August 4, 1999

FOR: The Commissioners

FROM: William D. Travers /s/
Executive Director for Operations

SUBJECT: KAOWOOL AND FP-60 FIRE BARRIERS

PURPOSE:

To inform the Commission about the results of the U.S. Nuclear Regulatory Commission (NRC) staff's review of Kaowool fire barriers at Joseph M. Farley Nuclear Plant, Units 1 and 2 (FNP) and the staff's plans to address technical issues with Kaowool and FP-60 barriers.

BACKGROUND:

In a memorandum dated June 9, 1998, the staff informed the Commission that the Office of Nuclear Reactor Regulation (NRR) was evaluating the fire-resistive capabilities of Kaowool fire barriers in response to a Task Interface Agreement (TIA) with Region II regarding the barriers installed at FNP. As detailed below, the staff could not find a sound technical basis for concluding that Kaowool barriers provide adequate fire protection for equipment that needs to remain functional during and after a nuclear power plant fire. The questions regarding the Kaowool fire barriers at FNP may also apply to FP-60 barriers and to other plants that use Kaowool or FP-60 barriers.

DISCUSSION:

Kaowool is a noncombustible, flexible, ceramic-fiber blanket originally manufactured by Babcock and Wilcox. FP-60 is basically an upgraded version of Kaowool with aluminum foil laminated to both surfaces. It is manufactured by Thermal Ceramics. Certain reactor licensees wrap Kaowool or FP-60 blankets around electrical raceways that contain circuits needed to achieve and maintain post-fire safe shutdown. To the best of the staff's knowledge, Kaowool and FP-60 are used to construct barriers intended to have a 1-hour fire resistance rating, but not barriers with a 3-hour rating. Some licensees may also use Kaowool and FP-60 barriers to separate certain electrical systems in accordance with the guidance of Regulatory Guide (RG) 1.75, "Physical Independence of Electrical Systems." The technical issues detailed below apply only to Kaowool and FP-60 fire barriers installed to protect the post-fire safe shutdown capability. The staff is not concerned about the use of Kaowool and FP-60 to meet RG 1.75 criteria.

- Applicable Regulatory Requirements and Staff Review Guidance
- Previous Generic Communications Applicable to Kaowool and FP-60 Fire Barriers
- Results of the Farley Review
- Plants That Use Kaowool or FP-60 Fire Barriers
- Generic Implications of the FNP Review

APPLICABLE REGULATORY REQUIREMENTS AND STAFF REVIEW GUIDANCE

On February 19, 1981, the new fire protection regulation, Section 50.48, "Fire protection," of Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 50), and Appendix R to 10 CFR Part 50 became effective. Appendix R establishes the fire protection features required to satisfy General Design Criterion 3, "Fire protection," of Appendix A to 10 CFR Part 50 with respect to certain generic issues for nuclear power plants licensed to operate before January 1, 1979. In the statement of considerations (SOC) for Appendix R (45 FR 76602), the Commission stated that it had decided to retroactively apply the fire protection requirements for post-fire safe shutdown to all facilities, including those that the staff had previously approved. These requirements are specified in Section III.G, "Fire protection of safe shutdown capability," of Appendix R. In the SOC, the Commission stated that licensees should either reexamine previously approved fire protection configurations that do not meet the requirements of Section III.G of Appendix R or else apply for an exemption that justifies alternatives. This is codified in 10 CFR 50.48(b).

The underlying purpose of Section III.G of Appendix R is to ensure that at least one means of achieving and maintaining safe shutdown will remain available during and after any postulated fire in the plant. Section III.G specifies three options for limiting fire damage so that one train of systems necessary to achieve and maintain hot shutdown remains free of fire damage. Two of the options rely on fire-rated barriers. The SOC stated:

> Fire barriers are "rated" for fire resistance by being exposed to a "standard test fire." This standard test fire is defined by the American Society for Testing and Materials in ASTM E-119, "Standard for Fire Resistance of Building Materials." Fire barriers are commonly rated as having a fire resistance of from 1 to 8 hours.

In accordance with 10 CFR 50.48(b), for nuclear power plants licensed to operate prior to January 1, 1979, fire barriers installed to protect the post-fire safe-shutdown capability, whether installed before or after Appendix R became effective, are required to satisfy the technical requirements of Section III.G. (Alternatively, if installing new barriers or modifying existing barriers would not have enhanced fire safety, the licensees for such plants could have requested exemptions from the requirements of Appendix R.)

In Generic Letter (GL) 86-10, "Implementation of Fire Protection Requirements" (April 24, 1986), the staff presented acceptable methods for satisfying the technical requirements of Appendix R, including guidance for fire barriers. In GL 86-10, the staff stated that the documentation required to establish the fire rating of a fire barrier should include the design description of the barrier and the test reports that verify its fire rating. The staff also discussed the fire test acceptance criteria for establishing the fire rating of a fire barrier. With respect to the cold-side temperature criterion used to establish that cables enclosed within a fire barrier will be free of fire damage, the staff stated:

> Conduit and cable tray enclosure materials accepted by the NRC as 1 hour barriers prior to Appendix R (e.g., some *Kaowool* and 3M materials) and already installed by the licensee need not be replaced even though they may not have met the 325 F criteria [cold-side temperature

criterion] [emphasis added].

Plants licensed to operate prior to incorporating Appendix R in the regulations, are still required to satisfy Appendix R requirements. However, GL 86-10 states that licensees need not replace Kaowool materials that were installed before Appendix R became effective and that were accepted by the NRC as 1-hour fire-rated barriers. The guidance in GL 86-10 is silent on fire test acceptance criteria other than cold-side temperature. It is also silent on whether or not licensees should reexamine previously approved Kaowool raceway fire barriers and request exemptions for those that do not meet the technical requirements of Appendix R. It appears that the staff and the licensees have interpreted the GL 86-10 guidance to mean that Kaowool raceway fire barriers installed before Appendix R became effective and that were accepted by the NRC as 1-hour fire-rated barriers are "grandfathered" and that exemptions are not needed even though the barriers may not meet the technical requirements of Appendix R.

PREVIOUS GENERIC COMMUNICATIONS APPLICABLE TO KAOWOOL AND FP-60 FIRE BARRIERS

In GL 92-08, "Thermo-Lag 330-1 Fire Barriers" (December 17, 1992), the staff stated that it expected the recipients to review the information in the GL to determine if it applied to other barrier materials and systems used at their facilities and consider actions, as appropriate, to avoid problems similar to the Thermo-Lag fire barrier problems. In 1993, the staff issued two information notices (INs) regarding potential problems with Kaowool and FP-60 fire barriers. In IN 93-40, "Fire Endurance Test Results for Thermal Ceramics FP-60 Fire Barrier Material," (May 26, 1993), the staff reported that failures occurred in the joints of the fire barriers during the fire-endurance testing. Later, in IN 93-41, "One-Hour Fire Endurance Test Results for Thermal Ceramics Kaowool, 3M Company FS-195 and 3M Company Interam E-50 Fire Barrier Systems," (May 28, 1993), the staff reported problems with the methods and results of fire tests of Kaowool fire barriers.

RESULTS OF THE FARLEY REVIEW

At FNP, about 6300 linear feet of electrical raceways (conduits and cable trays) are protected with Kaowool fire barriers. On the basis of its review and evaluation of these barriers (attached), the staff found that:

1. It had accepted the use of Kaowool raceway fire barriers at FNP both before and after Appendix R became effective. However, the staff could not find any evidence that the staff that originally approved the barriers had reviewed the Kaowool fire test reports or the licensee's design bases for the barriers. Consequently, the staff could not find a technical basis for having originally accepted Kaowool barriers as 1-hour fire-rated barriers.

2. The fire rating of the Kaowool barriers installed at FNP is indeterminate, but less than the 1-hour needed to met the Appendix R requirements. In addition, the fire-resistive performance of the Kaowool barriers and, therefore, their ability to maintain the protected components free of fire damage is indeterminate.

3. FNP has not established an acceptable design basis for the Kaowool fire barriers installed to satisfy Appendix R. That is, FNP has not established the actual fire-resistance rating of the barriers on the basis of fire test results that are applicable to the as-installed barrier designs. Similarly, FNP has not demonstrated that the barriers will maintain the protected components free of fire damage.

NRR and Region II met with the licensee for FNP and discussed the results of its review of the Kaowool fire barriers installed at FNP. Later, by memorandum dated June 18, 1999, NRR provided to Region II the results of its review of the Kaowool barriers installed at FNP. Region II will provide the results of the review to FNP. FNP has implemented appropriate compensatory measures pending resolution of the issues discussed in this paper.

PLANTS THAT USE KAOWOOL OR FP-60 FIRE BARRIERS

On the basis of an informal survey it conducted in 1993, the staff found that Kaowool or FP-60 barriers are used at 8 plants (14 units) to protect the post-fire safe shutdown capability. (The survey did not distinguish between Kaowool and FP-60 barriers.) The plants are Farley 1 and 2, Fitzpatrick, Hatch 1 and 2, Prairie Island 1 and 2, Salem 1 and 2, Sequoyah 1 and 2, Summer, and Susquehanna 1 and 2. After it completed the FNP review, the staff asked the Nuclear Energy Institute (NEI) if any other plants use Kaowool or FP-60 barriers to meet the regulatory requirements. NEI informed the staff that it contacted each licensee and found one additional plant that uses Kaowool fire barriers to meet regulatory requirements. This plant is Grand Gulf. Of these plants, the licensees for Hatch, Prairie Island, Salem, Sequoyah, and Susquehanna have voluntarily elected to eliminate the use of these barriers to meet regulatory requirements. Therefore, Farley, Fitzpatrick, Grand Gulf, and Summer still rely on Kaowool or FP-60 fire barriers to meet regulatory requirements.

GENERIC IMPLICATIONS OF THE FNP REVIEW

The staff's review of the Kaowool barriers installed at FNP included reviews of a number of Kaowool and FP-60 fire test reports. It is likely that the other licensees that use Kaowool and FP-60 fire barriers rely on these same reports. Therefore, the questions regarding the Kaowool fire barriers at FNP may also apply to the Kaowool and FP-60 barriers installed at the other plants.

