A Review of the 10/3/97 Entergy River Bend Ampacity Derating RAI Response

A Letter Report to the USNRC

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Revision 0

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ATTACHMENT 3

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FORWARD

The United States Nuclear Regulatory Commission (USNRC) has solicited the support of Sandia National Laboratories (SNL) in the review of licensee submittals associated with fire protection and electrical engineering. This letter report represents the third report in a series of review reports associated with ampacity derating submittals from Entergy Operations Inc. (EOI) for the River Bend Station Unit 1 (RBS-1). The submittal reviewed by SNL under the current efforts documents the licensee's response to the USNRC RAI of May 2, 1997. This work was performed as Task Order 2 of USNRC JCN J-2503.

1.0 INTRODUCTION

1.1 Objective

The objective of this report is to document findings and recommendations resulting from a Sandia National Laboratories (SNL) review of a licensee submittal for the River Bend Station Unit 1 (RBS-1) on the subject of fire barrier cable ampacity derating. The subject submittal was forwarded to the USNRC Document Control Desk under an Entergy Operations Inc. (EOI) cover letter dated 10/3/97, and was provided by the licensee in response to an USNRC Request for Additional Information (RAI) of 5/12/97.

1.2 Background

This is the third in a series of SNL review reports associated with the River Bend Station. The history of this review effort is summarized as follows:

- 9/25/95: The USNRC issued a RAI requesting more information on ampacity load calculations for RBS-1 to further clarify the licensee position regarding Generic Letter 92-08.

- 11/9/95: The first licensee RAI response is forwarded to the USNRC Document Control Desk. This original submittal documented the licensee position regarding cable ampacity loads associated with its installed fire barrier systems.

- 6/7/96: SNL completes a technical review of the licensee 11/95 submittal under the terms of a general task ordering agreement, USNRC JCN J-2017.

- 10/16/96: A second RAI is submitted to the licensee by the USNRC.

- 12/19/96: The licensee responds to the 10/96 RAI. The response includes a new set of calculations for a range of non-standard barrier configurations including multiple items in common enclosures.

- 3/21/97: SNL completes a review of the 12/96 licensee submittal under USNRC JCN J-2503. This review finds that all of the previously identified items have been resolved, but also identifies a number of new points of potential concern regarding the new calculations.

- 5/12/97: A third USNRC RAI is issued to the licensee.

- 10/3/97: The licensee submits its response to the 5/97 RAI.

- 12/24/97: This review of the 10/97 submittal is completed by SNL and forwarded to the USNRC.

2.0 LICENSEE DIRECT RAI RESPONSES

2.1 RAI Item 1: Resolution of Overloaded Cables

Synopsis of Concern: The licensee was requested to describe the course of action to resolve nominally overloaded cables. It was also stated by the USNRC that the NEC overcurrent protection ratings cannot be used as a basis for the resolution of overloaded cables. An assessment of remaining life for the overloaded cables was requested.

Synopsis of Response: The licensee response has included the following points:

- The licensee stated that "the SNL comment related to the use of the NEC overcurrent protection provisions" has been incorporated.
- The licensee also cites that the concept of "qualified life" is "not meaningful" for the impacted cables because they are not subject to severe accident environment and are hence not encompassed by the plant EQ program requirements.
- An assessment is described in which the cables were physically inspected including testing with an EPRI device called the Franklin Indenter or the Cable Indenter. It was noted that the cables were "absent of any observable change" in comparison to un-used stockpiles of the same cable.
- The licensee cites that the fire barrier in question has been removed.

Assessment of Response: SNL's assessment of these points is as follows:

- SNL takes the first point, incorporation of the NEC overcurrent comments, to imply that the licensee will not use this as a basis for resolving cable overloads. Given this interpretation, the licensee response is acceptable.
- SNL considers that the concept of life expectancy as is often applied in EQ studies is a meaningful concept in the ampacity arena. The major difference is that cable life is considered in comparison to the nominal cable insulation temperature rating of 90°C as compared to the cable equipment qualification qualified life temperature that will typically be much lower. Nonetheless, the same concepts of accelerated aging can be applied to non-EQ based applications.
- The licensee assessment of the cable based on physical inspection and measurements with the indenter are considered adequate demonstration that premature degradation of the cables has not been realized.
- The removal of the fire barrier implies that future life performance will not be compromised.

