UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

REVISED SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

AMPACITY DERATING ISSUES

ENTERGY OPERATIONS, INCORPORATED

RIVER BEND STATION

DOCKET NO. 50-458

BACKGROUND

Listed below is a brief outline of the history associated with the matter under review:

9/25/95:	The staff issued a Request for Additional Information (RAI) to obtain information on ampacity load calculations for River Bend, Unit 1, with respect to Generic Letter 92-08.
11/9/95:	The licensee responded documenting initial position regarding cable ampacity loads associated with its installed fire barriers systems.
10/16/96:	The staff issued a second RAI to obtain information regarding licensee Calculation E-218.
12/19/96:	The licensee responded with a new set of calculations (Calculation G13.18.14.0-178) for a range of non-standard fire barrier configurations.
5/12/97:	The staff issued a third RAI to obtain information regarding licensee Calculation G13.18.14.0-178.

By letter dated October 3, 1997, Entergy Operations, Inc., (EOI) submitted its response to the third Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) dated May 12, 1997, related to cable ampacity due to application of Thermo-Lag fire barrier for River Bend Station, Unit 1.

The subject staff RAI had identified a number of open issues and concerns requiring clarification by the licensee. The subject licensee submittal contained the response to staff questions regarding its ampacity methodology. A follow up conference call was held on January 20, 1998, between the staff, Sandia National Laboratories (SNL) and the licensee to discuss the licensee response to RAI Item 2d. The staff issued its evaluation of the outstanding

ampacity derating methodology issues for River Bend Station on September 3, 1998. By letter dated November 2, 1998, the licensee requested greater clarification from the safety evaluation dated September 3, 1998. The revised safety evaluation follows.

EVALUATION

After reviewing the licensee's submittals and SNL Technical Letter Reports (see Attachments 2 through 5), the staff agrees with the SNL analyses and conclusions. The ampacity derating analysis questions associated with the staff RAI dated May 12, 1997, the licensee's response, and the staff's evaluation of the responses follow.

Ampacity Derating Analysis Review

- Question 1

  Please identify what course of action will be taken to resolve those cables that were identified as overloaded for application in the plant. The staff agrees with the SNL assessment that the National Electric Code (NEC) overcurrent protection provisions [i.e., Articles 240-3(b) and 240-6] as described in the licensee's submittal dated December 19, 1996, cannot be used as a basis for the resolution of the overloaded cable issue (see Section 4.1.3 of the SNL letter report dated March 21, 1997 [Attachment 4], for details). In addition, you are requested to estimate conservatively the remaining cable life for those cables that have operated under overloaded conditions.

  Licensee Response

  In its submittal dated October 3, 1997, the licensee stated that the use of the NEC overcurrent protection provisions has been incorporated in the appropriate design documents. In addition, supplemental information was provided by the licensee to the staff and SNL during a follow up conference call on January 20, 1998, to address the assessment of remaining life for the subject cables.

  Staff Response

  The information provided by the licensee fully resolves the staff's concerns.

- Question 2

  SNL found that Calculation G13.18.14.0-178, which was included in your submittal dated December 19, 1996, was significantly flawed in terms of the implementation of the thermal model. Please address the following points raised by SNL:

  (a) You have inappropriately applied convection coefficients for surface heat transfer in an unrestricted open (external) environment to the highly confined interior of the fire barrier systems analyzed. This observation applies to both the conduit and cable tray analyses. You are requested to provide an explicit justification for