Because it could not find a technical basis for having originally accepted Kaowool barriers as 1-hour fire-rated barriers, the staff reconsidered its position, as documented in GL 86-10, regarding the grandfathering of Kaowool barriers. The staff has decided not to include this position in the comprehensive regulatory guide that it is currently preparing for reactor fire protection.

PLANNED STAFF ACTIONS:

The staff plans to address the Kaowool and FP-60 barriers issues with the licensees for the 4 plants that have not already addressed the issues as a voluntary industry initiative. Specifically, the staff will provide the results of the Farley review to the affected licensees and then meet with them as a group to discuss the technical issues, the applicability of the issues to the affected plants, and the need for compensatory measures. The staff will request that the affected licensees take the issue on as a voluntary initiative and propose an approach for resolving the issues. If the licensees do not agree to a voluntary initiative, the staff will consider other regulatory options such as compliance backfit, or generic letter.

The staff notes that one approach for resolving the issues discussed in this paper would be for the licensees (individually or as a group) to first conduct fire-endurance tests to establish the actual fire rating or the fire-resistive performance of the installed Kaowool and FP-60 fire barriers. Then, assuming the barriers fail to achieve a 1-hour fire-resistance rating, as appears likely, the licensees could perform plant-specific engineering evaluations and risk assessments, based, for example, on the fire test data and fire hazards analyses, to determine whether specific as-installed fire barrier installations

provide an adequate level of fire protection. In some cases, the as-installed barriers may be acceptable "as is" even though they are not qualified for 1 hour. In these cases, exemptions from the technical requirements of Appendix R may be needed. In other cases, the as-installed barriers may need to be replaced or upgraded to achieve an adequate level of fire protection for the post-fire safe shutdown capability. In the case of Thermo-Lag fire barriers, NEI and individual licensees conducted fire tests to establish the actual fire ratings of the barriers and to qualify barrier upgrades. Some licensees used the results of fire tests to justify exemptions for certain as-installed Thermo-Lag fire barriers.

RESOURCES:

NRR currently has adequate resources budgeted to address the issues discussed in this paper.

COORDINATION:

The Office of the General Counsel has reviewed this Commission paper and has no legal objections.

William D. Travers
Executive Director for Operations

Contact: Steven West, SPLB/DSSA/NRR
301-415-1220

Attachment: As stated

MEMORANDUM TO: Loren R. Plisco, Director
Division of Reactor Projects, Region II

FROM: Brian W. Sheron, Associate Director
for Project Licensing and Technical Analysis Office of Nuclear Reactor Regulation

SUBJECT: RESPONSE TO TASK INTERFACE AGREEMENT (TIA 96-023) REVIEW OF JOSEPH M. FARLEY, UNITS 1 AND 2, LICENSING BASIS AND ACCEPTABILITY OF KAOWOOL AS AN ELECTRICAL RACEWAY FIRE-BARRIER (TAC NO. M97701)

By letter dated November 26, 1996, Region II requested the Office of Nuclear Reactor Regulation's assistance with technical issues associated with the design, installation, and fire-resistive performance of Kaowool raceway fire barriers installed at the Joseph M. Farley Nuclear Plant (FNP).

We have completed our review; overall, we conclude that the licensee does not have a sound technical basis for concluding that the Kaowool raceway fire barriers installed at FNP meet the regulatory requirements or provide an adequate level of fire protection for the post-fire safe-shutdown capability. Our evaluation is attached.

NRC's overall plan for addressing this issue was discussed in a teleconference including representatives from NRR, Region II, and OEDO on June 1, 1999. As discussed during the teleconference, the questions regarding the Kaowool barriers at FNP may apply to other plants that use Kaowool barriers. NRR's Plant Systems Branch will prepare a Commission Paper to inform the Commission about the results of its review of Kaowool fire barriers at FNP and its plans to address potentially generic issues with Kaowool barriers. This paper is currently in concurrence.

Region II should send the attached TIA response to the Farley licensee. In light of the potential generic issues, the Region's cover letter to the licensee enclosing the TIA response should indicate that:

(1) NRC is not requiring any action from the licensee at this time, based on this evaluation, beyond continuing the compensatory measures the licensee already has in place.

(2) NRC is examining the potential generic implications of the issue. If the issue has generic implications, NRC will address them through its normal processes for generic issues.

(3) If the issue has no generic implications, NRC will pursue appropriate action with the licensee.

Docket Nos. 50-348 and 50-364

Attachment: As stated

cc w/att: A. Blough, DRP, RI
G. Grant, DRP, RIII
T. Gwynn, DRP, RIV

CONTACT: L. Mark Padovan, DLPM/PDII
415-1423

ATTACHMENT

TASK INTERFACE AGREEMENT 96-023 RESPONSE
BY THE OFFICE OF NUCLEAR REACTOR REGULATION

DOCKET NOS. 50-348 AND 50-364

- 1.0 BACKGROUND
- 2.0 APPLICABLE REGULATORY DOCUMENTS
- 3.0 LICENSING BASIS FOR KAOWOOL RACEWAY FIRE BARRIERS INSTALLED AT FNP
  - 3.1 Pre-Appendix R
  - 3.2 Post-Appendix R
- 4.0 GENERAL DESCRIPTION OF KAOWOOL RACEWAY FIRE BARRIERS INSTALLED AT FNP
  - 4.1 Amount and Location of Kaowool Raceway Fire Barriers
  - 4.2 Types of Electrical Raceways Protected
  - 4.3 Kaowool ERFBS Design
- 5.0 REGULATORY ACTIVITY - GENERIC COMMUNICATIONS
- 6.0 KAOWOOL DESIGN BASIS AND SUPPORTING TESTS
  - 6.1 Review of Fire-Endurance Test Reports
  - 6.2 Review of Farley Ampacity Derating Testing
  - 6.3 Comparison of Tested Barrier Configurations with Installed Barriers
- 7.0 PUBLIC MEETING WITH SNC REGARDING KAOWOOL RACEWAY FIRE BARRIERS
- 8.0 CONCLUSIONS

1.0 BACKGROUND

During a routine inspection (NRC Inspection Report 50-348, 364/96-09), Region II inspectors identified technical issues associated with the design, installation, and fire-resistive performance of Kaowool raceway fire barriers installed at the Joseph M. Farley Nuclear Plant (FNP). By memorandum dated November 26, 1996, Region II staff submitted Task Interface Agreement (TIA) 96-023, and requested that the Office of Nuclear Reactor Regulation (NRR) review these issues. During a follow-up inspection (NRC Inspection Report 50-348, 364/97-12), Region II staff obtained additional information regarding the Kaowool raceway fire barrier. By memorandum dated November 21, 1997, Region II submitted to NRR staff the additional information that it had obtained. By letter dated December 24, 1997, NRR staff sent a request for additional information (RAI) to Southern Nuclear Operating Company (SNC), the licensee for FNP. By letter dated March 28, 1998, the licensee responded to the RAI.

2.0 APPLICABLE REGULATORY DOCUMENTS

Kaowool raceway fire barriers are installed at FNP to protect circuits needed to achieve and maintain post-fire safe shutdown. The licensee installed portions of the Kaowool fire barriers before the Commission issued Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, and installed additional Kaowool fire barriers after Appendix R became effective.

On February 19, 1981, the new fire protection regulation, 10 CFR 50.48, "Fire protection," and Appendix R became effective. Appendix R establishes the fire-protection features required to satisfy General Design Criterion 3, "Fire protection," of Appendix A to 10 CFR Part 50 with respect to certain generic issues for nuclear power plants licensed to operate before January 1, 1979. In the statement of considerations (SOC) for Appendix R (*Federal Register*, Vol. 45. No. 225, November 19, 1980), the Commission stated that it had decided to retroactively apply to all facilities, including those that the staff had previously approved, the

fire-protection requirements regarding post-fire safe shutdown. These requirements are specified in Section III.G, "Fire protection of safe shutdown capability," of Appendix R. In the SOC, the Commission stated that licensees should either reexamine previously approved fire-protection configurations that do not meet the requirements of Section III.G of Appendix R or should apply for an exemption that justifies alternatives. This backfit is codified in 10 CFR 50.48(b).

The underlying purpose of Section III.G of Appendix R is to ensure that at least one means of achieving and maintaining safe shutdown will remain available during and after any postulated fire in the plant. In Section III.G, the staff specifies three options for limiting fire damage so that one train of systems necessary to achieve and maintain hot-shutdown conditions from either the control room or emergency control stations is free of fire damage. Two of the means rely on fire-rated barriers. The SOC for Appendix R stated:

> "Fire barriers are 'rated' for fire resistance by being exposed to a 'standard test fire.' This standard test fire is defined by the American Society for Testing and Materials in ASTM E-119, 'Standard for Fire Resistance of Building Materials.' Fire barriers are commonly rated as having a fire resistance of from 1 to 8 hours."

In accordance with 10 CFR 50.48(b), fire barriers installed to protect the post-fire safe-shutdown capability, whether installed before or after Appendix R became effective, such as the Kaowool raceway barriers installed at FNP, would be required to either satisfy or have an exemption from the technical requirements of Section III.G of Appendix R.

In Generic Letter (GL) 86-10, "Implementation of Fire Protection Requirements," April 24, 1986, the staff presented acceptable methods for satisfying the technical requirements of Appendix R, including guidance for fire barriers installed to protect post-fire safe-shutdown systems in accordance with Section III.G of Appendix R. In GL 86-10, the staff stated that the documentation required to establish the fire rating of a fire barrier should include the design description of the barrier and the test reports that verify its fire rating. In GL 86-10, the staff also discussed the fire-test acceptance criteria for establishing the fire rating of a fire barrier. With respect to the cold-side temperature criterion used to establish that cables enclosed within a fire barrier will be free of fire damage, the staff stated in GL 86-10:

> Conduit and cable tray enclosure materials accepted by the NRC as 1 hour barrier prior to Appendix R (e.g., some Kaowool and 3M materials)

and already installed by the licensee need not be replaced even though they may not have met the 325 F criteria [cold-side temperature criterion]. However, for newly identified conduit and cable trays requiring such wrapping, new material which meets the 325 F criterion should be used, or justification should be provided for use of material which does not meet the 325 F criterion. This may be based on an analysis demonstrating that the maximum recorded temperature is sufficiently below the cable insulation ignition temperature.

