A Technical Evaluation of the Florida Power and Light Fire Barrier Ampacity Derating Assessments for St. Lucie and Turkey Point

A Letter Report to the USNRC

Revision 1

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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 Florida Power and Light (FPL) for the St. Lucie and Turkey Point nuclear power stations. This revision reflects the licensee responses to concerns raised in the original review (Revision 0, August 1997). The subject submittals deal with the assessment of ampacity loads for cable trays and conduits protected by Thermo-Lag fire barriers. This report focuses on a technical assessment of the licensee's calculations, and on an overall assessment of the adequacy of the licensee's ampacity treatment. This work was performed as Task Order 4, Subtask 2 of USNRC JCN J-2503.

1.0 INTRODUCTION

1.1 Background

This report is related to ampacity assessment submittals from two Florida Power and Light (FPL) nuclear plants; namely, St. Lucie Plant (SLP) Units 1 and 2, and Turkey Point Plant (TPP) units 3 and 4. The approach to ampacity assessment is quite similar for each of these two plants, and one of the supporting calculations submitted by FPL was common to both plants. However, in assessing the adequacy of these submittals Sandia National Laboratories (SNL) has reviewed each plant's documentation somewhat independently.

The original FPL submittals were provided in response to two preliminary USNRC Requests for Additional Information (RAIs); one for SLP dated 11/6/96, and one for TPP dated 1/29/97. The RAIs in each case were quite direct and requested (1) the supporting calculations cited as the basis for the licensee assessments and (2) additional justification for the extrapolation of Texas Utilities (TUEC) test results to the FPL fire barriers. The licensee responses were provided under FPL cover letters dated 12/19/96 (SLP) and 3/7/97 (TPP). Included in each response is a fairly extensive set of supporting calculations including for SLP:

- Calculation PSL-OFJE-96-001, "Cable Derating in Conduits with Fire Barrier Coatings", Revision 1, Approved 12/96.
- Calculation PTN-BFJM-96-005, "Fire Barrier Ampacity Correction Factors - Extrapolation of Test Results for 3 Hour Barrier", Revision 0, Approved 4/96.
- Calculation JPN-PSL-SEES-96-059, "Engineering Evaluation of the Application of Thermo-Lag to Meet R. G. 1.75 Requirements", Revision 0, Approved 8/96.[1]

and for TPP:

- Calculation PTN-BFJE-93-001, "Ampacity Derating Response to NRC GL 92-08 for Cables Routed in Conduit and Tray with Thermo-Lag 330-1 Fire Barrier System Coating", Revision 0, 7/90.[2]
- Calculation PTN-BFJM-96-028, "Fire Barrier ACF for T-Lag 330-1/770-1 Assemblies", Revision 6/94.
- Calculation JPN-PTN-SEEP-96-011, "Review of Ampacity Ratings for Power Cables in conduits and Trays with Thermo-Lag 330-1 Covering", Revision 6/94.

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[1]As noted in the text below, this particular calculation is not in any way related to the ampacity assessments performed by the licensee, and has not been reviewed in detail by SNL.

[2]This document was cited by the licensee as of historical interest only having been superceded by JPN-PTN-SEEP-96-011, hence, SNL has not reviewed this calculation in detail.

- Calculation PTN-BFJM-96-005, "Fire Barrier Ampacity Correction Factors - Extrapolation of Test Results for 3 Hour Barrier, Revision 6/94.[3]
- Calculation PTN-BFSE-96-006, "Ampacity Derating for Cables in Raceways and Boxes with Thermo-Lag 330 and with Thermo-Lag 330 w/Layer of Thermo-Lag 770 Fire Barrier Coating", Revision 6/94.

SNL originally reviewed these calculations in August 1997 as documented in Revision 0 of this letter report. In that review, SNL found that (1) the licensee had provided sufficient information to conclude that cables at the plants were being operated within acceptable ampacity limits, but that (2) the submittals did contain a number of apparent discrepancies. That is, despite the discrepancies noted SNL did have sufficient information available to re-analyze the effected cases and was able to show that the cited ampacities were acceptable. Hence, while the overall conclusion was that the licensee ampacity loads were acceptable, it was recommended that the apparent discrepancies be brought to the attention of the licensee. As a result, an additional follow-up RAI was forwarded to each plant. This revision of the SNL review report includes consideration of the licensee responses to this second set of RAIs. The most recent RAI response for TPP is contained in a licensee letter of June 30, 1998 (licensee item L-98-150) and the SLP response is contained in a licensee submittal dated June 26, 1998 (licensee item L-98-175).

Note that in this revision, SNL has deleted much of the detailed supporting information originally presented as a part of the August 1997 SNL review. This information can be found in Revision 0 of this report. The current revision (Revision 1) provides a summary overview of the previous favorable findings, and considered the licensee response to the apparent discrepancies noted in the earlier review as raised in the RAIs.

