if a 1.25 load factor is applied. However, the licensee has provided two alternative assessment bases for this cable. The first is based on the limited time operation of this cable; no more than two hours at a given time under any conditions. The second is based on a relaxation of the depth of fill assumption to actual depth of fill. This second assessment yields a modified margin of 36.5%, even including the 1.25 load factor. SNL finds these reassessments acceptable, and finds the second reassessment especially telling in this regard given the more solid quantitative nature of the result. SNL recommends that given that a margin of 36.5% has been demonstrated, even including a 1.25 load factor, that this cable is operating under acceptable conditions.

SNL finds that the licensee assessment for the clad cables in this area has demonstrated an acceptable margin for all cases.

4.4 Fire Zone CB-1e

All of the fire wraps in CB-1e are 1-hour barrier systems. Hence, screening based on a 32% ADF is appropriate for the clad cables in this zone. The initial licensee assessment for this area demonstrated a minimum margin of 35% for all cables based on nominal load ratings and operation. Hence under nominal operating conditions all cables are found to be acceptable based on the screening against a 32% ADF.

The licensee has provided supplemental discussion for this zone in which a 1.25 load factor is considered for all non-resistive loads. This discussion includes specific consideration of any cable with less than a 60% margin based on the nominal load analysis (with no load factor applied). There are 11 such cables in zone CB-1e. Nine of these 11 cables have been shown to have an excess margin that exceeds the fire barrier 32% ADF even given a 1.25 load factor. The remaining two cables are addressed as follows:

- Cables 1DG29A and 1DG30A are air compressor feeds associated with the DG startup system. The licensee cites that these cables are operated for a maximum of five minutes on a daily basis, and hence, overheat is not a significant concern. SNL concurs with this assessment. Given a five minute operating time with a 24 hour cycling time, there is insufficient time for these cables to approach an equilibrium operating condition. (See related discussion of RAI item 6 in Section 3.6 above.)

In summary, SNL finds that the licensee has adequately demonstrated that the fire barrier clad cables in this fire zone are operating within acceptable ampacity limits.

4.5 Fire Zone CB-1f

The barriers in CB-1f are apparently comprised of 3-hour cable tray wrap(s). For this zone, SNL recommends screening against an ADF of 41.4% (as compared to the licensee cited ADF of 32%, see related discussion in Section 2.2 above).

The licensee has provided supplemental discussion in which a 1.25 load factor is considered for all non-resistive loads. This discussion includes specific consideration of any cable with less than a 60% margin based on the nominal load analysis (with no load factor applied). This initial screening is acceptable, even in light of the higher ADF recommended by SNL. There are 15 cables in zone CB-1f that survive this screening. Of these 15 cables, four were located in the "Division II power tray" and were included in the analysis of zone CB-1e. Of these four cables, 3 were shown in the initial analysis to have adequate margin to cover the 41.4% ADF recommended by SNL. For the fourth cable:

- Cable 1CM09K is cited as feeding a resistance heating circuit and is hence not subject to motor overload. The initial licensee analysis yielded a nominal margin of just 31.25%. However, a supplemental assessment (based on information in the original licensee submittal) that considered that only two of the three conductors is actually powered (the third being the ground wire) yielded a modified margin of 43.6%. This margin is sufficient to allow for the anticipated 41.4% ADF. No further assessment is needed.

The remaining 11 cables given special consideration in this zone are located in a "balance of plant" tray. Of these 11 cables:

- Seven are resistance heating loads not subject to motor overload conditions. Of these seven, only two have margins which are potentially not adequate. These are cable 1VL01A with a nominal margin of 37.57% and cable 1WY11A with a

nominal margin of 37.71%. If the ADF is raised to 41.4% as recommended by SNL then these cables would be judged to be nominally overloaded. However, SNL does not recommend that additional interactions on these two cables is warranted for the following reasons:

- A note to the licensee's original submittal analysis cites that these cables are each carrying a common load in parallel with other cables (1VL01B and 1VL02B). Hence each cable carries nominally 50% of the device load. However, the base analysis assumed that each cable carried 55% of the device load to allow for a conservative bound on length mis-match. This implies an additional 10% margin of conservatism in the analysis (55% versus 50% implies the assumed is 110% of the actual). Hence, if this conservatism is relaxed, the actual cable margin would, in fact, exceed the anticipated ADF impact.
- In addition SNL notes that the nominal overload for these two cables is quite modest, on the order of just 3-4%. Further SNL notes that this tray has a very significant level of load diversity, even if all of the cables in the tray are operating at the full load currents. Based on the information provided in the licensee's submittal of 11/3/95 there are a total of 26 cables in this tray. Of these 26 cables half (13) are operating at less than 25% of the nominal rated ampacity limit. In fact six cables are operating at less than 1% of the rated ampacity, and an additional three are operating at less than 10% of the rated ampacity. While it is difficult to quantify the actual ampacity gain that would result from this diversity, it is SNL's judgement that for this case it would be sufficient to allow for the modest overload on these two cables.

SNL recommends that the licensee demonstrated ampacity margin is acceptable for this particular case.

- Two additional cables are shown to have margins in excess of 41.4%, even considering a 1.25 load factor.

- One additional cable is dismissed based on the relaxation of the assumed loading condition to reflect the actual cable load. This case involves cable 1LV53D which is a DC load feeder for a calibration lab. The cable is used only to provide load currents in calibration activities. Normally there is no load on the cable, but the licensee assessment is based on an assumed load of 12 amps, or 80% of the breaker rating. When a 1.25 load factor is applied, a 15A load is postulated, and the available margin is reduced to 6.2%. SNL concurs with the licensee assessment that this cable is unlikely to ever be loaded to this level. Further, this is obviously a non-safety grade cable and hence is of no real safety significance. SNL recommends that this assessment be accepted as adequate.

- The last cable, 1VW03A is shown to have a nominal margin of almost 50% under normal load conditions, but only 37.3% if a 1.25 load factor is considered. SNL recommends that this is sufficient margin in this case because the load is associated with a motor driven fan. As noted above, fans are not likely to experience significant motor overloads due to the nature of the fan design and operation. The

licensee demonstrated margin is sufficient to allow for under-voltage and more limited motor overload conditions, and hence, should be adequate.

In summary, SNL finds that all of the cables in this fire zone have been shown to be operating under acceptable conditions. No further actions on these cables are recommended.

4.6 Fire Zone CB-5

The fire barriers in zone CB-5 are of a 1-hour configuration. Hence, comparison of the cable margin to a 32% ADF is appropriate. All cables in this area are shown to have a margin in excess of this value, even considering a 1.25 load factor. SNL recommends that the cables in this area have been shown to be operating under acceptable conditions.

4.7 Fire Area D-8

The barriers in Area D-8 are associated with 3-hour conduit installations Hence, a screening based on a 32% ADF is conservative for this area. The cables in this area have been shown to have a margin of over 34% based on the nominal load conditions for the cables. Even including a 1.25 load factor, these cables would still have sufficient margin to bound typical conduit derating factors. Hence, SNL finds that all of the cables in this area have been demonstrated to be operating under acceptable ampacity load conditions.

4.8 Summary of Margins Findings

SNL finds that the licensee's margins analysis is sufficient in an of itself to provide reasonable assurance that all of the fire barrier clad cables at CPS are operating under acceptable ampacity conditions. No further review of the cited cables is recommended. This finding includes the consideration of the concern raised in Section 2.2 above regarding the lack of conservatism in the licensee ADF assessment for a three-hour fire barrier. For the one fire area containing three-hour tray barriers, SNL has applied a more stringent screening margin of 41.4% to the cables analyzed. All were found acceptable.

5.0 A REVIEW OF THE LICENSEE SUPPORTING CALCULATIONS

5.1 Overview

The licensee has provided two principal supporting calculations as a part of it submittal package. The first documented an alternate licensee analysis approach based on cable heat intensity. This calculation was provided as a part of the original licensee submittal of 11/3/95, and was the subject of considerable discussion in SNL's review report of 5/16/96. Section 5.2 provides a brief summary discussion of those areas of the calculation that SNL finds remain open (unresolved) even given consideration of the licensee's RAI responses.

The second calculation was performed by the licensee in order to estimate the ADF impact of a 3-hour cable tray fire barrier system. This calculation was requested in the RAI, and was provided by the licensee in its RAI response. A review of this calculation is provided in Section 5.3.

