A Review of the South Texas Project Fire Barrier Ampacity Assessments

A Letter Report to the USNRC

Revision 0

June 28, 1996

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

Prepared for:
Ronaldo Jerkins
Electrical Engineering Branch
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTACHMENT 1(a)

TABLE OF CONTENTS:

FORWARD

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 South Texas Project (STP) nuclear plant. These submittals deal with the assessment of ampacity loads for cable trays and conduits protected by Thermo-Lag 330-1 fire barriers. In particular, the submittals document a test report cited by STP as the basis for its ampacity derating assessments, and provides specific responses to previous USNRC RAI questions. These documents were submitted by the utility in response to USNRC Generic Letter 92-08. This work was performed as Task Order 8, Subtask 4 of USNRC JCN J2017.

1.0 INTRODUCTION

1.1 Scope and Objective

In response to USNRC Generic Letter 92-08, and a subsequent USNRC Request for Additional Information (RAI), the South Texas Project (STP) nuclear plant provided documentation of the utility position regarding ampacity derating factors associated with its installed Thermo-Lag 330-1 fire barrier systems. The objective of this subtask was to review and evaluate these utility submittals. The relevant documents reviewed are:

- Letter, April 24, 1995, T. H. Cloninger, Houston Lighting & Power Company/STP to the USNRC Document Control Desk, item ST-HL-AE-4982, File No. G03.08, with one attachment as follows:

  - Attachment 1: "Ampacity Testing in UL" Report, Bechtel Log No. 14926-C042-0017-B3M (24 Pages).

- Letter, December 20, 1995, T. H. Cloninger, Houston Lighting & Power Company/STP to the USNRC Document Control Desk, item ST-HL-AE-5255, File No. G03.08, with one attachment as follows:

  - Attachment: Additional Information Regarding Ampacity Derating

SNL was requested to review these submittals under the terms of the general technical support contract JCN J-2017, Task Order 8, Subtask 4. This letter report documents the initial results of this review. The intent of this review was to provide support to the USNRC in determining the adequacy of the utility submittals, and in the potential development of a supplemental RAI. Based on the results of this review, it is recommended that such a request should be pursued.

1.2 Overview of the Utility Submittal

The utility submittals reviewed by SNL are quite sparse in comparison to other plant submittals reviewed to date and in comparison to the level of documentation considered as the minimal "set" required to support a review of this type. In particular, the utility has not provided any specific examples of it ampacity calculations, and has not, in fact, provided even a generic description of the overall utility ampacity assessment approach or methods. For example, the utility has provided no information on its installed barrier configurations, the types of cables involved, the types of fire barriers installed, how in-plant service loads were determined, which cables were examined, where the base ampacity values were obtained, nor how corrections were made to baseline ampacity values to account for factors such as grouping of cables in a common raceway or the ambient temperature in the room of interest. The utility has not even provided a description of how the ampacity derating factors it has cited have been applied to its in-plant cables.

In a typical submittal, all of these factors are discussed in some detail. An evaluation of all of these factors is required before a full assessment of the utility in-plant service load evaluations can be made. As a minimum, a discussion of the overall utility assessment process, a limited set of illustrative detailed calculation examples, and a summary of assessment results is needed. **The STP submittals do not meet this minimum level of documentation, and hence, one primary finding of this review is that the utility has not demonstrated that its cables are operating within acceptable ampacity limits.** Section 3 below provides recommendations regarding the specific additional documentation considered necessary to complete this review.

2.0 THE TSI SPECIAL INVESTIGATION AT UL

2.1 Overview

The utility documentation is primarily associated with the tests upon which STP is basing its assessment of the ampacity derating impact of its installed fire barriers. The cited test report is actually one of the original manufacturer (TSI) test reports. In particular, STP cites a report which documented the results of a "Special Investigation" commissioned by TSI using UL equipment and facilities. As will be noted below, there are significant concerns associated with that test report which render its results of very questionable merit.

2.2 The Intent and Objective of a UL Special Investigation

The tests being cited by STP as the basis for its assessment of fire barrier ampacity derating effects were performed by TSI using UL equipment and facilities under the terms of a "Special Investigation" contract. This is a very unique type of contract with UL and there is one critical factor which should be recognized in order to fully appreciate the nature of that study.

That is, under the terms of a UL "Special Investigation" contract, the sponsoring organization is basically paying for access to the UL facilities and support structure in order to perform some specific and specialized tests. However, the tests are performed under the full supervision and control of the sponsoring organization, in this case TSI, and UL neither approves nor endorses the test practice or test results. This is quite different from a typical UL test in which a product is evaluated by UL for compliance with specific UL performance standards. In these more typical investigations, all testing activities would be under the direct control and supervision of UL, not the sponsoring organization.