1.2 Review Scope and Objectives

This letter report documents SNL's findings and recommendations resulting from a review of the licensee submittals as identified above. This review has focused on assessing the technical merits of the licensee calculations. 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. The utility submittals include documentation of other aspects of the Thermo-Lag issue including quality control, material consistency, and the decision making process associated with installation of fire barriers to meet the separation requirements of Regulatory Guide 1.75. SNL has not reviewed these portions of the documents.

[3]This is identical to one of the documents submitted by SLP as well.

1.3 Organization of Report

Section 2 provides an assessment of the licensee calculations associated with SLP. Section 3 of provides an assessment of each of the calculations for TPP. Section 4 summarizes the SNL findings and recommendations for each of the two plants. Section 5 identifies referenced documents.

2.0 ST. LUCIE CALCULATIONS

2.1 Overview

The SLP submittal originally reviewed by SNL in August 1997 included three calculations. Of these, one dealt exclusively with cable separation criteria and the use of fire barriers to meet these criteria, Calculation JPN-PSL-SEES-96-059. This calculation was not reviewed by SNL. The other two calculations were reviewed by SNL:

- Calculation PSL-OFJE-96-001, "Cable Derating in Conduits with Fire Barrier Coatings", Revision 1, Approved 12/96: This calculation documents the results of a licensee ampacity margins assessment and is reviewed in Section 2.2 below.

- Calculation PTN-BFJM-96-005, "Fire Barrier Ampacity Correction Factors - Extrapolation of Test Results for 3 Hour Barrier": This calculation presents the licensee assessment of the ADF for upgraded fire barriers based on an extrapolation of test results from TUEC. This calculation is reviewed in Section 2.3 below.

2.2 Calculation PSL-OFJE-96-001

2.2.1 Overview

Calculation PSL-OFJE-96-001 is entitled "Cable Derating in Conduits with Fire Barrier Coatings." This calculation represents a relatively straight-forward ampacity margins assessment for the fire barrier clad cables at SLP. All of the clad cables are housed in conduits, and there are no clad cable trays. The fire barriers include both 1-hour and 3-hour configurations. Most installations are of a standard configuration with the exception of certain cases where multiple conduits have been clad using a common fire barrier system.

The general approach to the margins assessment was based on a direct comparison of actual in-plant service loads to derated ampacity limits for the cables. As is common, the analysis has excluded the consideration of instrument, control, and intermittent load power cables (such as valves).

2.2.2 Summary of August 1997 SNL Findings and Recommendations

Based on SNL's August 1997 review, SNL found that the licensee's margins analysis approach as documented in Calculation PSL-OFJE-96-001 was an acceptable means of addressing the issues of fire barrier ampacity derating. Further, SNL was provided with sufficient information to conclude that the fire barrier clad cables at SLP were operating within acceptable ampacity limits. Overall, SNL recommended acceptance of the method and results.

There were, however, two relatively minor points of concern identified as follows:

- Baseline ampacity limits are taken from standard IEEE-835-1994 [1], a widely accepted industry trade standard applicable to this assessment. One discrepancy in this practice was noted related to the selection of baseline values from the tables. This discrepancy was raised in item 2.1.b of the follow-up USNRC RAI.

- Fire barrier ADF values were based on TUEC ampacity tests, either directly or as extrapolated in a supporting calculation (see section 2.3), without consideration of the uncertainty associated with those test results. The licensee was asked to address this point in RAI items 2.1.a and 2.1.c of the follow-up RAI. These two RAI items are discussed in Section 2.3 below as they are primarily factors associated with the supporting calculation, Calculation PTN-BFJM-96-005. The findings presented in Section 2.3 also apply here and SNL does find that the concerns have been adequately addressed.

SNL was able to show that ultimately neither of these items would impact the overall results of the licensee assessments. That is, even given the noted concerns, the conclusion that the SLP clad cables were operating within acceptable limits would not change. However, SNL did recommend that the concerns be brought to the attention of the licensee. This was, in fact, done and the licensee responses to the RAI is discussed in section 2.2.3 immediately below.

2.2.3 The Follow-Up RAI and Calculation PSL-OFJE-96-001

There were three items raised in the follow-up RAI to the licensee. Two of these items, 2.1.a and 2.1.c, were in fact primarily related to Calculation PTN-BFJM-96-005 as discussed in Section 2.3 below. RAI item 2.1.b was directly related to Calculation PSL-OFJE-96-001. This RAI item and the licensee response are summarized as follows:

- RAI Item 2.1.b noted that the licensee had used baseline ampacity for cables under "no sun - 2 ft/s" installation conditions and that this was contrary to accepted practice. The licensee was asked to either apply the "no sun - 0 ft/s" conditions, or to justify the assumption of 2 ft/s continuous air flow.
  - The licensee response includes updated calculations that were performed using the "no sun - 0 ft/s" conditions as requested. As expected all cables were still found to be operating at acceptable ampacity limits.
  - SNL finds that the updated calculations fully address the identified concern.
  - No further actions on this RAI Item are recommended.