Findings and Recommendations: The licensee response is considered fully adequate to resolve the identified concerns. In particular, the measurement of the in-service and stockpiled cables with the EPRI indenter, and the removal of the fire barrier are especially telling points. SNL recommends that no further action on this RAI item is required.

2.2 RAI Item 2

2.2.1 RAI Item 2a: Internal Convection Coefficients

Synopsis of Concern: The licensee applied convection coefficients for an external surface to the confined spaces interior to the fire barriers.

Synopsis of Response: The licensee response recognizes the point of the concern raised by SNL. The response correctly points out that the complex geometry of the interior spaces means that no direct correlations for confined space convection are available. The licensee also provides a comparison of the values used in the study to those obtained using the available confined space correlations and shows that the chosen values are generally conservative.

Assessment of Response: Of the points raised by the licensee, the comparison of the convection values used in practice to the corresponding confined space coefficients was most telling. This comparison has demonstrated that the licensee chosen values are conservative. This is largely because of the small temperature differences that result in relatively small convection coefficients in general. In this case, the convection treatment is approaching, or has passed, the point where conduction through the air gap is actually more efficient. Hence, use of the convection correlations actually results in a more conservative heat transfer prediction.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.2 Item 2b: Treatment of External Convection

Synopsis of Concern: The licensee had provided a very crude treatment of external convection that was not consistent with common practice in this regard.

Synopsis of Response: The license response cites that while crude, the treatment given was, in fact, conservative. This includes comparison of the chosen correlation parameters to those considered representative for the conditions under analysis.

Assessment of Response: The licensee response has demonstrated that the treatment provided will be conservative.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.3 Item 2c: Treatment of Conduits

Synopsis of Concern: It was not clear from the submittal how the licensee had handled the problem of heat transfer between the cables and the conduit.

Synopsis of Response: The licensee response has clarified that the cable to conduit heat transfer has been based on an examination of the IEEE conduit ampacity tables. A composite heat

transfer coefficient is developed on the basis of these tables. Hence, the treatment is in fact consistent with the Neher/McGrath approach.

Assessment of Response: The licensee response was fully adequate to resolve the identified concern. The licensee practice of "backing out" the cable to conduit heat transfer coefficients, and then applying those same coefficients is technically valid.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.4 Item 2d: Calculation of Radiation View Factors

Synopsis of Concern: The licensee had apparently not calculated radiation view factors properly for cases involving multiple raceways in a common fire barrier enclosure.

Synopsis of Response: The licensee response has further discussed the process by which radiation view factors have been calculated. There are two points of particular importance in the licensee response as follows:

- The licensee modified analyses are now crediting heat transfer to the concrete surfaces which form one or more sides for certain of the analyzed enclosures. Hence, the radiation view factors should include communication with these surfaces.

- In the discussion of heat transmission to the walls and to blocking raceways, the licensee makes the following statements: "Regardless, the assumption of no heat dissipation through the concrete walls does not imply that they can not receive and reradiate/convect the heat received from the raceways. This is also valid for the control/instrument raceways in the same enclosure. These raceways may block the view of the power raceways but still participate in radiative heat transfer. Accordingly, the calculation of the shape factors does not consider the concrete walls or the non-power raceways as radiation blocking elements."

The licensee closes with a revised set of radiation view factors.

Assessment of Response: With regard to crediting the concrete walls in the heat transfer process, SNL has no objections in principal to this practice. That is, SNL finds that crediting of the heat transfer role of the concrete in this process is an appropriate approach to analysis. Clearly the concrete walls may absorb a significant amount of heat from the system depending on their own temperature conditions.