5.2 The Licensee Heat Intensity Analysis

One part of the licensee submittals had documented an analysis approach based on a comparison of plant design cable heat intensity limits to those observed in the SNL/NRC clad case ampacity test. In its previous review, SNL had raised a number of points of concern associated with this methodology. The licensee was asked to respond to these concerns in RAI item 4. The objective of this section is to review the licensee RAI response for item 4, and to reassess the SNL position regarding this approach to analysis.

RAI item 4 had requested clarification of and additional justification for the proposed methodology. In particular, the licensee was specifically asked to address five points of concern:

a) inadequate treatment of depth of fill,
b) removal of conservatism from tabulated ampacity limits,
c) inadequate justification for an assumed 32% ADF as a bounding limit,
d) deviation from a testing based approach without adequate justification, and
e) inadequate justification for applicability of the heat intensity analysis method.

The licensee response included both a general response to the SNL identified concerns, and specific responses for each of the five specific points identified in the RAI. The following six sub-sections, 5.2.1-6 provide for a brief review of each of these parts of the response. The final sub-section, 5.2.7, provides a summary of SNL's current findings and recommendations regarding this method.

5.2.1 Insights Based on the Licensee's General Response

The first point addressed in the licensee's general response appears to be based on a misunderstanding of SNL's findings. That is, the licensee provides a redefinition of the term heat intensity and discusses the fact that this approach derives from Stolpe's work. SNL is well aware of this fact, and indeed cited this in its own review. SNL has no

difficultly with the concept of heat intensity, nor with its proper application to ampacity analyses. In fact, it is a commonly applied approach to extending the ICEA tables to cable conditions not specifically covered by those tables. In practice, heat intensity for individual cables and cable ampacity limits are essentially interchangeable concepts and either can be used with equal validity. SNL does not take exception to this method in general, only to the specific application presented by the licensee.

The second point discussed by the licensee is SNL's objection to use of the ampacity derating test results presented in SAND94-0146 and IEIN 94-22. While the licensee discussion does provide some additional insights, it does not address SNL's fundamental underlying concern. The cited SNL/NRC test was intended to reproduce a specific manufacturers test conditions and, as compared to currently accepted test procedures, this test suffered from a number of severe experimental deficiencies which render its results highly questionable. The use of these results by the licensee in this context is simply inappropriate. There are a wide range of experimental results available to the licensee from a number of other utility sources (including at the least TUE, FPL, and TVA) that are based on currently accepted ampacity test methods. As a minimum, the licensee should validate its approach by comparison to these alternate test cases. The cited SNL/NRC test is not an appropriate basis for this comparison. The licensee has provided no new information to alter SNL's findings in this regard.

5.2.2 Inadequate Treatment of Depth of Fill

In SNL's review, it was cited that the licensee appeared to be comparing "apples and oranges" in that the cited heat intensity limits were all for different depth of fills, and hence, a direct comparison of these values was inappropriate. The licensee response to this aspect of the question indicates that SNL was mistaken in this regard and that, in fact, the licensee had attempted to compare on a consistent basis by correcting the CPS design values to a 1.5" depth of fill. This in part addresses SNL's concern, but not in full. Heat intensity is a strong function of depth of fill. Any comparison of this type should be based on all values being normalized to the same depth of fill. Comparison of the 2" ICEA limit, the 1.5" "project" values, and the 1.4" SNL test value is still considered inappropriate. All values should be normalized to the same depth of fill.

The licensee response to this RAI item has actually raised an additional point of concern regarding this comparison. This is related to the licensee treatment of ambient temperature. It was not clear in the original submittal what ambient temperature had been assumed in the analyses (see related RAI item 1). SNL had assumed that all values were based on the same ambient, 40°C. It is now clear that the licensee calculations of the "project ampacity" and hence its own heat intensity limits are based on a 50°C ambient. Hence, the licensee is comparing the results for its own assessments at 50°C to an SNL test normalized to a 40°C ambient. This again is clearly inappropriate. The ambient temperature correction should be viewed and treated as a separate issue altogether in an analysis of this type. Comparing these results directly without a clear and explicit discussion of this difference is highly misleading. If the licensee considered the 50°C ambient to be a conservatism, then this conservatism should be pointed out and treated separately.