2.2.4 Summary of Final Findings and Recommendations

SNL finds that the licensee has fully addressed all of the identified concerns related to Calculation PSL-OFJE-96-001. As was noted in the August 1997 review, SLP has provided sufficient information to conclude that the fire barrier clad cables at SLP are operating within acceptable ampacity limits. The revised calculations simply provide a more solid basis for this conclusion and resolve any uncertainty in this regard. SNL recommends acceptance of the licensee calculations and findings without further interaction.

2.3 Calculation PTN-BFJM-96-005

2.3.1 Overview

Calculation PTN-BFJM-96-005 is entitled "Fire Barrier Ampacity Correction Factors - Extrapolation of Test Results for 3 Hour Barrier". The purpose of the calculation is to estimate the fire barrier ADF for the 3-hour fire barriers at SLP based on the extrapolation of 1-hour system test results. In practice, calculations were performed for both conduits and cable trays, although for SLP it would appear that only the conduit results have been applied (no clad cable trays are identified in the SLP margins analysis). The cable tray results were however used in the TPP assessments.

2.3.2 Summary of August 1997 SNL Findings and Recommendations

In the August 1997 review, SNL found that in principal the thermal model used in Calculation PTN-BFJM-96-005 was technically sound, and no discrepancies in its application were identified. There were two points of concern related to the use by SLP of the TUEC test results as the basis for the calculations:

- The licensee failed to consider uncertainty in the TUEC test results deriving from the fact that different physical test specimens were used for the baseline and clad tests. This was raised as RAI Item 2.1.a.

- The licensee failed to consider uncertainty in the TUEC tests deriving from inductive heat losses. This was raised as RAI Item 2.1.c.

2.3.3 The Follow-Up RAI and Calculation PTN-BFJM-96-005

There were three items raised in the follow-up RAI to the licensee. Two of these items, 2.1.a and 2.1.c, were related to Calculation PTN-BFJM-96-005. These RAI items and the licensee response are summarized as follows:

- RAI items 2.1.a related to uncertainties in the TUEC tests used by SLP that were not considered by in the analysis. In particular, uncertainty was introduced in the tests due to the fact that TUEC used physically different specimens for the clad and baseline tests. In Item 2.1.a the licensee was asked to consider more recent test results for other industry sources or to include the uncertainty bounds in application of the TUEC data.
  - The licensee response indicates that the calculations have been updated using the FPL test results rather than the TUEC results. The licensee did conclude that these tests were applicable to SLP. As expected, the results still show that the cables at SLP are operating within acceptable ampacity limits.
  - SNL finds that the updated calculations fully address the identified concerns.
  - No further actions on this RAI Item are recommended.

- RAI Item 2.1.c noted that the licensee had not addressed the concerns related to inductive heating in its analysis of the TUEC tests. The licensee was requested to

either consider other industry test results of use the more conservative ADF values that include consideration of uncertainty in the TUEC tests.

- As noted in regard to Item 2.1.a above, the licensee has updated the calculation using data from the FPL tests.
- SNL finds that the updated calculations fully address the identified concerns.
- No further actions on this RAI Item are recommended.

2.3.4 Summary of Final Findings and Recommendations

SNL finds that the licensee has fully addressed all of the identified concerns related to Calculation Calculation PTN-BFJM-96-005. SNL recommends acceptance of the licensee calculations and findings without further interaction.

3.0 TURKEY POINT CALCULATIONS

3.1 Overview

The original Turkey Point Plant (TPP) submittal included five supporting calculations:

- (Calculation PTN-BFJE-93-001) had been superceded and was included only for historical interest. This calculation was not reviewed by SNL in any detail.

- Calculation PTN-BFJM-96-028, "Fire Barrier ACF for T-Lag 330-1/770-1 Assemblies": The stated purpose of this calculation is to extrapolate TUEC ampacity test results for 1-hour and 3-hour installations to the TPP installations involving Thermo-Lag 770-1 upgrades. This calculation is reviewed in detail in Section 3.2.

- Calculation JPN-PTN-SEEP-96-011, "Review of Ampacity Ratings for Power Cables in conduits and Trays with Thermo-Lag 330-1 Covering": This calculation presents the results of the licensee evaluation of individual cable ampacity loads in light of the anticipated fire barrier ADF impact. This calculation has been reviewed in detail as discussed in Section 3.3.

- Calculation PTN-BFSE-96-006, "Ampacity Derating for Cables in Raceways and Boxes with Thermo-Lag 330 and with Thermo-Lag 330 w/Layer of Thermo-Lag 770 Fire Barrier Coating": This calculation deals with the addition of a 770-1 upgrade to existing installations. The calculation has been reviewed in detail as discussed in Section 3.4 below.

- Calculation PTN-BFJM-96-005, was common with a submittal from SLP. SNL's original 8/97 review evaluated this calculation in the context of the SLP submittal (see Section 2.3 above) and noted that the same findings also applied directly to TPP. The licensee response to identified concerns is discussed in Section 3.5 below.