With regard to the licensee statements related to blocking elements, SNL finds this argument to be without merit. While blocking elements are available to participate in the heat transfer process, the efficiency of this process is much lower than is the assumed efficiency of the tray to enclosure surface heat transfer provided in the licensee model. Consider the case of a control tray that is blocking the radiative view between a power tray and the barrier wall. While it is true that the blocking tray can participate in the heat transfer process, this participation will introduce a significant "penalty" in the form of a sharply reduced heat transfer rate. This is because the heat

must first pass from the surface of the power tray, to the near surface of the control tray, through the control tray, and finally from the far surface of the control tray to the fire barrier wall surface. Each of these interfaces/elements introduces its own unique temperature drop. For radiative heat transfer these temperature drops are especially important given the dependence of radiation on temperature to the fourth power. To propose that this has no impact and need not be considered in the formulation of the heat transport model is technically insupportable. The heat transfer through this blocking element will be far less efficient than direct unobstructed communication between the power tray and the barrier wall surface. The licensee practice of ignoring blocking elements in the formulation of radiation view factors is not valid and is unrealistically optimistic. As noted by the licensee elsewhere in the submittal (see response to item 2a for example), for these analyses the radiative heat transfer terms are dominant as compared to the convective heat transfer rates. Hence, the licensee practice will likely result in overly optimistic assessments of the clad case ampacity limits.

Findings and Recommendations: SNL finds that the licensee has not adequately addressed the identified concern. The failure to consider thermal blocking elements in the formulation of raceway-to-enclosure wall radiation view factors introduces an obvious and inappropriate source of excessive optimism in the licensee thermal model. SNL recommends that the licensee be once again asked to correct its assessments in this regard.

2.2.5 Item 2e: Consistency

Synopsis of Concern: The licensee was asked to ensure that the baseline and clad case ampacity limits were derived on a consistent basis.

Synopsis of Response: The licensee has provided a further clarification of its modeling practice as regards the baseline ampacity limits. The cable trays model in a baseline configuration was compared to the ICEA ampacity limits and was found to yield conservative results. The conduit thermal model derives the conduit to cable heat transfer behavior from the IEEE tables using conservative assumptions regarding the conduit thermal properties. Hence, consistency is maintained inherently by this practice.

Assessment of Response: The licensee response has clarified that appropriate consideration was in fact given to internal consistency between the clad and baseline models. The licensee has demonstrated adequately that use of the tabulated ampacity limits is equivalent to or more conservative than would be reliance on a full implementation of the baseline model.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.6 Item 2f: Conduit Conductor Count Factors

Synopsis of Concern: The licensee had committed to use of the more modern non-diversity based conduit conductor count ampacity correction factors but it appeared that the older diversity based values were still used in the submittal.

Synopsis of Response: The licensee has reiterated its commitment to use the non-diversity based correction factors where appropriate. The case from the submittal cited in SNL's review was noted as an application error, and has been corrected.

Assessment of Response: The licensee response has adequately addressed the concern raised by SNL.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.7 Item 2g: Independent Treatment of Multiple Source Heat Transfer

Synopsis of Concern: The licensee thermal model appeared to be treating heat transfer between the various raceways of a multiple raceway enclosure to and through the surface of the enclosure as independent processes, rather than as simultaneous processes.

Synopsis of Response: The licensee response has clarified that the thermal model does indeed provide for the simultaneous treatment of the heat transport.

Assessment of Response: The licensee response has clarified the model practice in this regard. Given the new information provided, SNL has been able to verify that the licensee model is appropriate in this regard.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.2.8 Item 2h: Use of Test Data

Synopsis of Concern: SNL had recommended that the licensee calculations for single conduits may be unnecessary. It was recommended that industry test data be reviewed for applicability at River Bend.

Synopsis of Response: The licensee has reviewed the available test results and will base single conduit ADF values on testing by Texas Utilities (TUE) including the uncertainty in those results documented during the USNRC test review process. The licensee compares the TUE value of 21% ADF to the model result of 20%.

Assessment of Response: The licensee use of industry test data is consistent with SNL's recommendations. Indeed, the licensee has chosen to apply the most conservative of the available ampacity derating test results when in fact more optimistic results might have been cited.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.3 RAI Item 3: Reassessment of Supported Calculations

Synopsis of Concern: The licensee was asked to review calculation E218 in light of the comments raised in the previous RAI items.

Synopsis of Response: The licensee has provided a revised version of the calculation.