Thus, although the staff specified in 10 CFR 50.48(b) that fire barriers installed before or after Appendix R became effective are required to either satisfy Appendix R, or have an exemption, GL 86-10 states that licensees do not need to replace Kaowool materials that were installed before Appendix R became effective. The guidance in GL 86-10 is silent on fire test acceptance criteria other than cold-side temperature. It is also silent on whether or not licensees should reexamine previously approved Kaowool raceway fire barriers and request exemptions for those that do not meet the technical requirements of Appendix R. It appears that the staff and the licensees have interpreted the GL 86-10 guidance to mean that Kaowool raceway fire barriers installed before Appendix R became effective are "grandfathered" and that exemptions are not needed even though the barriers may not meet the technical requirements of Appendix R to 10 CFR Part 50. However, the GL 86-10 guidance does not relieve the licensee from establishing and maintaining the design bases for the fire barriers it has installed to satisfy the NRC's fire-protection requirements.

3.0 LICENSING BASIS FOR KAOWOOL RACEWAY FIRE BARRIERS INSTALLED AT FNP

As noted above, Kaowool raceway fire barriers are installed at FNP to protect circuits needed to achieve and maintain post-fire safe shutdown. The licensee installed some of the Kaowool barriers before Appendix R became effective and others after Appendix R became effective.

3.1 PRE-APPENDIX R

On April 13, 1979, before the Commission issued Appendix R, the NRC staff issued the Farley Nuclear Plant Fire Protection Safety Evaluation Report (SER). This SER documented the staff's evaluation of the FNP "Fire Protection Program Re-evaluation Report," dated September 15, 1977, and its Amendments 1 through 4, dated February 23, July 14, and October 27, 1978, and January 3, 1979, respectively. In this SER, the NRC approved the licensee's commitments to provide the following:

(1) 1-hour fire-rated barriers for one train of component cooling water (CCW) cables in the CCW pump area for each unit,

(2) 30-minute fire-rated barriers on the control and power cables to the CCW pumps and on other essential cables, and

(3) either a double-thick barrier consisting of two layers of 30-minute fire-rated enclosure around one train, or a half-hour barrier around both trains for the cables located in fire areas 1, 4, 5, 6, 9, 13, 20, 21, 34, 41, 42, 51, and 72.

This is in accordance with section 4.3.5.1 of the FNP "Fire Protection Program Re-evaluation Report."

3.2 POST-APPENDIX R

By letters dated March 13 and May 31, 1985, the licensee requested exemption from the technical requirements of Section III.G of Appendix R to the extent that it requires one train of redundant safe-shutdown cables to be enclosed by a 1-hour fire-rated barrier. The licensee based its exemption requests on Appendix R interpretations made in GL 83-33, "NRC Positions on Certain Requirements of Appendix R to 10 CFR Part 50," October 9, 1983, and Information Notice (IN) 84-09, "Lessons Learned From NRC Inspections of Fire Protection Safe Shutdown Systems (10 CFR Part 50, Appendix R)," February 13, 1984.

In support of certain exemptions, the licensee committed to install additional 1-hour fire-rated barriers. These barrier installations should have conformed to 10 CFR 50.48 and Section III.G of Appendix R to 10 CFR Part 50. The staff reviewed certain aspects of the FNP Kaowool raceway fire barrier installations, or SNC commitments to install rated barriers, as a part of its exemption review. To support its evaluation of the fire-resistive performance of the fire barriers installed by the licensee to support its exemption requests, the staff requested that the licensee submit the following additional information: "For exemption requests 1-22, 1-26, and 2-4, the licensee stated that some of the pre-existing raceway fire-barrier installations were adequate because their fire-resistive rating exceeded the potential fire severity in the fire area. For these cases, provide the analysis which supports the conclusion that the protected cables would be free of fire damage in the event of a fire."

In its response to the RAI, the licensee stated, in part, that Kaowool was selected for use at FNP on the basis of numerous tests that had been conducted and NRC's acceptance of Kaowool as a 1-hour fire barrier. Therefore, these exemption requests were based, in part, on NRC acceptance of two 1-inch layers of Kaowool as a 1-hour fire barrier and the determination that the maximum fire severity for those areas was less than 1 hour.

The licensee also stated that it had not performed an analysis to verify that the protected cables would be free of fire damage.

By letter dated February 6, 1986, the staff approved exemption requests for FNP based, in part, on the adequacy of the Kaowool raceway fire barriers. The exemptions discussed in the FNP FSAR, (Volume 17, Section 9B), appear to be based on the initial staff reviewers' conclusions that the installed Kaowool electrical raceway fire barrier systems (ERFBS) were either 1-hour fire-rated or that the licensee had demonstrated by analysis (based on acceptable fire testing), that the fire resistance of the ERFBSs would have been greater than the fire severity of the worst-case postulated fire in the area of concern.

4.0 GENERAL DESCRIPTION OF KAOWOOL RACEWAY FIRE BARRIERS INSTALLED AT FNP

4.1 AMOUNT AND LOCATION OF KAOWOOL RACEWAY FIRE BARRIERS

Kaowool is the only fire-barrier material used at FNP to construct ERFBSs to protect circuits needed for achieving and maintaining post-fire safe shutdown in accordance with the technical requirements of Appendix R. About 6300 linear feet of Kaowool raceway fire-barrier material are installed at FNP (both units). The Kaowool ERFBSs are primarily located in the auxiliary building.

4.2 TYPES OF ELECTRICAL RACEWAYS PROTECTED

The range of electrical raceways protected at Farley are:

- 1-inch to 5-inch-diameter rigid steel conduits
- 3/4-inch to 5-inch-diameter rigid aluminum conduits
- 12-inch to 24-inch-wide National Electrical Manufacturers Association (NEMA) Class II aluminum, ladder-type cable trays
- 4-inch-wide aluminum cable channels

4.3 KAOWOOL ERFBS DESIGN

FNP used the following three designs of Kaowool ERFBSs:

- Type R. This design consists of two 1-inch-thick Kaowool blankets wrapped completely around the electrical raceway with an external layer of Zetex 800 fabric wrapped around the Kaowool.
- Type H. This design consists of one 1-inch-thick Kaowool blanket wrapped completely around the electrical raceway with an external layer of Zetex 800 fabric wrapped around the Kaowool.
- Type J. This design consists of one 1-inch-thick Kaowool blanket installed on the bottom and sides of the electrical raceway (i.e., cable tray) with an external layer of Zetex 800 fabric wrapped around the Kaowool. No Kaowool blanket is installed on the top side of the cable tray. On February 6, 1998, SNC had submitted an exemption request to 10 CFR Part 50, Appendix R for this design. Staff review of this exemption request is scheduled to be performed after this TIA is issued.

The Kaowool for all three designs is fastened to the electrical raceway with carbon steel banding placed at maximum 14-inch centers. Banding is also located within 4-inches of the Kaowool end-joints. The Zetex 800 fabric is installed over the Kaowool and fastened with ring staples.

5.0 REGULATORY ACTIVITY - GENERIC COMMUNICATIONS

As part of its response to this TIA, the staff reviewed the licensee's responses to NRC generic communications regarding potential problems with fire barriers.

In GL 92-08, "Thermo-Lag 330-1 Fire Barriers," December 17, 1992, the staff noted that it would evaluate other fire-barrier materials and systems used by licensees to satisfy NRC fire protection requirements. In GL 92-08, the staff stated that it expected the recipients of GL 92-08 to review the information in the generic letter to determine if it applies to other barrier materials and systems used at their facilities and consider actions, as appropriate, to avoid problems similar to the Thermo-Lag fire-barrier problems. SNC responded to GL 92-08, by stating that no Thermo-Lag was installed at FNP.

In 1993, the staff issued two INs regarding potential problems with Kaowool ERFBSs. IN 93-40, "Fire Endurance Test Results for Thermal Ceramics FP-60 Fire Barrier Material," May 26, 1993, identified potential problems with an upgraded Kaowool-based ERFBS (Thermal Ceramics FP-60). The staff reported that failures occurred in the joints of the Kaowool-based ERFBSs during the fire-endurance testing. The licensee's review of the information notice determined that the upgraded materials were not installed at FNP and, therefore, no review was required. Later, in IN 93-41, "One Hour Fire Endurance Test Results for Thermal Ceramics Kaowool, 3M Company FS-195 and 3M Company Interam E-50 Fire Barrier Systems," May 28, 1993, the staff reported problems with the methods and results of fire tests performed in 1978 by Babcock & Wilcox (B&W), the manufacturer of Kaowool. SNC contracted with Bechtel to review the information presented in the information notice and determine if the problems existed at FNP. Bechtel attempted to resolve the staff's concerns and determined that FNP was within its licensing basis. As part of its response to this TIA, the staff reviewed the Bechtel evaluation and concluded that it was inaccurate, and that the problems identified in IN 93-41 do exist at FNP.

In conclusion, the licensee missed three separate opportunities to identify and address technical concerns associated with Kaowool raceway fire barriers. Additional information and discussion of these generic communications and the licensee's responses to them are presented in Appendix A.

6.0 KAOWOOL DESIGN BASIS AND SUPPORTING TESTS

Region II staff was concerned that the fire test reports and evaluation data for the Kaowool raceway fire barriers installed at FNP did not demonstrate that the installed fire barriers had a 1-hour fire-endurance rating. The staff requested additional information from the licensee and performed a detailed review of the Kaowool ERFBS design basis and testing program. Details of this review are contained in Appendix B.

6.1 REVIEW OF FIRE-ENDURANCE TEST REPORTS

Sixteen of the references submitted by the licensee documented the results of fire tests. These were FNP References E.4 to E.17, and E.26 and E.27. This section summarizes the results of the staff's review of these fire endurance tests. In summary, on the basis of its review of the fire test documentation submitted by the licensee, the staff identified the following testing deficiencies.