The implications of this distinction are profound in this context. The TSI "Special Investigation" was not an independent test of the product, but rather, was a manufacturer test of the product. While the test was observed by both UL and Bechtel personnel, the test was performed under the control of TSI. UL does not in any way endorse or guarantee the results of such investigations, and in fact, the cover letter from UL makes this point quite clear. Citing this document as an "Underwriters Laboratory test report" would seem inappropriate. In particular, the STP letter of 4/24/95 states that:

"In reference 1, Houston Lighting & Power submitted a response to the Nuclear Regulatory Commission Request for Additional Information dated September 19, 1994 .... The response indicated that site ampacity derating tests were conducted by Underwriters Laboratories in accordance with selected specifications."

This statement is considered to overstate the role of UL in the performance of these tests. The report is, in effect, a TSI report on tests which happened to be performed using UL facilities. It is not a report on tests conducted by UL, but rather, a report on tests conducted by TSI at UL facilities. The importance of this distinction will become more clear in the following subsections.

2.3 The USNRC Inspector General's Report

In 1992 the USNRC Office of the Inspector General (OIG) issued its final report on the "Inspection of the NRC Staff's Acceptance and Review of Thermo-Lag 330-1 Fire Barrier Material" [ref. 1]. This report included a discussion of the TSI "Special Investigation" tests cited by STP as the basis for its ampacity derating assessments.

Of particular note is the fact that as a part of that investigation the cognizant UL personnel who had supported the TSI "Special Investigation" were interviewed, and provided first hand accounts of their concerns related to that testing effort. Also identified as a result of that interview was the fact that UL considered its concerns to be serious enough that it undertook, at its own expense, a retesting of the baseline portions of the cable tray ampacity derating test set, and a reevaluation of the test data given the results of this retest. Documentation of those test results was provided by UL to the OIG investigators. This documentation included characterization of the original TSI test results as "bogus," a very strong, albeit colloquial, term. This characterization was also repeated to the USNRC/OIG investigators.[1]

The revised results based on more stringent adherence to UL recommended test protocol indicated significantly higher ampacity derating factors for the fire barriers than those reported by TSI. However, UL also noted that even its re-testing of the baseline cable tray did not fully address its concerns. The concerns cited by UL were that:

'All panels provided by TSI appeared "wet" (uncured), [and] in the opinion of the project engineer, were not representative of installed field conditions. ... In the opinion of the project [engineer], all tests [with] the TSI [products] were bogus because of (1) uncured [products], (2) insufficient stabilization time, [and] (3) bogus baseline tests on 9-23-86 & 9-30-86. Deratings derived from cable tray baseline test on 10-28-86 are deemed more realistic, although the

---

[1] Based on personal communication with G. Mulley of the USNRC/OIG

"wet" condition of the panels probably made the TSI [products] look better than they are.'[2]

These concerns are potentially quite significant. The potential impact of the first two concerns is highlighted as follows:

> Uncured material: If the materials used in the TSI tests were not fully cured, then during testing of the clad article, significant quantities of water would be driven off from the barrier system. This water would carry significant quantities of heat away from the test article by virtue of the heat of vaporization. This would artificially increase the systems heat rejection capacity, and hence, increase the clad test ampacity values resulting in nonconservative estimates of the ADF impact. It is critical that only fully cured test articles be tested.

> Failure to achieve steady state: Achieving a stable steady state condition is critical to the validity of an ampacity test set. If an inadequate settling time is allowed, the predicted ampacity values in a given test could be seriously distorted. In the TSI baseline test it appears that the initial current settings "overshot" the desired end state conditions, and the currents were subsequently cut back to bring the test article down to the desired temperature. After such and "overshoot" there would be a significant tendency to "undershoot" the final values in order to compensate for the initial overheat. If the article were not allowed to fully settle, then the baseline ampacity values might be significantly understated, resulting in a nonconservative estimate of ADF. Given the UL retesting results, it appears that this was, in fact, the case. While UL only retested the baseline cable tray, steady state conditions are also critical, and perhaps even more critical, to the clad test. In particular, if an inadequate settling time were allowed in the clad test, then the most significant impact would be that the fire barrier materials would not have been heated to their steady state temperature. This would act to artificially inflate the clad test ampacities, and result in nonconservative ampacity derating results.