3.2 Calculation PTN-BFJM-96-028

3.2.1 Overview

Calculation PTN-BFJM-96-028 is entitled "Fire Barrier ACF for T-Lag 330-1/770-1 Assemblies." The stated purpose of this calculation is to extrapolate TUEC ampacity test results for nominal 1-hour and 3-hour Thermo-Lag 330-1 single layer installations for cable tray and conduits to the TPP installations involving Thermo-Lag 770-1 overlay upgrades.

The calculation was essentially identical in approach and implementation to the thermal model employed in Calculation PTN-BFJM-96-005 which was reviewed in the context of the SLP submittal as documented in Section 2.3 above. The TPP version had basically been extended by comparison to additional test results (tests by TVA)

3.2.2 Summary of August 1997 SNL Findings and Recommendations

As a general finding, SNL concluded in August 1997 that the approach to assessment used by the licensee in Calculation PTN-BFJM-96-028 was technically appropriate. Further, SNL found that the licensee has established an adequate basis of thermal similarity for the extrapolation of the TUEC conduit test results, and for the direct application of the TVA test results for the upgraded tray barriers. Two minor discrepancies were noted by SNL in the August 1997 review and were raised in the USNRC follow-up RAI. These items are discussed in Section 3.2.3 immediately below.

3.2.3 RAI Item 2.2.b and Calculation PTN-BFJM-96-028

There were two minor discrepancies noted by SNL in regard to calculation PTN-BFJM-96-028, and these two items were raised as a part of item 2.2.b of the follow-up USNRC RAI. In the August 1997 SNL review it was concluded that neither of these items had actually compromised the calculation, but it was recommended that they be brought to the attention of the licensee. The licensee has responded to each of the two items sufficiently to resolve any remaining uncertainty as summarized immediately below:

- The first apparent discrepancy noted by SNL was that in the analysis of the cable tray case the assumed thickness of the TVA installed fire barriers appeared to be in error.
  - The licensee response has clarified that the test being simulated in this particular calculation is not TVA Test Item 7.1 as had been assumed by SNL. Rather, the test in question is an alternate TVA/Omega Point test described in a journal article attached to the licensee calculation. The cited thickness values are appropriate for the cited test.
  - The licensee response has fully resolved the apparent discrepancy. It is now clear that the licensee calculation is fully consistent with the intended test simulation.
  - There are no further unresolved items related to this concern.

- In one table of results, Sheet 6 from the original submittal, it appeared that there was a typographical error in the cited thickness of the 330/770 upgrade system (the last line in the table). The table cited a value of 0.75" when the full thickness of the upgraded barrier was 2".
  - The licensee response has clarified that each case presented in Sheet 6 is actually presented in a "cumulative effect" format. That is, the cited 0.75 thickness in the last line of the table is added to the previous lines 1.25" thickness to obtain the full 2" thickness.
  - It is now clear that the apparent discrepancy was simply a matter of mis-interpretation of the table values by SNL. The licensee response has fully resolved the apparent discrepancy, and it is now clear that the licensee calculations are fully correct as presented.
  - There are no further unresolved items related to this concern.

3.2.4 Summary of Final Findings and Recommendations

As noted in 3.2.2 above, in August 1997 SNL found the licensee calculation to be technically appropriate, but noted two minor apparent discrepancies. The licensee response to RAI Item 2.2.b of the follow-up USNRC RAI has fully resolved the apparent discrepancies. It is now clear that the calculation has been properly executed, and that the apparent discrepancies were merely the result of mis-interpretation by SNL of certain elements of the licensee results tables. SNL can now recommend, without qualification, that the results of Calculation PTN-BFJM-96-028 are appropriate. There are no further unresolved concerns related to this calculation.

3.3 Calculation JPN-PTN-SEEP-96-011

3.3.1 Overview

Calculation JPN-PTN-SEEP-96-011 is entitled "Review of Ampacity Ratings for Power Cables in Conduits and Trays with Thermo-Lag 330-1 Covering." The objective of the calculation is to assess ampacity loads on individual cables when clad with nominal (non-upgraded) 1-hour and 3-hour Thermo-Lag barrier systems.[4] This assessment includes consideration of the fire barrier ACF factors as estimated in the supporting Calculation PTN-BFJM-96-005 (this calculation was discussed in the context of the SLP submittal as presented in Section 2.3 above).

The approach to the direct ampacity analysis is virtually identical to the methodology applied to SLP as described in Section 2.2 above. The licensee has determined the ampacity load and physical installation characteristics of each of the identified power cables of interest. Baseline ampacity limits are determined, and applicable derating factors are applied to estimate the derated ampacity limit. For conduits the derating factors include a fire barrier ACF, a temperature correction for an 85°C conductor temperature (vs. the more common 90°C conductor temperature), and additional factors for grouping of conductors within a common conduit and for the grouping of conduits are also applied. For cable trays it appears that only the fire barrier ACF has been applied. The resulting actual load ampacity is then compared to the estimated derated ampacity limit for a final assessment of acceptability.