Of the 16 test reports submitted by the licensee:

1. 5 tests submitted by the licensee were not fire endurance tests of Kaowool ERFBSs, but dealt rather with penetration seals, Institute of Electrical and Electronics Engineers (IEEE) 383 cable flame spread requirements, Regulatory Guide 1.75 separation requirements, and American Society for Testing and Materials (ASTM) E-84 flame-spread testing. For example, in Reference E.10, the licensee discussed using Kaowool as an internal filler in penetration seals.
2. 9 tests were conducted in-house by the vendors and not by independent testing laboratories with fire-endurance-testing experience. For example, Reference E.4 was conducted in a B&W small-scale test furnace. In this test, B&W reported that the Kaowool material was standard 1-inch, 8 lb/ft^3 material. The Underwriters Laboratories, Inc., (UL) report documenting its witnessing of the test documents the Kaowool as 1-inch, 9.4

lb/ft^3 material. Without properly documented and controlled testing, the reports are of little technical value. The UL report also cautions against using this type of testing to determine full-scale performance.

3. 11 tests were conducted in small-scale or non-standard fire test furnaces. Some of the tests were conducted in open unspecified rooms, using pans of heptane as the fire source (Reference E.14). This test method does not produce the ASTM E119 standard time-temperature test fire necessary to evaluate and rate raceway barrier fire performance.

4. 11 tests did not have adequate thermal instrumentation for the furnace/test specimen. Reference E.4, for example, had only one thermocouple to control the furnace. The single thermocouple presents two problems. First, if this single device is out of calibration, the entire test is invalid. Second, a single thermocouple can only take a reading at one small location in the furnace. This does not present an accurate description of the overall thermal environment inside the furnace. Recognized testing standards such as ASTM E-119 require a minimum of nine thermocouples arranged in the furnace to develop the thermal insult profile.

5. At least 11 tests did not include a hose stream test. Without these data, it is not possible to determine if the Kaowool raceway fire-barrier designs that were tested would survive the impact, erosion, and cooling effects they could be expected to encounter in actual fire events.

6. At least 10 tests were of Kaowool raceway fire-barrier designs that were substantially different from those installed at FNP. For example Reference E.26 tested an upgraded -inch version of a Kaowool blanket covered with 2-mil-thick aluminum foil. These assemblies were installed in multiple layers with staggered joints and are a more conservative design than those installed at FNP. Even with this conservative design, six of the test specimens failed to achieve a 1-hour fire-endurance rating.

7. At least 6 test reports had significant cable damage in less than the 1-hour testing period. Some examples from Reference E.26 documented failures such as, "50% of the cables fused together," "cable jacket was melted at 10 points along its length," and "blisters were present on the cables."

On the basis of its review of the fire-test reports, as documented above and in Appendix B, the staff concludes that:

(1) The tests documented in the fire-test reports submitted by the licensee contained numerous errors.

(2) None of the test reports submitted by the licensee included tests of Kaowool raceway fire-barrier configurations that are analogous to those actually installed at FNP.

(3) Kaowool raceway fire barriers more conservatively designed than those installed at FNP failed to achieve acceptable test results.

(4) Two layers of 1-inch-thick Kaowool (FNP design Type R) have not been qualified by fire tests to demonstrate the design provides a 1-hour fire-rated barrier when exposed to the standard time-temperature test fire specified in ASTM E119. FNP Kaowool ERFBS designs Type H and J are less conservative designs and can be expected to provide even less fire resistance protection. The licensee has not established the actual fire-resistance rating of the Kaowool raceway fire barriers on the basis of fire-test results that are applicable to the barrier designs installed at FNP.

6.2 REVIEW OF FARLEY AMPACITY DERATING TESTING

The NRC RAI of December 24, 1997, asked if ampacity derating factors had been tested and developed for the derating of cables protected with Kaowool raceway fire barriers. SNC submitted the results of a test performed in 1979 to determine the potential heat buildup from the Kaowool raceway fire-barrier installations. The referenced ampacity derating test (Reference E.28) was not used. A FNP specific test, "Self Heating of Electrical Cables in Conduit, Channel and Tray Wrapped With Kaowool" (Reference F.1) was used. This test determined that the installation of two layers of 1-inch Kaowool will increase the temperature by 50 F. The test report cautions: "It must be understood that this series of tests was never intended to be ampacity tests for derating practices, but rather to demonstrate that no adverse effects would be experienced in the cable raceways if some of the raceways were required to be wrapped with Kaowool."

This issue is further complicated by the FNP installation procedures for cable trays (Reference E.1) which states, in part: "For cable trays with no cover and not completely full, Kaowool blanket shall be cut to the same width as the cable tray and laid on top of the cables to bring the level of Kaowool to the same height as the top of the tray."

Installation requires that additional insulation material be placed on the top section of the cable trays, which, in turn, provides a more restrictive heat transfer system, potentially causing the cables to heat up to temperatures higher than those predicted by the test. This is a non-conservative requirement outside the bounding limits of the test. The 50 F rise above ambient temperature is questionable since the tests were performed in a warehouse without controlling the surrounding ambient air temperature.

Because of overriding concerns about the fire-resistance capabilities of the Kaowool raceway fire barriers discussed in the TIA, further ampacity derating was not reviewed.

6.3 COMPARISON OF TESTED BARRIER CONFIGURATIONS WITH INSTALLED BARRIERS

FNP's FSAR Section 9B, Section 4.1.2 states that "raceways have been protected by a fire barrier enclosure having a 1-hour fire-rating: (See pages B-195 through B-202 for a list of the protected raceways.)"

The NRC RAI of December 24, 1997, requested that SNC provide fire-test reports, data, and engineering evaluations that support the fire resistive ratings of the licensee's Kaowool ERFBS. The licensee responded to these questions as follows: "Although documented evaluations specifically requested in the subject RAI can be performed, to do so would be burdensome, redundant to the efforts performed by numerous fire protection experts as

documented in the references and is not required by FNP's licensing basis requirements." On the basis of this response and the engineering review performed by the staff (See Appendices A and B), it is concluded that the licensee has not established an engineering or design basis that supports the ability of the installed Kaowool raceway fire barriers to protect the post-fire safe-shutdown capability.

7.0 PUBLIC MEETING WITH SNC REGARDING KAOWOOL RACEWAY FIRE BARRIERS

On December 15, 1998, staff of NRR and Region II met with representatives of SNC to discuss this issue. The licensee advanced positions that the design of the Kaowool raceway fire barriers installed at FNP offers an adequate level of fire protection and that the staff had previously approved the barriers. After the presentation, the staff gave the results of its preliminary review of the information discussed in this TIA response. Overall, the staff concluded that SNC does not have a sound technical basis for concluding that the Kaowool raceway fire barriers installed at FNP meet the regulatory requirements or provide an adequate level of fire protection for the post-fire safe-shutdown capability. At the meeting, SNC agreed to consider the results of the staff's review, when the results became available, and to develop an approach for addressing the staff's concerns and findings. SNC has implemented appropriate compensatory measures at FNP and will maintain them until it resolves the concerns and findings. The staff documented the meeting in a memorandum dated December 31, 1998, from J. I. Zimmerman to Docket Files 50-348 and 50-364.

8.0 CONCLUSIONS

On the basis of its review and evaluation, as documented above and in the appendices, the staff concludes the following:

(1) The NRC staff accepted the use of Kaowool raceway fire barriers at FNP both before and after Appendix R to 10 CFR Part 50 became effective. (During the review documented in this TIA response, the staff could not find any evidence that the staff granting the original approvals had reviewed the Kaowool fire-test reports or the licensee's design bases for the raceway barriers. Consequently, the staff could not find a technical basis for why it had originally accepted Kaowool barriers as 1-hour fire-rated barriers).

(2) The actual fire-resistance rating of the Kaowool ERFBSs installed at FNP is indeterminate. This is based on the lack of adequate fire testing and lack of tested configurations that are representative of the as-built plant Kaowool ERFBS. Subsequently, since the fire-resistive performance of the Kaowool ERFBSs is not established, the fire barriers' ability to maintain the protected components free of fire damage is likewise indeterminate.

(3) The licensee has not established an acceptable design basis for the fire barriers it has installed to satisfy the technical requirements of Section III.G of Appendix R to 10 CFR Part 50. That is, the licensee has not established the actual fire-resistance rating of the Kaowool raceway fire barriers on the basis of fire-test results that are applicable to the barrier designs installed at FNP. Similarly, the licensee has not established the fire-resistive performance of the barriers and their ability to maintain the protected components free of fire damage.

(4) The licensee missed three separate opportunities to identify and address technical concerns associated with Kaowool raceway fire barriers.

(5) The ampacity derating testing used for the Kaowool ERFBS installed on cable trays may not be appropriate due to the lack of ambient temperature control during the testing and the differences between the tested configuration and the installed configurations.

In addition, on the basis of its review of the information provided by Region II and submitted by the licensee, the staff could not determine the following:

(1) Which Kaowool raceway fire barriers were installed before Appendix R to 10 CFR Part 50 became effective and which Kaowool raceway fire barriers were installed after Appendix R became effective.

(2) Which, if any, of the Kaowool raceway fire barriers installed at FNP would provide an adequate level of fire protection for the protected components.

Appendix A: Detailed Technical Review of Regulatory Activity and FNP Response
Appendix B: Detailed Technical Review of FNP Testing and Design Basis

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Appendix A

Detailed Technical Review of Regulatory Activity and FNP Response

- A-5.1 Issues Regarding Fire and Ampacity Derating Testing
- A-5.2 Farley Position on NRC INs 93-40, and 93-41, and GL 92-08

A-5.1 ISSUES REGARDING FIRE AND AMPACITY DERATING TESTING

A-5.1.1: In Information Notice (IN) 93-40, "Fire Endurance Test Results for Thermal Ceramics FP-60 Fire Barrier Material," May 26, 1993, the staff identified problems with the fire-endurance performance of Thermal Ceramics raceway fire-barrier system (using two FireMaster FP-60, 1-inch-thick, ceramic fiber blankets) installed on a 36-inch-wide cable tray. Note that FP-60 is an "upgraded" form of Kaowool. At approximately 20 minutes into the test, the barrier developed an opening at a butt joint, which resulted in a 3 -inch opening at the end of the test (60 minutes). The temperature as measured on cables inside the barrier system ranged from 400-500 F at the end of the test. Hose stream tests were not performed. This test did not meet the fire-test acceptance criteria.