Given the fact that UL is a world-wide recognized testing laboratory with significant expertise in this area, the concerns must be viewed seriously. One must also acknowledge the context in which the concerns were expressed. In particular, the UL concerns were reiterated to the USNRC/OIG investigators during first-person interviews of the cognizant UL personnel. This lends additional credence to UL's concerns.

Any one of the three specific concerns cited by UL could easily compromise the test results. It is also important to note that UL was, apparently, unable to address all of its concerns in its re-testing efforts. In particular, both the cure state issue and the

---

[2] This quotation is taken directly from the revised data sheet provide by UL to the USNRC/OIG investigator. The items shown in square brackets, [], are expansions of abbreviations in the original notation from UL.

concerns regarding how well a steady state was achieved for the clad tests would still leave considerable uncertainty, even given that UL re-ran the cable tray baseline test. Given the UL cable tray baseline retest, the ampacity derating factor (ADF) associated with a standard 1 hr barrier jumped from 28.0% to 36.1%. That for a standard 3hr barrier jumped from 31.2% to 38.9%. These differences are quite large in the context of ampacity derating factors, and cannot be dismissed.

2.4 STP Response to USNRC Query of 10/23/95

On 10/23/1995, the USNRC sent an additional RAI to STP highlighting the concerns cited in the revised UL data sheet as discussed in Section 2.3 above (see item 4 of that RAI and the utility response of 12/20/95). The STP response to this query cited several factors which it considered as mitigating the UL observations. SNL finds that these discussions are unconvincing as follows:

- STP cites that the UL observations were unsigned: While the UL revised data sheet was unsigned, the USNRC/OIG investigators conducted personal interviews of the cognizant UL personnel at which time these concerns were reiterated. As noted above, this is a matter of public record by virtue of the OIG inspection report. Whether or not the data sheet was signed appears irrelevant.

- STP cites that UL's concerns should have been stated in the UL report to TSI and were not: It would appear that UL expressed its concerns to the personnel present at the time of the test, and that it subsequently reported the factual test results to TSI. The fact that UL did not note its observations in its contract report to TSI would be considered typical of a UL Special Investigation contract. That is, such contracts generally call for UL to report only the facts of the investigation without making any observations or interpretations. The OIG investigation did reveal that UL had, in fact, communicated its concerns and the results of its re-testing effort to TSI via a separate communication. The fact that the official UL report to TSI does not cite its concerns would again appear to be irrelevant to the overall validity of these tests and the potential validity or significance of UL's concerns.

- STP cites that stability was achieved in the tests by showing that the temperature was maintained at the desired level: UL has specifically disagreed with this statement, and UL must be recognized as possessing some considerable expertise in this area. Further, given the very significant difference between the baseline ampacity values cited by TSI (32.1A) and that found by UL in its retesting effort (36.15A) it is difficult to see how STP can argue that an adequate equilibrium was achieved by TSI.

- STP also argues that consistency in the baseline and clad test procedures would further ensure the validity of the data: One must recognize that the fire barrier material itself introduces a significant increase in the total thermal mass of the system (on the order of doubling the total system thermal mass) and that this additional thermal mass is displaced from the heating source (the cables)

and would therefore respond much more slowly than does the original cable mass (the bulk of the thermal mass in the baseline case). This would be reflected in the fact that the thermal "time constant" for the baseline and clad trays are very different, and much longer than 15 minutes in either case. STP argues that:

> "the same 15 minute criteria was used for both tests" and that "since the testing was done by the same procedure, at the same test facility, with the same cabling and by the same personnel, it is reasonable to believe that the slope of the heat up is similar and therefore, the data can be used to calculate the percent ampacity derating"

This STP argument is considered to be without merit. Given the significant differences in both the magnitude and configuration of the thermal mass, significant differences in the transient thermal behavior, the "slope of the heat up", would be expected. Consistently applying a fundamentally poor practice to two fundamentally different thermal systems cannot be cited as an adequate experimental practice.

2.5 Summary

Overall, the STP response to the USNRC questions related to the TSI "Special Investigation" report are considered inadequate. SNL recommends that the concerns expressed by UL be considered credible given the level of expertise known to exist at UL and the context in which those concerns have been stated by UL. SNL further finds that these UL concerns are very significant in the context of both the general validity and final magnitude of the experimental results reported by TSI. The utility has failed to provide convincing arguments as to why the UL concerns would not impact the test results, or why these concerns should be considered incredible. Given these findings, SNL recommends that the TSI "Special Investigation" results should not be considered an adequate basis for the assessment of the ampacity derating impact of Thermo-Lag fire barriers due to the uncertainty which exists in the test results, and the impact that the UL concerns would have on the overall validity of those results. It is recommended that STP should provide an alternate basis for its assessment of fire barrier ampacity derating effects.