In addition, the licensee has also documented certain supplemental calculations of the heat load for the individual cables and for each cable tray or conduit as a whole. This is put forth as a "final check" on acceptability, and has not been utilized as a primary basis for acceptability assessment. This is essentially a "Watts per foot" type of analysis.[5] As SNL has noted in past reviews, the "Watts/foot" method of analysis is not technically adequate

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[4] Note that cables clad with upgraded barriers (330/770 systems) are addressed separately in Calculation PTN-BFSE-96-006 (see Section 3.4 below).

[5] This method has been encountered in previous review efforts conducted under this USNRC JCN. It is known most commonly as the "watts/foot" method and is an early method of analysis that has since been discredited.

for ampacity assessments of individual cables. In this case it is quite clear that the licensee has not put these calculations forth on such a basis; hence, SNL has taken no specific exceptions to this part of the calculations. However, SNL also has given essentially no credit to these supplemental assessments in making our own recommendations regarding the technical acceptability of the licensee submittals. SNL finds that the margins assessment approach is sufficient in and of itself to demonstrate the acceptability of in-plant service loads.

3.3.2 Summary of August 1997 SNL Findings and Recommendations

Overall, SNL found the ampacity margins assessment of Calculation JPN-PTN-SEEP-96-011 to be appropriate to its stated purpose, to have been properly implemented, and that these margins calculations were sufficient in and of themselves to justify the ampacity loads.

SNL further recommended that the supplemental "Watts/foot" based calculations not be credited at all. However, SNL also found these supplemental calculations to be unneeded and this finding did not compromise the overall conclusion that the licensee had demonstrated adequate ampacity margin.

Given these general conclusions, SNL did identify three apparent discrepancies in the calculation. The licensee was asked to resolve the apparent discrepancies in the USNRC follow-up RAI, Item 2.2.b. These three items and the licensee response to this RAI are discussed in Section 3.3.3 immediately below.

3.3.3 RAI Item 2.2.b and Calculation JPN-PTN-SEEP-96-011

SNL identified three apparent discrepancies in the licensee calculations, and the licensee was asked to address these discrepancies in Item 2.2.b of the follow-up USNRC RAI. The concerns and licensee responses are summarized as follows:

- There was no documentation on how the licensee obtained the cited baseline ampacity limits for cable trays. Further, based on a simple comparison of the licensee cited values to those obtained by SNL using the ICEA P-54-440 methodology certain of the licensee cited values appeared non-conservative.
  - The licensee response to this item states that the baseline ampacity values were taken from the original design calculations prepared in 1985 and 1990. The licensee further notes that "It is common practice to use prior calculation results as a basis for new calculations in lieu of performing duplicate calculations. As such, these values are consistent with the design basis for Turkey Point and are considered reasonable and conservative."
  - The licensee response "dodges" the question entirely. The licensee was asked to verify that the cited baseline ampacity values were appropriate and were consistent with accepted methods of practice. The licensee has offered no new information that contributes to the technical resolution of this concern.
  - This concern remains unresolved.

- In one particular cable tray case study, tray 4AXT10, the licensee applied a baseline ampacity calculation methodology from IPCEA P-46-426 that has been specifically superceded by the ICEA P-54-440 methodology. Further, in one particular case a 3-conductor cable was evaluated based on single conductor ampacity limits when the more restrictive 3-conductor values should have been used.
  - The licensee response to this concern acknowledges that the P-46-426 methods were used in early design calculations, and that the resulting values have been retained in more recent calculations. The date of the original calculation (5177-304-E005) is not identified, but the re-analysis of ampacity loads considering fire barrier derating were apparently performed in 1985. The licensee concludes that "The use of IPCEA P-46-426 in lieu of IPCEA P-54-440 is considered appropriate in order to remain consistent with the methodology used in the original calculation."
  - With regard to the use of P-46-426 methods, the licensee response does not address the identified concern. Basically, the licensee has put forth the argument that because P-46-426 was used in the past, its continued use is appropriate. An assessment of the validity of this argument ultimately lies outside the expertise of the SNL reviewers. From a technical standpoint, the licensee position is not defensible. That is, P-54-440 clearly and explicitly states that the methods of P-46-426 for random fill cable trays were to be superceded by the new methods.[6] Indeed, P-54-440 was originally published in 1972, the same year that TPP began operations. Hence, the random fill methods from P-46-426 have been considered inappropriate methods of analysis since 1972. Also note that this change in accepted methods can result in significant reductions in baseline ampacity using the newer methods of P-54-440 as compared to those obtained using the P-46-426 methods. The licensee argument is basically a "legalistic" argument that boils down to "grandfathering" of the original calculations despite changes in accepted methods.
  - No discussion of the use of single conductor ampacity limits in the evaluation of 3-conductor cables was provided in the licensee response. Even putting questions of the acceptability of the P-46-426 methods, if SNL's observation is indeed correct and 3-conductor cables were analyzed based on single conductor ampacity limits, then this would constitute a clear mistake in the evaluation. The licensee is again relying on the assumption that older calculations would not be questioned in later calculations, and this fails to address the concern.
  - SNL is not in a position to judge the "legal" or "regulatory" merits of the licensee position regarding "grandfathering" of the outdated calculations. One factor that should be considered here, however, is when the original calculations were actually performed. If performed after 1972, then the licensee position is not defensible because by 1972 the new standards of practice had already been published. Further, the licensee has not addressed

[6] See the section of the standard entitled "History" on page iii.