Assessment of Response: The revised calculation has included the updated results. Note that SNL found one RAI item unresolved, Item 2d, hence, the update does not reflect resolution of this item.

Findings and Recommendations: The licensee has updated its supported calculations. However, resolution of item 2d may require that the licensee once again update Calculation E-218.

2.4 RAI Item 4: Conduit Fill Questions

Synopsis of Concern: The licensee had cited conduit fills in excess of 100%. An explanation was requested.

Synopsis of Response: The licensee has clarified that the cited conduit fills are relative to the recommended NEC fill limits. Actual conduit fill limits have been based on manufacturer specifications regarding conduit fill and pull tension limits for the installed cables.

Assessment of Response: The licensee response has clarified this point of uncertainty.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern, and no further actions on this item are recommended.

2.5 RAI Item 5: Conduit Fills in Excess of NEC Limits

Synopsis of Concern: The licensee had cited conduit fills in excess of the NEC guidelines.

Synopsis of Response: The licensee response refers the reader to its response for Item 4. In particular, the response to item 4 cited that "the NEC conduit fill limits are based on 'common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits.'" They further cite that "the absolute restriction is defined by the cable manufacturer's allowable cable pulling tension. Utilities perform calculations and measure pulling tension during certain pulls to assure that pulling tension does not exceed manufacturer's limits." The licensee also cites that cable ampacity limits are derated on the basis of conductor count rather than fill.

Assessment of Response: SNL has reviewed the applicable sections of the NEC. It would appear that the licensee interpretation is correct in that the primary intent of the NEC fill limits is to prevent damage to the cables during installation. Indeed, there is no direct tie made between conduit percentage fill and ampacity in any of the code provisions. While the licensee does appear to be taking a somewhat liberal interpretation of the applicability of the cited NEC fill limits, SNL finds that the nominal overfill conditions have no relevance to the assessment of cable ampacity limits.

Findings and Recommendations: SNL finds that the licensee has adequately addressed the identified concern in the context of the ampacity assessments, and no further actions on this item are recommended.

3.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

SNL finds that the licensee has adequately responded to all of the specific RAI items with one significant exception; namely, RAI Item 2d. Unfortunately, SNL finds that this RAI item concerned an error in a critical element of the thermal model that has not been corrected. Hence, SNL recommends further interactions with the licensee to resolve this concern as follows:

- RAI item 2d requested that the licensee correct its calculations for the radiation view factors for multiple raceway enclosure systems. These factors are critical to the analysis because they characterize the radiative heat transfer behavior that takes place between the powered raceways and the surfaces of the surrounding barrier enclosure. In particular, the licensee had not given proper treatment to thermal blocking elements such as other trays and conduits. The licensee was not responsive to this concern. An alternate justification for the previously reviewed practice was provided, and SNL found this justification to be without technical merit. SNL finds that the licensee's current treatment of radiation view factors is technically indefensible, inappropriate, and overly optimistic. Thermal radiation plays a dominant role in the overall heat transfer process based on the licensee's own assessments. Hence, SNL finds that the licensee ampacity assessments for multiple item enclosures are excessively optimistic.

  It is recommended that the licensee again be asked to correct its model and to incorporate realistic source-to-target radiation view factors that fully account for blocking elements in the thermal system. That is, the radiation view factor applied to each heating source should reflect <u>only</u> the <u>direct</u> view between that source and the surfaces of the surrounding enclosure. Any and all blocking elements, whether these be powered and/or unpowered trays and/or conduits, should be appropriately factored into the analysis. SNL notes that the methods required for a proper analysis of the radiation view factors are readily available to the licensee and well documented in the public literature.

  If credit for heat transfer through blocking elements is to be taken, then SNL recommends that an explicit treatment of this behavior including all associated temperature drops be requested by the USNRC. As a minimum this would require that each blocking element be treated as a heat transfer path acting in parallel to the direct source-to-barrier radiative exchange. This will in turn, as a minimum, require appropriate treatment of both the "near" and "remote" surface temperatures, radiative exchange between the source and the blocking element and between the blocking element and the barrier surfaces, and conduction through the blocking element.