any such cases that includes a discussion of item-to-item, item-to-barrier surface, and item-to-wall/ceiling clearances. (See Sections 3.2.1 and 3.2.2 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(b) Your treatment of external convection for cable tray systems is unnecessarily crude and does not adequately treat the differences associated with surface orientation. You are requested to modify your thermal model so that more realistic external convective heat transfer coefficients are derived. (See Section 3.2.3 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(c) Your treatment of internal heat transfer behavior within a conduit has not been adequately justified and appears to be inappropriate and non-conservative. You are requested to modify its analysis methodology to conform to accepted practices for the analysis of cable-to-conduit heat transfer. (See Section 3.2.4 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(d) You have not calculated radiation view factors correctly, in particular, for those analyses involving multiple raceways in a common enclosure. You are requested to correct your analysis in this regard. (See Section 3.2.5 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(e) Your comparison of clad case ampacity limit estimates derived from your own thermal model to tabulated base line ampacity limits is inappropriate. You have failed to demonstrate that your thermal model is consistent with the thermal models used to develop the standard tables, and the consistency between the clad case and base line case analyses is critical to the reliability and robustness of the calculations. You are requested to explicitly determine base line ampacity limits using a thermal model consistent with that applied to the clad case analyses. (See Section 3.2.7 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(f) The ampacity correction factors associated with the number of current carrying conductors in a conduit have either not been properly calculated or are still based on the older pre-1990 NEC correction factors. This item was also identified as a concern in SNL's earlier review, and your response to the question in Section 2.3 of the staff's October 16, 1996, RAI cited that the newer NEC correction factors would be used in all calculations. (See Section 3.2.6 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.)

(g) For cases involving multiple raceways (trays and/or conduits) in a single enclosure, your independent treatment of convective heat transfer between each of the raceways and the inner surface of the fire barrier system is inappropriate. You are requested to modify the thermal model to account for the simultaneous transfer of the total convective heat load from all sources. (See Section 3.2.8 of the SNL letter report dated March 21, 1997 [Attachment 4], for details.

(h) Your calculations for single aluminum conduits may be unnecessary. You could instead apply test data available from industry for steel conduits as conservative

estimates of the Ampacity Derating Factor (ADF) for an aluminum conduit (provided, of course, that the fire barrier configurations are roughly equivalent). While this may actually result in less conservative estimates of the derating impact as compared to your current estimates, this would remove one significant source of uncertainty in your assessments, and would simplify both this calculation and the overall licensee submittal. You are requested to consider whether to abandon your calculations for single aluminum conduits and to instead rely on industry data for steel conduits in any case in which an appropriately tested configuration can be identified for River Bend plant installations.

Licensee Response

In its submittal dated October 3, 1997, the licensee provided the following information:

2a: 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 or confined space convection are available. The licensee also provides a comparison of the values used in the study of those obtained using the available obtained space correlations and shows that the chosen values are generally conservative.

2b: The licensee 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.

2c: The licensee response has clarified that the cable to conduit heat transfer has been based on an examination of the Institute of Electrical and Electronic Engineers (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.

2d: The licensee response cities that the fire barriers in question have been removed. However, the response also further discussed the process by which radiation view factors have been calculated and made two points of particular importance 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 of 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.

Supplemental information regarding this response was provided by the licensee on January 20, 1998, in a conference call between the NRC, SNL, and the licensee. In particular, the licensee cited that there was a direct link between the response to Item 1 and to Item 2d. In particular, the findings discussed in response to Item 1 apply to the exact same cables, conduits and trays as those impacted by the calculations discussed in Item 2d. The licensee clarified that the response to Item 1 was intended to demonstrate that the calculation was indeed conservative because the calculated cable temperature far exceeded the actual cable temperature based on field observations. The licensee cited this as a basis for concluding that the radiation view factors used in the calculation were actually conservative.

2e: 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 Insulated Cable Engineers Association (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.

2f: 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.

2g: The licensee response has clarified that the thermal model does indeed provide for the simultaneous treatment of the heat transport.

2h: The licensee has reviewed the available test results and will base single conduit ADF values on testing by Texas Utilities Electric (TUE) including the uncertainty in those results documented during the staff's test review process. The licensee compares the TUE value of 21 percent ADF to the model result of 20 percent.

Staff Response

The information provided by the licensee fully resolves the staff's concerns in all of the above items except item 2d.

Question 3

It is noted that Calculation E-218 includes the use of ampacity derating factors derived from Calculation G13.18.14.0-178, which SNL has determined to be significantly flawed in terms of model implementation. You should revise Calculation E-218 in light of any resolution for the concerns stated in Item 2 above.

Licensee Response

In its submittal dated October 3, 1997, the licensee provided a revised version of the subject calculation.

- Question 4

You have documented conduit cable fills as high as 124 percent in your December 19, 1996, submittal. It appears physically unrealistic to have a conduit load of greater than 100 percent. You are requested to explain this apparent inconsistency.