Given the new information provided in the licensee response it is now clear to SNL what the net results of the licensee heat intensity analysis are. To illustrate, it is necessary to place the two values on a consistent basis for comparison. Recall that the licensee project ampacities are based on the ICEA tables as the base line. Hence, the licensee approach can be made more transparent by similarly evaluating the measured ampacity from the SNL/NRC clad case test in comparison to these same ICEA tables. The net result of these two cases can then be compared directly. Consider:

- In effect the licensee has taken the tabulated ampacity (or heat intensity) limits from the ICEA tables, derated them by 5% for the presence of tray covers, by 10% for an assumed 50°C versus 40°C ambient, and by 32% for the fire barrier. Thus the licensee has applied a net ACF of (ACF_{net}=0.95*0.90*0.68=0.581) or a net ADF of 41.9%. This is the ultimate basis for the licensee cited derated "project ampacity" or "CPS design" limits.

- The licensee compares these limits to the SNL/NRC clad test ampacity (or heat intensity) as taken directly from the test measurements. If those results are compared to the same ICEA tables then the SNL/NRC test results represent a derating of the ICEA limits by 17.0-28.8% depending on the cable size.[3]

Now that a consistent base line is applied, it becomes clear that, in effect, the licensee heat intensity comparisons are simply showing that a 41.9% ADF is more conservative than a 17.0-28.8% ADF, and nothing more. All of the intermediate discussion serves only to confuse this ultimate result. All of the licensee results for each of the cables considered in its individual case analyses can be directly attributed to and fully accounted for based only on this difference in ADF values.

Whether or not the 41.9% ADF is sufficient to conservatively bound the impact due to ambient temperature, the tray covers, and the fire barrier has not been demonstrated by this analysis unless one accepts that (1) the SNL/NRC clad case test results are acceptable as a direct measure of the actual clad case ampacity limits fully independent of the ICEA ampacity tables or any ADF values (2) the licensee relaxation of the 50°C ambient assumed in its design to the 40°C ambient prevailing in the SNL/NRC test is acceptable, and (3) that the direct extrapolation of these results to any other cable based on heat intensity is acceptable. It is SNL's fundamental contention that the quality and scope of the SNL/NRC test results is insufficient to support such a broad and sweeping interpretation and extrapolation of the results.

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[3]These values use the licensee calculated NEMA/ICEA ampacity limits for the SNL/NRC cables from the original licensee submittal (Attachment 4 to U-602512, pg.3) as the base line condition, and the measured ampacity as the clad condition. The ADF values are lower than those cited in the test report because the ampacity limits measured in the SNL/NRC base line test were higher than the ICEA nominal limits as expected given the inherent conservatism in the ampacity tables.

5.2.3 Removal of Conservatism from Tabulated Ampacity Limits

This point is considered by SNL to be the most significant and fundamental of the concerns raised. It is SNLs interpretation of the licensee treatment that the licensee is, in effect, performing a direct comparison of project ampacity limits to those obtained in the clad case test from the SNL test set. Recall that heat intensity and ampacity are directly related values. The terms can essentially be used interchangeably. Hence, when the licensee compares heat intensity values, they are for all intents comparing ampacities.

The licensee response to this aspect of the RAI did not address SNL's fundamental concern in this regard. The licensee has attempted to further justify its treatment by citing that the intent was not to compare actual in-plant cables to the SNL clad test, but rather to illustrate that the plant design approach yields more conservative results than those measured in the SNL test. SNL concurs that the licensee is comparing its design approach to the test result. Nonetheless, this is still considered an inappropriate approach.

The comparison of the actual ampacity from a single ampacity test result, and one of highly questionable merit to begin with, is simply inappropriate. The licensee is in effect citing the SNL test as the basis for establishing the clad case ampacity limits directly. Consider as an analogy that the IEEE 848 standard test does not allow for the comparison of a clad case test result to tabulated ampacity limits to determine ADF. Instead, the ADF must be based on the comparison of a clad and base line test results, even if the base line test yields an ampacity higher than the nominal tabulated ampacity. This practice preserves the conservatism that was intentionally built into the ICEA ampacity tables. The licensee practice raises the exact same concern.

5.2.4 Inadequate Justification for Assumed ADF

SNL had questioned the basis for the 32% ADF in the licensee assessments. The licensee response has provided the cited calculation upon which this value was based, and has further clarified its approach to analysis in this regard. While this response has resolved the concern in the context of the current discussion, the cited ADF value was found by SNL to be inadequate to bound the impact of a 3-hour cable tray fire barrier system. SNL's concerns regarding this calculation have been presented in Sections 2.2 and 5.3.