A-5.1.2: In IN 93-41, "One Hour Fire Endurance Test Results for Thermal Ceramics Kaowool, 3M Company FS-195 and 3M Company Interam E-50 Fire Barrier Systems," May 28, 1993, the staff identified conditions related to the thermal performance of a Kaowool raceway fire-barrier system when tested in a small-scale furnace. The staff reviewed a Kaowool fire test that had been performed in 1978. The report stated that cable temperatures exceeded

139 C (250 F) above ambient temperature in approximately 22 minutes. The temperature, as measured on the non-fire or unexposed side of the fire-barrier material on the cables, reached a maximum of 426 C (800 F) at 60 minutes. Examination of cables after the testing indicated fire damage such as charring. No hose stream tests were performed. (Note: This test attempted to follow the ASTM E-119 standard time temperature test fire exposure but failed to do so.) The test results presented in IN 93-41 are further discussed in a Underwriters Laboratories Inc (UL) report dated September 6, 1978, and are related to the cable tray fire test - Test No. 3. UL did not perform the test, classify the fire barrier product, issue a listing, or claim that this test would predict full-scale fire test performance.

A-5.1.3: In Generic Letter (GL) 92-08, the staff identified three principal areas of concern: fire-endurance capability, ampacity derating of cables enclosed in fire barriers, and the evaluation and application of the results of tests conducted to determine the fire-endurance ratings and the ampacity derating factors. In its RAI of December 24, 1997, the staff requested that SNC state whether or not it had assessed the Kaowool raceway fire-barrier design, fire endurance performance, and ampacity derating against the insights and concerns documented in GL 92-08. If an evaluation had been performed, SNC was asked to provide the results and discuss the subsequent actions taken to assess and correct any technical issues associated with the installed Kaowool raceway fire barriers.

A-5.2 FARLEY POSITION ON NRC INS 93-40, AND 93-41, AND GL 92-08

A-5.2.1: In response to IN 93-40, the licensee stated: " SNC has determined that FP-60 fire barrier systems are not installed in either Unit 1 or Unit 2 at FNP." No additional action was taken.

A-5.2.2: In response to IN 93-41, SNC hired Bechtel to review FNP Kaowool raceway fire-barriers and to determine "whether there was any safety significance" to the issue. Bechtel researched and restated the FNP licensing basis concerning Kaowool raceway fire barriers and responded to the licensee by letter dated October 1, 1993 (Bechtel Reference REA 93-0271). Bechtel concluded that "the existing installation of Kaowool at FNP is acceptable even though future applications are not covered by the referenced documents." On the basis of its technical review, Bechtel concluded that "Kaowool would provide adequate protection." The staff reviewed Bechtel's technical review and disagrees with its conclusions for the following reasons:

1. Bechtel determined that even though the testing was small scale, there was enough engineering data to justify the installation of Kaowool at FNP. The staff disagrees. The only cable tray tested was an 18-inch-wide aluminum ladderback cable tray with 30-35 percent cable fill. The test assembly did not include supports or changes of direction of the raceway. The furnace used for the testing was not designed for fire testing and only exposed 3 feet of the ERFBS to the fire conditions. The cable trays tested were 12 feet long. For the small size of the sample exposed to the furnace temperature, there was a large portion of cable and tray outside the furnace(i.e., 75 percent of the cable and tray were outside the furnace). This effectively acted as a radiator outside the furnace, convecting heat away, and lowering the temperatures inside the ERFBS. The small size of the furnace and the support offered by the fire bricks to close the furnace, offered no challenge to the Kaowool butt joint, as would be expected in actual installations. Even with this limited challenge, Test #3A of Babcock and Wilcox test report dated October 24, 1978, documented cable failure at 11 minutes owing to butt joint failures between the Kaowool blankets.

2. Bechtel determined that the testing was performed by an independent laboratory. This is incorrect. In IN 93-41, the staff clearly stated: "The tests were not conducted or controlled by an independent laboratory." Furthermore, the UL test report (File R8758, Project 78NK5345) stated: "The issuance of this Report in no way implies Listing, Classification, or other Recognition by UL and does not authorize the use of UL Listing or Classification Marks or any other reference to UL on or in connection with the product or system." The UL report summarized: " the foregoing Report is to be construed as information only and should not be regarded as conveying any conclusion or recommendation on the part of UL regarding the acceptability of the construction or performance of the product for recognition by any code or standard or for any other purpose. In general, small scale tests individually do not represent all factors associated with fire performance under actual field conditions."

3. Bechtel reported that no hose stream testing was performed. Bechtel further stated: "For a cable wrapping system that is designed to provide one hour protection, it is unclear and appears unreasonable that the NRC maintains that this test be a condition of acceptance." The staff disagrees. Hose stream testing was a condition of acceptance in the original test standard ASTM E119. Later guidance, specifically Supplement 1 to GL 86-10, continues to require hose stream testing as a condition of acceptance. Bechtel did not present a technical basis for accepting the test results without a hose stream test.

4. Bechtel reported that the cables used in the fire test were "charred" at the end of the test. Bechtel did not provide any explanation or justification regarding this test result. The Babcock and Wilcox test report dated October 24, 1978, stated that after Test #2 was completed and the assembly was removed from the furnace, "there was considerable heat storage in the tray, some of the insulation caught fire when the Kaowool was removed." In later tests it was decided to leave the Kaowool on the cable tray after the test, "since the blanket prevented oxygen from reaching the cables, they charred rather than burned." Charring (or burning) of a cable protected by an ERFBS is fire damage. This does not conform to the technical requirements of 10 CFR Part 50, Appendix R, Section III. G., which requires that one train be "free of fire damage."

5. Bechtel reported that the maximum temperature at 1-hour was "Approx. 425 F." In IN 93-41, the staff approximated the temperatures at around 800 F. Review of the test data (time vs. temperature graphs) from the UL documentation shows the following:

    - Test 1: Thermocouple #1 located on the jacket of a cable in the upper corner of the tray exceeded 1125F.
    - Test 2: Thermocouple #5 located in the lower left corner of the cable tray against the rail exceeded 925F.
    - Test 3: Thermocouple #5 located in the lower left corner of the cable tray against the rail exceeded 925F.
    - Test 4: Thermocouple #5 located in the lower left corner of the cable tray against the rail exceeded 900F.

Also note that the thermocouples attached to cables inside the assembly would provide non-conservative low readings since cable jacket material

is a good insulator.

A-5.2.3: On December 17, 1992, the staff issued GL 92-08, "Thermo-Lag 330-1 Fire Barriers," to all holders of operating licenses for nuclear power plants. GL 92-08 addressed fire-endurance and ampacity derating issues associated with Thermo-Lag 330-1 fire-barrier materials. GL 92-08 did not request specific action for other barrier materials. However, as documented in GL 92-08, the staff expected the licensees with fire barriers constructed from other materials to review GL 92-08 and determine if the technical issues applied to those other barrier materials used at their facilities and to consider actions, as appropriate, to avoid similar problems, "The staff is concerned that some licensees have not adequately reviewed applicable fire endurance test results to determine if the tests are valid and if the test results apply to their plant design." This staff's position was further strengthened with the issuance of Supplement 1 to GL 86-10 to clarify testing procedures and interpret results of ERFBS fire tests. In response to GL 92-08, SNC reported, "Thermo-Lag 330-1 fire barrier material is not used at the Farley Nuclear Plant facility." This was documented in a letter dated April 9, 1993. No additional information was provided. It appears that SNC did not review the issue past the fact that the plant does not use Thermo-Lag material to construct its ERFBS.

Appendix B

DETAILED TECHNICAL REVIEW OF FNP TESTING AND DESIGN BASIS

The NRC request for additional information (RAI) of December 24, 1997, sought specific information on the testing, installation, and correlation between the "tested configurations" and the "as installed" electrical raceway fire-barrier system (ERFBS). The staff used this information to assess the design basis and qualification of the Kaowool ERFBSs installed at the Joseph M. Farley Nuclear Plant (FNP). The RAI specifically requested the following information. (The RAI question number appears in parentheses, followed by the specific request, a discussion of the Southern Nuclear Operating Company (SNC) response, and the NRC staff's conclusion on the question.) This appendix presents the detailed summary of the licensee-supplied documentation.

***RAI (2.1.3)*: For each raceway fire barrier, provide the fire test reports, data, and engineering evaluations which support the fire resistive rating of the fire barrier used to meet the fire protection technical requirements as documented in the April 13, 1979, safety evaluation report (SER).**

Discussion: SNC stated, "Although the documented evaluations specifically requested can be performed, to do so would be burdensome, redundant to the efforts performed by numerous fire-protection experts as documented in the references, and is not required by FNP's licensing basis requirements." SNC also stated, "There is evidence of NRC review and discussion of test results and documentation that the NRC accepted Babcock and Wilcox (B&W) test data [Reference E.18] to substantiate a 1-hour rating availability with the Kaowool product enclosing cable trays." Reference E.18 is a letter to Mr. Earl A Borgmann (Cincinnati Gas and Electric) from John F. Stolz (Chief, Light Water Reactors Branch No. 1, NRC), dated April 19, 1979, regarding fire protection of the proposed William H. Zimmer Nuclear Power Station. The letter stated, "To date we (NRC) have accepted B and W test data to substantiate a 1-hour rating availability with the Kaowool products enclosing cable trays." No test reports or design details are provided with the letter. Therefore, the staff could not determine which Kaowool designs were accepted. Also, construction of the William H. Zimmer Nuclear Power Station was canceled before the detailed reviews and SER for an operating license were issued.

Conclusion: Based on Reference E.18, there is no substantiating documentation as to the acceptable fire rating of Kaowool ERFBS as installed at the FNP.