Licensee Response

In its submittal dated October 3, 1997, the licensee 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.

Staff Response

The information provided by the licensee fully resolves the staff's concerns.

- Question 5

In the December 19, 1996, submittal, you had documented numerous conduits that appear to be loaded in excess of the loading limits established in the NEC (generally limited to 40 to 53 percent loads depending on the conductor count). You are requested to explain these apparent violations of the NEC.

Licensee Response

In its submittal dated October 3, 1997, the licensee refers the staff 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.

Staff Response

The information provided by the licensee fully resolves the staff's concerns.

Application of Ampacity Derating Methodology

Calculation E-218, Revision 1

The licensee approach is to first establish a baseline ampacity limit for a given cable in a given raceway. The baseline ampacity values are taken either from the industry ampacity tables or are derived using the heat intensity approach as defined by J. Stople (Reference IEEE Paper, "Ampacities for Cables in Randomly Filled Trays," 1970). The baseline value is then derated for various factors including

- cable groupings for conduits and maintained spacing trays,
- inductive heating effects for unbalanced loads, and
- the fire barrier system ADF (values taken from industry test data)

Given the resolution of the nominally overloaded cables concerns as described in Attachment 3, the staff finds that the licensee methodology is generally acceptable for use based upon the plant-specific information provided. Although there are points of conservatism in the licensee's approach, the staff agrees with the discussion in Section 4.2.1 of Attachment 4 regarding the limitations of the licensee's linear heat intensity model. That is, if another plant used the same model where cable tray fills were higher, or if the licensee were to modify the plant, significant errors could result. However, the subject limitations do not materially affect the acceptability of the licensee methodology based upon the specific information provided for Thermo-Lag enclosed cables at River Bend, Unit 1.

Calculation G13.18.14.0-178

The staff finds that the licensee has provided sufficient information to conclude that the cables contained in the two multiple raceway, special configuration, fire barriers have not been subjected to adverse accelerated aging due to their life-to-date operation. This finding is based primarily on the cited Electric Power Research Institute (EPRI) indenter measurements for the worst-case cables, as installed in the plant, and the comparison of those measurements to uninstalled cables taken from the plant material stocks. Critical to this assessment is the fact that the cables in question are Hypalon jacketed, and the EPRI indenter test reveals aging induced changes for this material (based on Equipment Qualification test results from NUREG/CR-5772). The fire barriers in question have been removed and, clearly, continued operation in the absence of the fire barriers will also not be a concern.

There was one point of technical concern raised in the RAI that was not adequately resolved by the licensee. The staff noted in RAI Item 2d that the licensee practice in the calculation of radiation view factors for the multiple raceway special configurations was inappropriate and overly optimistic. The staff finds that the licensee failed to adequately address this concern and implemented no corrective actions in the updated thermal model. Hence, the licensee special configuration thermal model as currently implemented will not be accepted for ampacity assessments.

Given that the licensee has removed the subject fire barriers from the applicable electrical raceways and the licensee field observations of the condition of the formerly clad cables

indicates no sign of age related cable degradation the licensee thermal calculation is not necessary for issue resolution.

Given these observations, the staff finds that the licensee has provided adequate information to resolve the ampacity-related points of concern raised in Generic Letter 92-08.

CONCLUSIONS

From the above evaluation, the staff concludes that the licensee thermal model as detailed in Calculation G13.18.14.0-178 is not acceptable for ampacity assessments. In its submittal dated October 3, 1997, the licensee stated that the corrective action to remove the Thermo-Lag fire barriers from those cables which had been identified as overloaded have been completed at River Bend, Unit 1. Therefore, given that the field inspection of the subject cables indicates the absence of age related cable degradation there are no outstanding safety concerns with respect to ampacity. As noted above, the staff finds that the methodology associated with Calculation E-218 is generally acceptable for River Bend's plant-specific application, given the resolution of staff concerns as described in Attachment 3. Given the thermal model issues raised during this review it is recommended that the subject evaluation be used in any follow up staff review.

Principle Contributor: R. Jenkins

Date: November 15, 1999

ATTACHMENT 1 TO ENCLOSURE 1
NOT USED AT THIS TIME