5.2.5 Deviation from Testing Approach

It would appear that the licensee has mis-interpreted SNL's concern in this regard. SNL's concern was based on the fact that the licensee was apparently using a fire barrier ADF limit based on analysis when test results for nominally similar barriers are available. The licensee has focused on why it did not test its own barrier systems, and the process by which is has made its assessments. This has not resolved SNL's concerns. However, SNL has reviewed the licensee margins analysis results in light of the available test results, in particular, for the 3-hour cable tray system installed in Area CB-1f. These issues are discussed in detail in Sections 2.3, 2.4 and 4.

SNL also noted that the licensee response has included a discussion of a "Watts per foot" analysis of its clad cable trays and conduits. SNL does not credit this aspect of the analysis. The licensee cites that this step is performed to assess whether or not the total load on the system is sufficient to cause general aging concerns. SNL fundamentally disagrees with this assessment. The licensee also cites its individual cable assessments as determining whether on not individual cables are loaded sufficient to damage themselves. It is this aspect of the licensee assessments that SNL considers appropriate. If all of the individual cables are operating within acceptable limits, then the tray or conduit as a whole is acceptable. If an individual cable is operating at excessive ampacity loads, then all of its co-located neighbors are also potentially subject to accelerated aging (because they may come into contact with the overloaded cables at some point, and at that point premature aging could be experienced). The "Watts per foot" method, in SNL's view, provides no new or useful information and should not be credited.

5.2.6 Inadequate Justification for Analysis Method.

The licensee response to this concern cited that the method was based on the methods of Stolpe. While this is nominally true, Stolpe did introduce the concept of heat intensity, the licensee application of this concept is not consistent with accepted ampacity derating approaches. The licensee has not adequately addressed this concern in its response.

In particular, it was SNL's concern that the licensee has not validated its approach to direct application of test-based heat intensity limits for clad cable trays to actual cable ampacity assessments. While the licensee cites a long passage from Stolpe's paper, the licensee apparently fails to appreciate that Stolpe's work is backed up by a whole series of tests as well as thermal modeling results. The licensee comparison to a single test with significant and known shortcomings cannot compare to Stolpe's extensive validation efforts. The additional explanations offered by the licensee have offered no new information to alter SNL's finding that this approach lacks a sufficient basis for validation to allow for its general application as an ampacity assessment method for clad cables.

5.2.7 Summary of Findings and Recommendations

In summary, while the licensee has provided some new insights into its intentions and approach to analysis, SNL stands by its earlier recommendations. SNL recommends that this aspect of the licensee analyses should not be credited without significant additional review and validation, and that this approach to the analysis of clad cable ampacity limits should be viewed with scepticism. The licensee has not addressed SNL's most fundamental concerns which are:

- The licensee comparisons are inappropriate in that the compared limits represent a mixture of installation conditions.

- The licensee method, in effect, results in the comparison of project design ampacity limits for a clad cable to a single clad case ampacity test result, and in fact, to a test result with known significant shortcomings.

- Because the licensee is comparing, in effect, project and test ampacity limits directly, the approach will result in the removal of any conservatism that is derived from application of the ICEA tables.

In addition, the licensee responses have actually raised an additional concern that was not identified by SNL in its earlier review:

- The licensee comparisons of heat intensity limits are not appropriate because the licensee derived project design limits are based on an assumed 50°C ambient whereas the test results have been normalized for a 40°C ambient. To treat ambient temperature in this manner is highly misleading. Corrections for ambient temperature should be treated as an entirely separate issue. The licensee should base any such comparisons on a consistent set of installation conditions, including normalizing all results to the exact same ambient temperature.

Overall, SNL still considers the licensee approach to the heat intensity based analysis to be severely deficient. However, SNL also considers that this aspect of the analysis is not needed to support a conclusion that the licensee cables are in fact operating at acceptable ampacity levels. This is discussed further in Section 4 above.

5.3 The Licensee ADF Calculation

As a part of its RAI response of 3/31/97, the licensee has provided a copy of calculation 19-AI-08. The purpose of this calculation is to estimate the ADF impact of a nominal single layer 3-hour Thermo-Lag 330-1 cable tray fire barrier system. The basis of the analysis is relatively simplistic:

- The licensee begins by assuming that for a cable tray "the ampacity of cables with closed covers must be derated by 15%" based on certain test results from the Braidwood Station.