In response to the December 24, 1997, RAI, SNC provided a number of Kaowool fire-test reports (References E.4 through E.17). SNC did not provide any engineering review of these test reports. SNC stated: "Although the documented evaluations specifically requested can be performed, to do so would be burdensome, redundant to the efforts performed by numerous fire protection experts as documented in the references, and is not required by FNP's licensing basis requirements." Therefore, as a part of this task interface agreement (TIA), the staff performed a limited technical review of the test reports in order to establish the fire rating or fire-resistive performance of Kaowool ERFBSs. In reviewing the testing documentation submitted by the licensee, fundamental generic testing deficiencies were discovered in most of the tests reviewed. These generic deficiencies include (1) non-standard full-scale test furnaces, (2) non-standard furnace instrumentation, (3) non-standard fire exposures, and (4) no hose stream testing. Specific concerns with the individual tests, rather than repeating these generic deficiencies follows:

Discussion: Reference E.4, "Tests for Fire Protection for Complete Fire Engulfment of Cable Trays and Conduits Containing Grouped Electrical Conductors" by Charles E. Chaille, B&W, dated October 24, 1978, and Reference E.5, "Report on Cable Raceway Protection Systems Fire Test Investigation" (File R8758, Project 78NK5345), by Leon J. Przybyla, Underwriters Laboratories, Inc. (UL), dated September 9, 1978, have been previously reviewed for this report. See Appendix A of this report for the results of the review of this test report.

Conclusion: On the basis of its review of References E.4 and E.5, the staff concludes that there is no substantiating documentation as to the acceptable fire rating of Kaowool ERFBS as installed at FNP.

Discussion: **Reference E.6**, "Evaluation of Sealants for Prevention of Soaking of Flammable Liquids Into Kaowool Blanket Wrap Around Cable Trays During Complete Engulfment Fires," by Charles E. Chaille, B&W, dated January 5, 1978, discussed the problem of Kaowool acting as a wick when flammable liquids are spilled near vertical cable trays passing through floor assemblies. Three tests were performed. The test report did not identify the testing laboratory that conducted the test or the test standard used. The test used 1-gallon of heptane poured into a pan containing the vertical cable tray and Kaowool ERFBS. Fire exposure from the burning heptane varied from 15 to 37 minutes. The test concluded that Flammastic 77 and Intumatsic 285 were acceptable sealants to prevent wicking of flammable liquids into Kaowool ERFBSs that pass through floors. FNP is using this arrangement for horizontal Kaowool ERFBSs that pass through fire walls. That was neither the scope of the B&W test, nor the fire exposure tested. The FNP assembly (Kaowool ERFBS sealed to a fire wall with Flammastic 77 or Intumatsic 285) would experience a different and more severe thermal exposure in an ASTM E119 test.

Conclusion: On the basis of its review of Reference E.6, the staff concludes that this test is not applicable to the horizontal Kaowool/fire-wall interfaces

as installed at FNP.

Discussion: **Reference E.7**, "A Preliminary Report on Fire Protection Research Program Fire Barriers and Fire Retardant Coatings Test," NUREG/CR-0381 (SAND 78-1456) dated November 21, 1978, discussed the testing performed for the NRC by Sandia National Laboratories (SNL) to examine the effectiveness of fire-retardant coatings in preventing initiation or propagation of cable fires. Previous testing indicated that such coatings may provide adequate protection to cables not qualified according to Institute of Electrical and Electronics Engineers Standard 383 (non-IEEE 383 qualified cables) (i.e., equivalent performance to IEEE 383 cable) when coupled with Regulatory Guide 1.75 spatial separation for electrically initiated fires. The SNL testing demonstrated that the use of IEEE 383 cables and Regulatory Guide 1.75 spatial separation were not sufficient to protect against exposure fires. One test, No. 22, involved the use of a 1-inch-thick ceramic wool blanket installed on an 18-inch ladderback cable tray containing 3-C non-qualified PE/PVC cables. This testing was performed using a twin burner located 4.75 inches below the single cable tray. The burner was cycled on for 5-minute intervals to achieve ignition. The cables in Test No. 22 ignited in the first 5-minute cycle. The cables reached 900F in 11minutes, with a maximum temperature of 1200F. Electrical failure of the first cable occurred in 2 minutes. This was the poorest performer of the 10 full-scale single-cable tray tests using barriers or coatings.

Conclusion: The SNL testing demonstrated that spray applied cable coatings performed better than 1-inch-thick ceramic wool blankets with respect to enhancing non-qualified cable to IEEE 383 qualified cables performance for Regulatory Guide 1.75 criteria. Full-scale fire exposure testing (i.e., American Society for Testing and Materials [ASTM] E119 testing) was beyond the scope of this program. It is also noteworthy that the ASTM E119 thermal exposure is more severe than the ribbon burners used in the IEEE 383 testing. The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not provide any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.8** is a letter from R.A. Glasby (Bechtel Power Corporation) to K.M. Gillespie (Georgia Power), dated March 17, 1978. In the letter, Glasby discussed thermal qualifications of Kaowool at Toledo Edison Company's Davis-Besse Nuclear Power Station. "Test Report No.105 Thermal Effects of Kaowool Blanketing of Cable Trays" by M.D. Calcamuggio, dated November 2 and 3, 1976, was attached to the letter. The report did not identify where the test was run or who performed it. In summary, the test used ribbon burners (similar to those used in IEEE 383 cable testing) to ignite a cable tray. When 50 percent of the cables became involved in the fire, a Kaowool blanket was placed over the top of the burning tray. The test concluded that the Kaowool blanket smothered the cable fire and did not allow it to spread or become well established.

Conclusion: Reference E.8 suggests that IEEE 383 performance may be achieved for non-IEEE 383 cables by installing a layer of Kaowool. The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not provide any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.9**, UL, Test report on "Fire Hazard Classification Unfaced Batts and Blankets," dated September 14, 1979, File R8418, Project 79NK1036 was the UL version of ASTM E84, "Test for Surface Burning Characteristics of Building Materials." The test report documented that Kaowool batt material does not exhibit surface burning, that is, it does not aid combustion by burning along its surface (no flame spread).

Conclusion: This test is typically required for interior finishes. Kaowool demonstrated excellent performance (as an interior finish.) The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.10**, is an internal B&W memorandum from B.G. Coleman to R.P. Stuntz, dated November 14, 1980, that discusses: "Project No. 08-05-05-00-2964-02, The Testing of Kaowool Products as Fire Protection Materials in Electric Utilities (Part 1 and Part 2)," and contains portions of three fire tests. The memorandum stated, "This project was an early part of a marketing strategy to expand the sales of Kaowool into fire protection applications." The first test discussed was a flame spread test conducted by UL. This test is the same one discussed in Reference E.9. The second test was a penetration seal test in which Kaowool was used as a filler in the seal design. The testing was sponsored by Bechtel and performed at National Gypsum Laboratories. The test concluded that 3 inches of Kaowool in conjunction with Marinite board failed the 3-hour test, and 8 to 12 inches of bulk Kaowool in conjunction with Marinite board and silicone foam passed the ASTM E 119 test. The third test was a Regulatory Guide 1.75-type test conducted by SNL and discussed in Reference E.7.

Conclusion: Two of the tests were previously reviewed in References E.7 and E.9. The third test suggests that Kaowool is an acceptable filler material when used in conjunction with Marinite board and silicone foam in the proper proportions. The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire-barriers installed at FNP. In addition, this test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.11**, B&W letter from C.E. Chaille to P.B. Matthews USNRC, dated April 3, 1979, reviews additional testing performed by B&W for Plant Hatch. (The testing appears to be in-house B&W testing.) The testing of concern involves vertical cable tray interfaces with the floor and flammable liquids wicking into the Kaowool. The letter disputed testing performed at UL on September 15, 1978, "where the flammable liquid soaked through the Kaowool wrap and burned the cables." The B&W test suggested that the failures at UL were attributed to air movement and flames under the floor seal into the cable tray. The B&W letter stated that as long as the seal prevents air flow into the cable tray, the Kaowool will provide an acceptable fire barrier.

Conclusion: SNC did not reference (or provide) the UL test report of September 15, 1978. Therefore, the staff could not determine if the B&W testing and conclusions are correct.

Discussion: **Reference E.12**, UL test report on "Floor and Wall Penetration Fire Stops for Niagara Mohawk Power Corp., Syracuse NY," dated November 17, 1980, File NC601-1-2-3-4, Project 79Nk8678, documents a series of penetration seal tests conducted to IEEE 634-1978 test standard. The penetration seal design consisted primarily of 12 inch-deep Kaowool ceramic fiber packed around the cables (i.e., completely filled) and cut flush with the 12-inch minimum concrete floor/wall assembly. Then for a minimum 12 inches from the penetration, Flammastic 77 mastic coating was applied to the exposed cables and to Kaowool on both sides of the penetration. The Flammastic 77 was applied at its full thickness at the interface with the Kaowool and tapered to a thickness of approximately 1/8 to 1/4 inch out to the 12-inch mark. The test produced acceptable results within the limitations of the materials tested (i.e., the only cables used in the test were of small diameter, 7C-#12 AWG, which will not bound larger cable sizes, #10, #8, #00, etc.). However, this tested assembly is not representative of "as-installed" configurations at FNP. FNP's Final Safety Analysis Report (FSAR) Section 9B.4.1.4, "Fire Barrier Penetrations," states that, "with the exception of penetrations between containment and the electrical penetration rooms, all electrical and mechanical penetrations through fire-rated barriers are sealed with fire tested designs of either silicone foam, silicone rubber boots, non-shrink grout, or nelson multi cable transit systems. Silicone foam penetration seal designs were qualification tested in accordance with ASTM E119-73 and ASTM E84 testing criteria."