SNLs observations that indicate mistakes may have been made in the original assessments even if the question of acceptability of the P-46-426 methods is put aside.
  - This concern remains unresolved.

- In the assessment of conduit ampacity limits, the licensee applied conduit conductor count correction factors that inherently credit a 50% diversity without explicitly justifying that this level of diversity does in fact exist in the impacted conduits.
  - The licensee response cites that the conductor count correction factors were those used in an earlier calculation (5177-EF-15, date not given) and cites that "justification for load diversity has been established in the original design calculations."
  - The licensee has not provided the earlier calculations for review; hence, the licensee's statements cannot be verified. However, the statements are quite clear that the fact that the correction factors include diversity effects is acknowledged by the licensee and that in the view of the licensee diversity factors have been substantiated. On this basis, SNL finds the concern to be resolved.

3.3.4 Summary of Final Findings and Recommendations

As per the findings of the August 1997 review, SNL finds the overall approach to analysis documented in Calculation JPN-PTN-SEEP-96-011, in an of itself, to be acceptable. The only exception to this is with regard to the supplemental "Watts/foot" method calculation that SNL finds to be unneeded and recommends not be credited.

However, there were concerns identified in SNLs August 1997 review regarding the validity of the cited baseline ampacity limits that were used as inputs to this calculation. Based on the licensee response it is now clear that these values were taken directly from earlier design calculations. The licensee was asked to respond to three related points of concern in Item 2.2.b of the follow-up USNRC RAI. Their response basically calls for "grandfathering" of the earlier calculations. That is, the licensee cites that the earlier calculations were a part of the plant's original design basis and that they should be acceptable for use in newer calculations on this basis. SNL is not qualified to judge the "legal" or "regulatory" merits of this argument. From a purely technical standpoint this argument is without merit, and SNL would recommend that it not be accepted.

To clarify, the licensee response to RAI Item 2.2.b failed to provide a technical resolution for two of the three identified points of concern; namely:

- some of the cited baseline ampacity limits were optimistic in comparison to values obtained using current practices, and

- for certain cases the licensee had cited use of the IPCEA P-46-426 cable tray ampacity methods that have been superceded by ICEA P-54-440 and, even given

the older method, SNL noted apparent mistakes in those analyses (single-conductor ampacity limits were applied to multi-conductor cables).

It now clear that these two points are closely related. That is, based on the licensee response it is now clear that the optimistic cable tray ampacity values (point 1 above) are a direct result of the use of the P-46-426 methods (point 2 above). Further, the licensee did not address at all the concern that mistakes appear to have been made in the analyses.

On purely technical grounds, SNL finds that the licensee practice is not consistent with current practice; hence, recommends that it is not acceptable. The unresolved technical concerns can be summarized as follows:

The licensee has cited Calculation 5177-304-E005 as the basis for the evaluation of baseline ampacity limits for cables at TPP. In the case of random fill cable trays the analysis apparently relies on the methods of IPCEA P-46-426, and even given these methods it appears that mistakes may have been made in the analyses (it appears that single-conductor ampacity limits have been used in the analysis of multi-conductor cables). The methods of IPCEA P-46-426 as applied to random fill cable trays were explicitly superceded in 1972 by ICEA P-54-440. The newer methods establish more restrictive limits on cable tray ampacity limits than those obtained using P-46-426. The methods of P-54-440 represent the current accepted practice in industry. The continued reliance by TPP on the P-46-426 methods and the failure to address potential errors in the application of those methods cannot be justified on technical grounds.

SNL recommends that it is within the purview of the USNRC, rather than SNL, to decide the merits of the licensee's "legalistic" rational for using an outdated method of analysis and results that may contain mistakes in the assessment of baseline ampacity limits for random fill cable trays. That is, will the USNRC accept use of the outdated methods (P-46-426) and potentially erroneous results even given the method based on "grandfathering" of the original plant design calculations or should this argument be rejected?

If the licensee's "legalistic" argument for "grandfathering" of the original calculations is rejected, then SNL further recommends that the USNRC ask the licensee to (1) review the existing applications using currently accepted methods of analysis for the assessment of baseline ampacity values and (2) perform any future evaluations using current methods of accepted practice. In either case it is also recommended that the USNRC ask the licensee to review the earlier design calculations to ensure that no mistakes were made in these calculations (e.g., such as the single- versus multi-conductor cable ampacity question). . .