- The open or uncovered base line ampacity limit is presented in terms of the heat intensity limit, and is based on a citation to a LaSalle Station document.

- This base line heat intensity, derated by 15%, is used to estimate the thermal resistance between the cable mass and the surface of the surrounding steel covers.

- The licensee then assumes that this same thermal resistance will also apply to the resistance between a cable mass and the inside surface of a Thermo-Lag fire barrier system.

- The additional thermal resistance associated with conduction through the barrier material itself is mathematically added to the system, and a revised estimate of the cable heat intensity in the clad condition is generated.

- The clad and base line heat intensity limits are compared, and an estimate of the ADF is generated.

In principal, this approach can be made to work acceptably under the proper circumstances. It is for example somewhat similar to the approach taken by Braidwood in its own ampacity assessments.[4] However, there appear to be very significant differences that have the potential to seriously compromise, or even invalidate, the CPS implementation of this approach. Fundamentally, the licensee has not demonstrated that this approach to analysis is appropriate for CPS as will be discussed further below.

The bottom line on this calculation is that it has yielded a non-conservative estimate of the fire barrier ADF. The licensee results have found an ADF of 32% for a 3-hour fire barrier system. However, in recent years a number of ampacity tests have been performed, and hence, a set of direct experimental results are available. Of these, three are considered especially relevant (as cited in Section 2.2 above):

- TUE tested a 1-hour Thermo-Lag cable tray fire barrier system and found an ADF of 31.6%. A three-hour system should yield an ADF somewhat larger than this value.

- FPL tested a 3-hour single layer Thermo-Lag cable tray fire barrier system with no upgrades and no tray covers and found an ADF of 41.4% for this configuration. The CPS barrier should have a modestly higher ADF impact because of the presence of the solid tray covers not included in the FPL test.

- TVA tested a 3-hour single layer Thermo-Lag cable tray barrier system that included both material upgrades and solid tray covers and found an ADF of 48%. This test would be conservative in comparison to the CPS barrier because of the material upgrades.

Given these results, SNL finds that the licensee's conclusion that 32% would bound the impact of a 3-hour barrier is not conservative and is not acceptable. The 32% screening limit would, however, be adequate to bound for the 1-hour tray installations, and all of the CPS conduit installation.

In its review SNL has not attempted to provide a thorough and complete assessment of all aspects of the licensee model. In particular, SNL has made no attempts to confirm the actual numerical results, to reproduce the model as implemented by the licensee, nor to implement a modified version of the analysis model.

There are many factors that might have contributed to the licensee's non-conservative result. Based on SNL's limited review, it is suspected that the following factors have likely contributed to the non-conservative nature of the final ADF estimates:

- The licensee base line condition is based on a direct application of tabulated heat intensity limits, presumably derived from Stolpe's work, to a specific test result and to a specific thermal model. However, the licensee has not demonstrated that

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[4]See Braidwood submittal to the USNRC document control desk of July 12, 1996.

this assumption is compatible with either its thermal model nor with the cited Braidwood tests. Specific potential problems in this regard include:

- The licensee model has been simplified to a considerable degree, especially in the way the heat transfer within the tray system is treated.
- The licensee has provided full credit to heat transfer through all four faces of the barrier system, the top, bottom, and sides, whereas Stolpe's model only considered heat transfer from the upper surface of the cable mass.
- If the assumed base line heat load is not fully compatible with the thermal model, then the estimates of the thermal resistance values could easily be compromised.

At the least, the licensee should have provided for a validation of its external heat transfer treatment by analyzing the base line case (without the covers) to show that it could reproduce the estimated base line heat intensity limits given the cable installation assumptions, the assumed physical parameters, the assumed heat transfer correlations, the relative credit assigned to each surface of the system and the assumed ambient temperature. Without such a validation, the choice of the base line heat intensity is quite arbitrary in the specific context of the thermal model. That is, while the heat intensity was apparently derived from tabulated ampacity limits, it may not be at all compatible with the licensee thermal model. Self-consistency of the thermal model for the base line and clad conditions presumes a consistency in the projection and estimation of heat loads and is critical to this analysis.