Conclusion: The staff concludes that Reference E.12 is not applicable to FNP. The UL test performed for Niagara Mohawk utilized Kaowool as the internal filler (at a depth of 12 inches) for the penetration with a coating of Flammastic 77A as described above. FNP uses silicone foam as the internal filler for the penetration. Therefore, the application of Flammastic 77 on the Kaowool at the silicone penetration seal interface is not bounded by the Niagara Mohawk test. The staff concludes that this test did not establish the fire resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.13**, "Fire Protective Cable Tray Fire Test," by Construction Technology Laboratories, dated June, 1979, reviewed testing performed for the William H. Zimmer Nuclear Power Station, the LaSalle County Nuclear Power Station, and the Shoreham Nuclear Power Station in conjunction with B&W. The ERFBSs tested were a specific design consisting of three 1-inch-thick layers of Kaowool installed over insulated cable tray covers. FNP uses one or two 1-inch-thick layers of Kaowool. FNP does not use insulated cable tray covers. FNP does not use the installation procedures described in the test report to construct this test assembly.

Conclusion: The staff concludes that the Kaowool ERFBSs tested in Reference E.13 were more robust than those installed at FNP (i.e., three layers of Kaowool and an insulated cable tray cover in the test is a more conservative design than the one or two layers of Kaowool installed at FNP). Therefore, this test has no direct application to FNP. In addition, the staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. This test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.14** is an internal B&W memorandum from C.E. Chaille, to B.G. Coleman, dated October 12, 1978, that discusses fire testing at Huskey Products Inc., Florence, Kentucky. The testing was performed by Huskey (the cable tray vendor for Zimmer Station) in an outside building at the Huskey facility. The testing did not follow the ASTM E119 standard time/temperature curve, rather used a gas burner under the Kaowool ERFBS inside a "test chamber room." The first test involved an application specific to Zimmer of 2 inches of Kaowool on large power busses. The design intended to address ampacity derating concerns of large power cables. The design used expanded metal standoffs so that the Kaowool was suspended off the cable tray and would allow air flow. The cable tray cover, installed over the Kaowool, used an intumescent coating. The Kaowool was fastened using welded pin studs and speed clips. A second test was performed using a similar configuration but with 3 inches of Kaowool.

Conclusion: The staff concludes that the designs tested were specific to the Zimmer plant and bear no resemblance to installations at FNP. The Zimmer design is more conservative than the designs used at FNP. The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.15**, "Engineering Report No. 78-9-FP-1, Fire Protective Cable Tray Fire Tests September, 1978 through January 1979 for William H. Zimmer Nuclear Station, " reviewed testing performed by Huskey Products Inc., Florence, Kentucky. The testing was conducted at the Huskey facility. Huskey also prepared and issued the test report. There was no independent laboratory or approving body involved. The testing was the same as previously described in Reference E.14 above.

Conclusion: See Conclusion for Reference E.14 above.

Discussion: **Reference E.16** is an internal B&W memorandum from C.E. Challie to B.G. Coleman, dated June 13, 1980, which discusses "Trip Report-Factory Mutual Test of Kaowool Blanket Wrap Fire Protection Systems." This memorandum describes testing performed for B&W at the Factory Mutual (FM) Providence, Rhode Island, facility. (Note: the FM test report was not attached.) The testing consisted of 18-inch-wide ladderback cable trays covered with two 1-inch-thick layers of Kaowool and a layer of Zetex aluminized cloth. The tray contained a 5 percent fill of instrument cable. The fire exposure consisted of a 10-foot-square pan of heptane under the assembly in an open room. The test was set up to monitor cable continuity and temperature. The report stated that at 43 minutes one of the cables in the center of the tray melted and fused together with the tray. (The test was scheduled to run for 1 hour.)

Mr. Chaille recommended adding thermal mass in the form of 35-40 percent cable fill to future tests. Mr. Chaille also recommends that if cable trays are to be tested with less than 10 percent fill, an additional layer of Kaowool should be placed between the *cables and the tray ladder rungs* to provide, in effect, a three-layer system.

Conclusion: The staff concludes that the testing showed that two layers of Kaowool covered with Zetex would withstand a heptane pan fire for approximately 43 minutes. However, the staff also notes that the heptane pan fire in an open room does not simulate the complete engulfment of the

Kaowool ERFBS as would be experienced in an ASTM E119 test. The Kaowool ERFBS as described in the trip report resembles the most robust design used at FNP, namely a "Type H" design (see Section 4.3 of this report.) The staff concluded that this test did not establish the fire resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not provide any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.17** is an internal B&W memorandum from C.E. Challie to B.G. Coleman, dated October 3, 1980, which discusses "Trip Report-Factory Mutual Test of Kaowool Blanket Wrap Fire Protection Systems." This memorandum described testing performed for B&W at FM Providence, Rhode Island, facility. (Note: the FM test report was not attached.)

The test was a follow-up test to the one in Reference E.16. The testing consisted of an 18-inch-ladderback cable trays covered with two 1-inch-thick layers of Kaowool and a layer of Zetex aluminized cloth. The tray contained a 35 percent fill of 3C cable. The fire exposure consisted of a 10-foot-square pan of heptane under the assembly in an open room. The report stated that at 55 minutes the first cables began to fail. (The test was scheduled to run for 1 hour.) The second test consisted of a cable tray with 10 percent fill. An additional layer of Kaowool was *wrapped around the cables before they were installed in the cable tray.* The two-layer Kaowool and Zetex barrier was installed, which made, in effect, a 3-layer system. This design apparently passed the 1-hour heptane exposure. Mr. Challie stated in the report, "The Nuclear Regulatory Commission requires approximately one hour of protection. However Factory Mutual requires the system to provide at least 60 minutes of protection if not slightly more. Therefore, even if this design were retested and 60 minutes of protection was obtained, I doubt if Factory Mutual would approve it." He concluded with, "Before testing is continued, we need to know whether the market is requiring protection for the cables or protection for control over equipment. In the testing for NRC, control over equipment was all that was required. Damage to the cables during the fire was not important. However, for Factory Mutual it may be necessary for the system to adequately protect the cables during a relatively short-term fire so that they may be used again. Of course protecting cable integrity so they may be used after a fire will require thicker insulating systems."

Conclusion: The staff concludes that the testing demonstrated that two layers of Kaowool covered with Zetex on a 35percent filled cable tray would not withstand a heptane pan fire for 1 hour. Additionally, the heptane pan fire in an open room does not simulate the complete engulfment of the Kaowool ERFBS as would an ASTM E119 test. This test performed on September 18-19, 1980, appears to be the last test conducted by B&W. Appendix R had already been issued, which clearly states the requirements in Section III.G.2. that one train of equipment (including required cable) be "free of fire damage" and that fire barriers have a 1- or 3-hour "rating." It also appears that B&W had determined that its existing designs will not be acceptable to market as a rated system.

Discussion: **Reference E.26**, UL, "Report on Electrical Circuit Protective Materials, Babcock and Wilcox," dated March 22, 1985, File R11044-1, Project 84NK8356, reviews testing performed for B&W by UL on an upgraded version of the original Kaowool material. The new material was -inch-thick and had an external facing of 2-mil aluminum foil on both sides. The installation technique involved complete wrapping around the raceway with a minimum of four layers. The layers had staggered joints with a minimum of 3-inch overlap. This assembly tested is much more robust than what is currently installed in FNP. The 2-mil aluminum foil gives the material much greater strength and uniformity. The design included attributes such as "cable tray lids." The multiple layers of thinner material will outperform the fewer layers of thicker material, because trapped air in spaces between the layers acts as an insulator. The consequences of a joint failure are also lessened because of the multiple joints and staggering. The 1-hour fire test was performed in accordance with UL Subject 1724, which does not limit temperature rise, but relies on the end-user performing cable compressive testing at the elevated temperatures recorded during the fire test. This must then be integrated with the thermal mass inside the tested ERFBS, the physical load (weight from other cables) on the cable of concern, as well as the cable's function (power, control, instrumentation). The following was observed during the 1-hour test (note that systems 1-4 were 36-inch x by 4-inch side-rail cable trays tray, systems 5 and 6 were 5-inch rigid steel conduit, and system 7 was a 12-inch X 12-inch X 6-inch junction box. Cable type and fill varied.)

1. In system 1, the following was observed: "Approximately 50 percent of the two conductor No. 16 AWG [cables] located on the north bend of the tray were fused together. The cable jacket on the seven conductor No. 12 AWG [cables] melted and contained blisters approximately 1/8 to 1/4-inch in diameter along the entire length of the cable."

2. In system 2, the following was observed: "On the bottom surface of the protective enclosure, approximately one-half of the blanket was eroded by the water hose stream such that the bottom surface of the cable tray was exposed...The cable jacket of the two conductor No. 16 AWG cable[s] was melted at ten points along the length of the cable. The area of jacket damage was approximately 1 -inch in length. The cable jacket of the seven conductor No. 12 AWG [cable] was damaged at twelve spots along south section of the cable tray."

3. In system 3, the following was observed: "The cable jacket of the seven conductor No. 12 AWG cables was fused together at the center and north section of the cable tray."

4. In system 4, the following was observed: "Blisters were present on the cable jacket of both the two conductor No. 16 AWG [cables] and the seven conductor No. 12 AWG cables."

5. In system 5, the following was observed: "The cable jacket[s] of all three cables fused together only at one point."

6. In system 6, the following was observed: "On the bottom surface, the third layer of blanket was consumed and the fourth layer was fused together to the conduit."

7. In system 7, the following was observed: "All four layers of the blanket were consumed. The cable jacket of both the two conductor No. 16 AWG [cables] and the seven conductor cable[s] were fused together."

The testing also experienced problems in recording of data: "Thermocouples Nos. 183, 187, 190, 191, 192, 193, 197, 198, and 199 recorded

temperatures that were decreasing during the fire exposure test. The cause of the decreasing temperatures was either the thermocouple wires within the thermocouple plug were reversed or the two wires within the plug were touching each other. This situation was corrected during the test and the temperature readings increased. At this time, we cannot account for the sudden decrease in temperature for Thermocouple Nos. 203 through 206 at the end of the fire exposure test."