Once again note that the licensee provided sufficient information for SNL to independently verify, using currently accepted methods of analysis, that the clad cables at TPP are operating within acceptable ampacity limits. This finding derives from SNL's August 1997 review, and remains unchanged. The unresolved concerns identified here are issues primarily impacting the technical validity and defensibility of the licensee's compliance documentation. That is, updating the methods of analysis will not change the outcome of

the assessments, existing cable ampacity loads will still be found to be acceptable; rather, the abandonment by the licensee of superceded methods and the adopting of current methods would make the supporting compliance documents defensible from a technical standpoint. It should also be noted that, if not addressed by the licensee, the unresolved concerns could adversely impact future plant fire protection design changes and the assessment of plant life extension issues as they relate to the assessment of cable aging. This is because the methods of analysis currently applied by the licensee result in optimistic assessments of cable ampacity limits. It is only the apparent availability of a significant ampacity margin in the original plant design that led to the overall finding that under current conditions the existing ampacity loads are acceptable.

3.4 Calculation PTN-BFSE-96-006

3.4.1 Overview and Objective

Calculation PTN-BFSE-96-006 is entitled "Ampacity Derating for Cables in Raceways and Boxes with Thermo-Lag 330 and with Thermo-Lag 330 w/Layer of Thermo-Lag 770 Fire Barrier Coating." The objective of this calculation is to re-assess the ampacity margins for cable in applications that have been upgraded beyond the nominal 1-hour or 3-hour barrier installations (i.e., those considered in Calculation 96-011). The cited ACF factors for the upgraded barriers are cited as deriving from both Calculation 96-028 and 96-005.

The approach to analysis is nominally identical to the margins assessments performed in Calculation 96-011 as discussed in Section 3.3 above. The primary difference lies in the nature of the fire barriers under analysis. The only other significant difference between this and the previous margins assessments is that an alternative definition of the margin has been employed. In fact, in this calculation the licensee does not present the results in the form of an available margin, but rather, cites the actual in-plant ampacity load as a fraction of the allowable ampacity load. This is, in effect, a margins assessment, but should be viewed as an ACF-based margin as compared to an ADF-based margin. That is, the cited load fractions can be viewed directly as the maximum allowable ACF above and beyond the nominal assumed fire barrier derating that could be accepted by a given cable. There is nothing wrong with this approach, but it is both somewhat unusual, and different from the method used in the other FPL margins assessments; hence, it is noted here for clarity.

3.4.2 Summary of August 1997 SNL Findings and Recommendations

In general, SNL found the approach to margins assessments as documented in Calculation PTN-BFSE-96-006 to be appropriate and acceptable. SNL did identify one minor discrepancy associated with this calculation. This was related to the application of conduit conductor count correction factors that inherently credit a 50% diversity without adequate justification. However, SNL also found that only two of the licensee conduits were impacted by this discrepancy, and that in those cases the available margin was adequate to allow for the more conservative correction factors.

3.4.3 The Follow-up RAIs and Calculation PTN-BFSE-96-006

As a part of RAI 2.2.b the licensee was asked about the use of older diversity based conduit conductor count correction factors in the assessments. The licensee response has been discussed in detail in Section 3.3.3 above.

3.4.4 Summary of Final Findings and Recommendations

SNL finds that the margins analysis methods set forth in Calculation PTN-BFSE-96-006 are technically sound and appropriately executed. SNL recommends the acceptance of this approach as an appropriate method for demonstrating that the cables at TPP are operating within acceptable ampacity limits.

Note that to some extent this calculation is adversely impacted by the concerns discussed in Section 3.3.3 and 3.3.4 above as regards Calculation JPN-PTN-SEEP-96-011. That is, Calculation PTN-BFSE-96-006 is also dependent on the use of baseline ampacity values from the earlier plant design calculations, and the technical validity of those values has been questioned by SNL. However, as noted in the August 1997 review, the licensee provided sufficient information for SNL to independently verify, using currently accepted methods, that the clad cables at TPP are operating within acceptable ampacity limits.

3.5 Licensee Calculation PTN-BFJM-96-005

3.5.1 Overview

The details of Calculation PTN-BFJM-96-005 have been discussed in Section 2.3 above. This calculation is actually common to both the SLP and TPP submittals. All of the findings and recommendation cited above in the context of the SLP submittal also apply directly to the TPP submittal.

3.5.2 Summary of Findings and Recommendations

As discussed in greater detail in Section 2.3 above, SNL finds the licensee calculations documented in the revision to Calculation PTN-BFJM-96-005 to be appropriate and recommends their acceptance by the USNRC. All potential concerns regarding uncertainty in the cited validation case examples have been adequately resolved by comparison to alternate data sources. No further actions related to this specific calculation are recommended.