- The licensee has cited a heat intensity limit of 2.79 W/ft/in^2 for an open cable tray with a 2" depth of fill. Stolpe cited a limit of about 2.34 W/ft/in^2 for a 2" (66%) fill, and the ICEA P-54-440 tables set a 2.427 W/ft/in^2 limit for a 2" fill. The basis for the rather high licensee value is unclear.

- While it is not entirely clear, it would appear that the licensee trays are significantly different from those used in the Braidwood tests. In particular, the licensee trays appear to be ladder-type trays whereas the Braidwood tests used solid bottom trays. In the Braidwood tests, the cables were apparently in direct contact with the tray's solid bottom. If CPS does indeed use ladder style trays, then there will be an air gap between the cables and the bottom panel of the fire barrier system because the cables are supported by the tray rungs. This would lead to a significant difference in the heat transfer behavior of the cable-to-bottom plate in the Braidwood tests as compared to the cables-to-bottom Thermo-Lag sheet in the CPS case, and hence, might invalidate the CPS analysis altogether.

- The licensee analysis is apparently intended to include the presence of a solid steel tray cover in addition to the fire barrier. However, the licensee thermal model has inherently assumed that there will be no air gap between the cover and the fire barrier panels. The model has also assumed that no air gaps exist between the side rails and the barrier. (If the CPS trays are the solid bottom type, then there would also be a gap here as well.) This is clearly not an accurate representation of a Thermo-Lag panel installation is which some air gap is inevitable. The failure to include an air gap in the analysis is non-conservative.

- The licensee has assumed a relatively low value for the emissivity of the galvanized tray surfaces and covers (0.23). Galvanized materials will have emissivity values as high as 0.8 under realistic conditions. It is unclear based on SNL's review which extreme would be more conservative in this context. Some demonstration that the licensee treatment is conservative should be provided as a part of the analysis.

- In calculating the allowable heat load the licensee has applied an area correction factor of $\pi/4$ to it's total cable mass cross-sectional area calculation ($A=d_{fill}*w_{tray}*\pi/4$) which may be inappropriate. There are two ways to calculate depth of fill, one used by Stolpe based on the circular cross-section of a cable, and the second used in the ICEA tables based on a surrounding square section for each cable. The difference between the two is, indeed, $\pi/4$. However, the depth of fill and heat intensity limits should be self-consistent at the outset. Applying an additional correction at this stage of the analysis appears inappropriate, but because the licensee has cited a LaSalle Station calculation not provided for SNL review as the basis of the heat intensity, this aspect cannot be verified as correct or incorrect. (Note that this cannot account for the heat intensity discrepancies identified immediately above as correction of the heat intensity limit using the same $\pi/4$ factor still yields a significant discrepancy in comparison to either Stolpe or the ICEA).

- One additional discrepancy that was noted is that in the thermal model the licensee has assumed a 15% derating for its solid steel covers, but in the development of the licensee "project ampacity" limits, only a 5% derating was applied for the solid tray covers (see licensee Calculation 19-G-1). In this sense, the two calculations appear inconsistent and incompatible.

It is likely that a combination of these factors has led to the licensee's non-conservative ADF result. Of most significance are the issues of thermal model self-consistency. This is an especially critical aspect of an ampacity model. An analysis of this type should, at a minimum, provide for a direct validation of its self-consistency. In this case, this would require a direct validation of the assumptions made regarding the base line heat intensity limits and the licensee treatment of external heat transfer processes (the correlations for convection, crediting of the sides in the heat transfer process, and the values of emissivity chosen in the model).

As was noted above SNL does not recommend that any additional licensee interactions be undertaken to resolve these concerns. SNL has determined that the CPS cables that are housed in the 3-hour cable tray barriers do have adequate margin to allow for a 41.4% or higher derating. Hence, the licensee has demonstrated adequate ampacity based on the margins analysis approach. Given this, the role of these results in the licensee analysis is rendered moot. It is recommended that these concerns be noted "for the record" only.

6.0 SUMMARY OF REVIEW FINDINGS AND RECOMMENDATIONS

The sub-sections that follow provide a summary of the SNL specific review findings and recommendations regarding each of four aspects of the licensee submittals. In brief, the basic finding of the SNL review is that the licensee margins analysis is sufficient in an of itself to demonstrate the acceptability of ampacity loads on fire barrier clad cables. Further, SNL finds that the licensee has, in fact, demonstrated adequate margin for all of the cables considered in the analysis. On this basis, SNL recommends that no further interactions with the licensee are necessary to resolve the cable ampacity question for CPS.