3.0 SUMMARY OF REVIEW FINDINGS AND RECOMMENDATIONS

3.1 General Findings and Recommendations

SNL finds that the documentation as currently provided by STP is inadequate to demonstrate that in-plant cables are operating within acceptable ampacity limits. It is anticipated that significant additional documentation will be required to complete this assessment.

In particular, the utility has not provided a general description of its overall ampacity assessment process or procedures, and has provided no specific example calculations upon which to base a review of those practices In order to complete this review, significant supplemental information will be needed. It is recommended that as a minimum the utility should be asked to provide the following information:

- Provide an overall description of the approach taken by STP in the assessment of in-plant cable loads. This description should include the following:

  - describe how in-plant cable service loads are determined,
  - discuss which cables have been included in the analysis and the basis for exclusion of other cables from the analysis,
  - identify the source of the baseline ampacity limits assumed prior to derating (e.g., the NEC, ICEA tables, manufacturer data, etc.),
  - quantify and discuss the basis for the ambient temperatures assumed to exist in the plant and describe how these values have been incorporated into the ampacity analysis,
  - discuss how important environmental and installation factors are accounted for in the ampacity assessment (such as grouping of cables in conduits or trays, ambient temperature, grouping of conduits, cable load diversity if credited, etc.), and
  - describe how the effects of the fire barrier are accounted for in the ampacity analysis.

- Specific and detailed examples of the assessment process should be provided to illustrate typical examples for 1 and 3 hour barriers, for cable trays, conduits and air drops, and for bounding conditions of plant installation (loading factors, ambient temperature, etc). The examples should collectively illustrate all aspects of the overall utility process, and should be provided in sufficient detail so as to allow for verification of the analysis results.

- For the balance of the installed fire barriers, a summary of the cable service load factor assessments should be provided. This should include the identification of the barriers considered in the analysis, a brief characterization of the physical installation (dimensions, loadings, and barrier characteristics e.g.), and a summary of the ampacity derating results (e.g. a comparison of estimated ampacity limits to in-plant service loads).

- For any cables nominally identified as overloaded, detailed supplemental analyses should be provided if the plant concludes that these cables are operating within acceptable limits.

3.2 Findings on the TSI Special Investigation Test Report

The STP assessment of in-plant cable ampacity service loads is apparently based on the results of a series of tests performed by TSI under the auspices of a UL "Special Investigation" contract. It is a matter of public record that UL had significant concerns related to the manner in which tests had been conducted by TSI. These concerns were communicated to TSI shortly after completion of the initial TSI tests and promptly upon completion of a subsequent reinvestigation conducted by UL at its own expense, and were also reiterated to the USNRC/OIG during its investigation of the staff activities as related to Thermo-Lag acceptance by the USNRC (see ref. 1).

Given the overall level of expertise which must be acknowledged to exist at UL, and the fact that these concerns were related first-hand to the OIG investigators by the cognizant UL personnel, the UL concerns must be viewed seriously. Any one of the three specific concerns cited by UL could have seriously compromised the validity of the TSI "Special Investigation" test results. The STP response to USNRC questions in this regard was found to be unconvincing and inadequate. The utility has provided no convincing arguments which would demonstrate that the concerns raised by UL would not impact the validity of the test results. The most convincing facts related to this issue are those which are illustrated by the UL re-testing results. These results do indicate that the TSI testing practice may, indeed, have compromised the final results significantly. SNL finds that the utility has not provided convincing arguments which would mitigate the impact of these results.

SNL recommends that the TSI "Special Investigation" test report cited by STP should not be considered as an acceptable basis for the assessment of ampacity derating factors associated with TSI Thermo-Lag fire barrier systems. Further, given the nature of the concerns expressed by UL, and the rather long time since the original tests were performed, SNL does not expect that any technical arguments could be made which would fully resolve these concerns. SNL also finds that, as noted by UL, even the UL retesting of the baseline cable tray test article would not be expected to have fully resolved the concerns raised. SNL recommends that no further consideration be given to this TSI "Special Investigation" report as a potential basis for the current assessment of nuclear power plant cable ampacity service loads. STP should provide an alternate basis for the assessment of the ampacity derating impact of its fire barrier systems.

4.0 REFERENCES

1. "Office of the Inspector General Inspection Report: Adequacy of NRC Staff's Acceptance and Review of Thermo-Lag 330-1 Fire Barrier Material," Case 91-04N, submitted by the USNRC/OIG under cover letter dated August 12, 1992.