4.0 SUMMARY OF REVIEW FINDINGS AND RECOMMENDATIONS

4.1 Overall Findings and Recommendations for St. Lucie Plant

SNL finds that the licensee has fully resolved all of the concerns identified in our August 1997 review of the SLP fire barrier ampacity derating analyses. SNL further finds that the licensee has provided a fully adequate basis for concluding that all of the fire barrier clad cables at SLP are operating within acceptable ampacity limits. SNL recommends that the SLP submittals be accepted as a complete and appropriate basis for resolution of the ampacity derating concerns raised in Generic Letter 92-08 without need for further interactions.

4.2 Overall Findings and Recommendations for Turkey Point Plant

As documented in the August 1997 SNL review report, SNL finds that the TPP approaches to analysis as documented in the five supporting calculations reviewed by SNL, in and of themselves, were all acceptable and appropriate. In particular, SNL made the following observations and findings:

- The licensee thermal modeling efforts were found to have been well thought out and well executed.

- The licensee ampacity margins methods were found to represent an adequate basis for the resolution of the ampacity loading questions originally raised by the USNRC.

- Based on both the licensee calculations and independent calculations performed by SNL, SNL finds that sufficient information has been provided to concluded that the fire barrier clad cables at TPP are operating within acceptable ampacity limits.

- There was only one minor aspect of the actual supporting calculations that SNL did take exception to. SNL finds that the supplemental calculations based on the "Watts/foot" method as presented in Calculation JPN-PTN-SEEP-96-011 were not needed to support the final conclusions, and recommends that they not be credited by the USNRC. This does not adversely impact the other findings of this review; these calculations are simply unnecessary.

These findings remain unchanged. However, in the August 1997 review SNL did note a number of discrepancies in the licensee supporting calculations. The cited discrepancies were the subject of a follow-up RAI.

The licensee response to this follow-up RAI has left two points of concern from one of the RAI items unresolved; namely, RAI Item 2.2.b, points of concern 1 and 2 as related to Calculation JPN-PTN-SEEP-96-011. These concerns relate to the basis for the cited cable tray baseline ampacity limits. The licensee response states that the cited baseline ampacity limits are taken directly from an earlier calculation that was not submitted for review and that the results of that earlier calculation were not questioned nor updated. No

direct technical resolution for the identified concerns was provided. Instead, the licensee is relying on the fact that the earlier calculations are a part of the plant's original design basis and assumes that they are acceptable for use in subsequent calculations on that basis alone.

On purely technical grounds, SNL finds that the licensee practice in determining baseline ampacity limits for random fill cable trays is not consistent with current practice, and further, that the licensee has applied a method of analysis that is more optimistic than accepted current practice. Hence, SNL recommends that the licensee approach is not acceptable. The unresolved technical concerns can be summarized as follows:

> The licensee has cited Calculation 5177-304-E005 as the basis for the evaluation of baseline ampacity limits for cables at TPP. The analysis is stated to be based on the methods of IPCEA P-46-426, and even given these methods it appears that mistakes may have been made (it appears that single-conductor ampacity limits have been used in the analysis of multi-conductor cables). The methods of IPCEA P-46-426 as applied to random fill cable trays were explicitly superceded in 1972 by ICEA P-54-440. The newer methods establish more restrictive limits on cable tray ampacity limits than those obtained using P-46-426. The methods of P-54-440 represent the current accepted practice in industry. The continued reliance by TPP on the P-46-426 methods and the failure to address potential errors in the application of those methods cannot be justified on technical grounds.

In effect the licensee's response boils down to a "legalistic" argument for "grandfathering" of the original calculations. It is beyond the expertise of the SNL reviewers to assess the regulatory merits of this argument; this is a decision that lies within the purview of the USNRC rather than SNL. If the argument is rejected, then SNL recommends that the USNRC ask the licensee to (1) review the existing random fill cable tray applications using currently accepted methods of analysis for the assessment of baseline ampacity values and (2) perform any future evaluations using current methods of accepted practice. Whether or not the USNRC accepts use of the outdated methods, it is also recommended that the USNRC ask the licensee to review the earlier design calculations to ensure that no mistakes were made in these calculations (e.g., such as the single- versus multi-conductor cable ampacity question raised in the RAI).

Once again note that the licensee provided sufficient information for SNL to independently verify, using currently accepted methods of analysis, that the clad cables at TPP are operating within acceptable ampacity limits. Hence, the unresolved concerns are issues primarily impacting the technical validity and defensibility of the licensee's compliance documentation. The concerns could also impact future plant fire protection design changes and the assessment of plant life extension issues as they relate to the assessment of cable aging.

5.0 REFERENCES

1. *IEEE Standard Power Cable Ampacity Tables*, IEEE 835-1994, Sept. 1994.

2. *Power Cable Ampacities*, IPCEA P-46-426, AIEE S-135-1, a joint publication of the Insulated Power Cables Engineers Association (now ICEA) and the Insulated Conductors Committee Power Division of AIEE (now IEEE), 1962.

3. *Ampacities of Cables in Open-Top Cable Trays*, ICEA P-54-440, NEMA WC 51, 1986.