6.1 Summary of Findings on Licensee Margins Methodology

One of the two underlying methodologies employed by the licensee for the assessment of cable ampacity loads is based on an assessment of the available ampacity margin for the cables installed at CPS. The review findings with regard to this margins analysis methodology are as follows:

- The licensee margins analysis approach is, in and of itself, an appropriate and sufficient methodology for demonstrating the adequacy of in-plant cable loads.

- No significant errors or oversights in this aspect of the analysis were identified by SNL.

- The licensee has demonstrated an adequate margin for all cables identified in the analyses, including consideration of a 41.4% ADF for three-hour cable tray fire barriers (see related finding in 6.3 below).

Based on these findings SNL recommends that no further actions to resolve the ampacity loads for fire barrier clad cables at CPS are needed.

6.2 Summary of Findings on the Licensee RAI Responses

SNL finds that the most critical of the RAI items have been adequately addressed. This in particular relates to RAI items 1-3 and 5-8, all of which raised questions related to the licensee margins analysis and to specific cable margins assessments. However, in the case of the RAI item 4, which was related to the licensee heat intensity based analyses, SNL finds that several critical points of concern regarding that analysis approach have not been adequately resolved. No further actions to resolve these open items have been recommended as discussed in 6.4 below.

6.3 Summary of Findings on the Licensee ADF Calculation

The licensee Calculation 19-AI-8 has estimated the ampacity derating impact of a nominal 3-hour, single layer, Thermo-Lag 330-1 cable tray fire barrier system to be 32%. SNL finds that this estimate is non-conservative in comparison to available test results. In particular, SNL cites a Florida Power and Light test set in which the ADF for a nominally

identical fire barrier system was found to be 41.4%. Several points of potential concern in the licensee model have been identified by SNL in text above.

It is SNL's recommendation that this calculation not be credited as a realistic estimate of the fire barrier ADF impact. However, no specific interactions to resolve these concerns are recommended. This is because:

- SNL finds that the 32% ADF assumed by the licensee is adequate to bound the 1-hour cable tray barriers and all of the conduit barriers that represent the bulk of the licensee installations, and

- For the one fire area containing 3-hour cable tray barriers SNL has compared the licensee margins results to the higher screening value of 41.4% ADF and found that all cables did have adequate margin.

In the broader context, while the licensee has itself applied a non-conservative screening value to its 3-hour tray barriers, the supplemental SNL assessments have concluded that all of the cables do have adequate margin. Hence, the resolution of SNL's concerns regarding the licensee ADF calculation is not considered especially important. SNL recommends that these concerns simply be noted "for the record."

6.4 Summary of Findings on Licensee Heat Intensity Analysis

The licensee submittal included a number of supplemental ampacity assessments based in essence on a direct comparison of the heat intensity from a single SNL/NRC clad case ampacity test to the heat intensity obtained using the licensee cable design method. While the licensee has provided some additional insights into their intent and approach, SNL finds that a number of the most critical concerns have not been addressed adequately. SNL's recommendations regarding this method have not changed substantially. SNL continues to recommend that this aspect of the licensee analysis not be credited without significant additional review, assessment and validation. Further, while SNL has no difficulty with appropriate applications of the heat intensity method, this particular approach to a heat intensity analysis should be viewed with scepticism.

Offsetting this finding is the fact that, fundamentally, SNL considers this aspect of the analysis to be entirely unnecessary. As noted in 6.1 above, the margins approach is sufficient in and of itself to resolve the ampacity load concerns, and has in fact demonstrated adequate margin for all of the fire barrier clad cables at CPS. No further analysis is required to demonstrate adequacy of the cable loads.

Given these findings, SNL does not recommend additional interactions with the licensee at this time to resolve the open concerns related to the heat intensity approach as applied by the licensee. Only if the same methodology is invoked by another licensee, or if the methodology is re-introduced by CPS for subsequent analyses that do not satisfy the margins analysis approach would a need arise to resolve the identified concerns. It is recommended that SNLs concerns regarding this method should be noted for the record only.