Conclusion: The staff concluded that the design tested was more robust than the one installed at FNP. When exposed to the standard ASTM E119 fire exposure, six of the seven upgraded Kaowool ERFBSs experienced cable damage. The test had numerous problems recording thermocouple data. The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not present any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.27**, South West Research Institute test report, "One-hour Fire Qualification Test of a Protective Envelope for Class 1E Electrical Conduit Circuits," dated February 1986, SwRI Project No. 01-8305-053, reviewed a small-scale test that exposed a maximum test specimen of 66 square inches. The test was limited to a small sample consisting of an approximately 36-inch section of 1-inch conduit, a 30-inch air drop, and a 12-inch x 12-inch x 6-inch junction box. The Kaowool ERFBSs were essentially the same designs as tested in Reference E.26. There were problems with the burners at the start of the test; however, the lab restarted the test and maintained the furnace temperature within ASTM E119 limits. With the exception of the cable air drop failing the Megger testing (greater than 100 megohms leakage), the small assemblies appeared to perform well.

Conclusion: This test documented NRC and UL concerns that small scale fire testing may not accurately reflect full-scale performance as was stated in IN 93-41. This is further reinforced by UL in Reference E.5. The UL report summarized the test report as follows: "The foregoing report [Reference E.5] is to be construed as information only and should not be regarded as conveying any conclusion or recommendation on the part of UL regarding the acceptability of the construction or performance of the product for recognition by any code or standard or for any other purpose. In general, small scale tests individually do not represent all factors associated with fire performance under actual field conditions." The staff concludes that this test did not establish the fire-resistance rating of the Kaowool raceway fire barriers installed at FNP. In addition, this test did not provide any test data that could be used to establish that the Kaowool raceway fire barriers installed at FNP will maintain the protected components free of fire damage in accordance with the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.

Discussion: **Reference E.28**, South West Research Institute test report, "Ampacity Derating of Fire Protected Cables in Conduit/Cable Trays Using Babcock & Wilcox Inc., Passive Fire Protective Systems," dated July 8, 1986, SwRI Project No. 01-8818-210, reviewed testing based on the four-layer FP-60 ERFBS. This is not what is installed at FNP. Furthermore, FNP installation procedures instructed installers, "For cable trays with no cover and not completely full, Kaowool blanket shall be cut to the same width as the cable tray and laid on top of the cables to bring the level of Kaowool to the same height as the top of the tray," (Reference E.1, step 5.1). This introduces a variable in the thickness of the Kaowool, which is not accounted for in the testing.

Conclusion: The staff concludes that the ampacity derating testing reports provided by SNC are for a different Kaowool ERFBS. This fact, coupled with the variable in the number of layers of Kaowool installed on the top of the FNP cable trays, may produce non-conservative ampacity derating values.

***RAI 3.1.1*: Identify the new raceway fire barriers (i.e., installed after the effective date of Appendix R) and their fire-resistive rating. In addition, for each of these fire barriers, identify the fire-area/room where they are located, the raceway/cable tray they are protecting , and the safe-shutdown or safety-related function that is being protected.**

Discussion: RAI 3.1.1 was written to specifically identify the pre-Appendix R Kaowool ERFBS from the post-Appendix R installations. SNC stated that, "there are no new raceway installations at FNP other than the Kaowool installations described in NRC-approved exemption requests." Review of FNP FSAR Volume 17, Attachment B lists many Kaowool-protected raceways.

Conclusion: The staff could not determine which Kaowool raceway fire barriers were installed before Appendix R became effective, nor could it determine which Kaowool raceway fire barriers were installed after Appendix R became effective.

***RAI (3.1.2)*: For these raceway fire barriers, provide the design details (e.g., typical design and installation drawing details) and installation instructions that were developed and used to install the barriers,**

Discussion: SNC stated, "It was also during this time that B&W formulated [its] installation instruction/guidelines (Tab E.17), which were adopted for use at FNP. These instructions remain basically unchanged. The current Kaowool (now FireMaster) installation manual (Tab E.31) contains the same installation instructions, with the same critical dimensions as the criteria developed by B&W in 1979 and 1980."

The staff reviewed References E.17 and E.31 in addition to the FNP original installation instructions provided in Reference E.1 (Bechtel Corp. Job 7597-03/20). There are many differences in the design information. Reference E.1 has no provisions for the Zetex outside wrap as stated in Reference E.17, although Zetex is installed at FNP. Reference E.1 does not provide any requirements for installing the layer of Kaowool between the cables and cable tray as stated in Reference E.17 for trays with less than 20 percent cable fill. Reference E.17 never tested or addressed installation on conduits, yet Reference E.1 includes channels and conduits. Testing of other ERFBSs has demonstrated that the electrical raceway type, size, and cable fill are critical parameters to the ERFBS. The requirement to add the required amount of Kaowool filler blankets on cable trays to level them off at the top introduces an unqualified variable on power tray ampacity derating. There is no guidance for support protection or intervening item protection (i.e., other raceways, supports, interferences that affect the installation of the ERFBS).

Conclusion: The staff concludes that there was not enough representative testing performed to develop adequate design details, parameters, or limitations. The original installation instructions are inadequate to support a qualified installation.

***RAI(3.1.3)*: For each fire barrier, provide the fire test reports, data, and engineering evaluations that support the fire-resistive rating of the fire barriers.**

Discussion: SNC stated, "Kaowool installations were recognized as not being bounded by fire tests for every conceivable configuration (BTP APCSB 9.5-1, response item 4). However, sufficient data is available to support the viability of Kaowool as a raceway wrap material (Tabs E.4 through E.31), and sound engineering judgment was employed to develop design details for construction of the wrap assemblies. The designers were very knowledgeable in the early 1980's of the Kaowool material, its application, and the safety significance of its use at FNP. No formal, configuration-specific engineering evaluations supporting the fire-resistive ratings of the fire barriers were documented at that time, nor were any required."

Issues associated with the fire testing have been previously discussed under RAI (2.1.3). Issues associated with the qualification of the standard installation details have been previously discussed under RAI (3.1.2). That section determined that fundamental design parameters and attributes were missing. Generic Letter 86-10, under RAI (3.2.2) provided guidance on fire barrier installations that deviated from their tested configuration. If this guidance is used, it is reasonable to expect that the analysis was documented in a quality assurance (QA) fashion that is audit able. Not having performed the analysis is unacceptable.

Conclusion: The staff concludes that FNP does not have engineering analysis (e.g., design baseline) to support the fire rating or installation details of its installed Kaowool ERFBS.

***RAI (4.1.1)*: Describe the butt joint design used at FNP and discuss how it meets or exceeds the design attributes used in 1978 by the Babcock and Wilcox tested configuration. State whether or not an analysis was performed which evaluated the butt joint design deficiency noted in IN 93-40, and its potential applicability to the designs used at FNP. Provide the analysis.**

Discussion: SNC has determined that the butt joint failures were "more likely attributed to an installation anomaly rather than a design deficiency." This differs from the B&W test report of 1978 which states, "it was obvious that the cable tray at the butt joint had burned through." To correct this problem B&W installed 1 -inch x 0.130-inch galvanized "holding brackets" within 3-inches of each side of the joint. The large "holding brackets" are not incorporated in FNP design.

Conclusion: The staff concludes that the FNP design is significantly different from the one in the B&W test report. The FNP installation for cable trays relies on -inch banding rather than on the 1 -inch "holding brackets" used by B&W. The FNP design does not use the fastening methods developed by the B&W test performed in 1978.

RAI (4.1.2): Discuss the design/installation attributes of the FNP Kaowool raceway fire barriers as compared to those tested and for each of the critical attributes (e.g., raceway size, raceway orientation, air drops, cable fill, cable size, cable type, joint and seam design, fastener/ band spacing), and summarize how deviations between the tested and installed attributes affect the fire-resistive characteristics of the installed fire barriers. Provide any additional information that demonstrates that the installed Kaowool raceway fire barriers meet NRC requirements and licensing commitments.

Discussion: SNC stated, "It has not been verified that every configuration existing at FNP is enveloped by these tested configurations. However, the configurations at FNP were designed and examined by knowledgeable fire protection engineering personnel during the Kaowool installation process." This issue was previously raised in Generic Letter 92-08: "The NRC is concerned that some licensees have not adequately reviewed and evaluated the fire endurance test results and ampacity derating test results used as the licensing basis for their Thermo-Lag 330-1 barriers to determine the validity of the tests and the applicability of the test results to their plant design."

Conclusion: The staff concludes that FNP does not have engineering analysis (e.g., design baseline) to support the fire rating or installation details of its installed Kaowool ERFBSs.

***RAI (4.1.3)*: Babcock and Wilcox tests performed in 1978(4-inch-diameter conduit and 18-inch-wide cable tray) evaluated limited raceway configurations. In addition, the raceway fire-barrier system test specimens extended through the furnace wall and terminated outside the test fire's zone of influence. Bechtel, in a letter dated October 1, 1993, indicated that the 1978 Babcock and Wilcox test results of 1978 provided sufficient test data to justify acceptance of non-tested configurations. Provide the engineering analysis that supports the conclusions made that the 1978 tests bound the actual installations. Specifically, address the Kaowool raceway fire-barrier interface with other fire barriers (e.g., fire walls).**

Discussion: SNC response stated, "FNP's use of Kaowool, and our opinion that the Kaowool installed as the raceway fire protection barrier at FNP will perform its intended design function, is based on an understanding of Kaowool and its performance characteristics derived from significant amounts of testing conducted by numerous fire protection experts across the nation, and from discussions, presentations, and meetings with manufacturer and other industry experts, and the use of engineering judgement by qualified fire protection engineers." Although this statement sounds convincing, it is un-substantiated. The simplest details have not been addressed; for example the use of -inch banding vs. B&W's 1 -inch x 0.130-inch galvanized "holding brackets." As to the quality of the testing, most of the tests did not conform to a nationally recognized testing procedure (e.g., ASTM E119 vs. heptane pan fires), and even where the testing could be considered as appropriate, there are material concerns. For example, the October 24, 1978, B&W test report states that the Kaowool used in the test was "1" thick, 8 lb/ft^3 needled" but the UL report of the same test states," 1" thick 9.4 pcf ceramic fiber blanket designated as 'Kaowool'." The material installed on conduits in Test #4 was also different,"1 in. thick 11.8 pcf rigid pearlite-cement material designated as 'Kaotemp'." Clearly the denser insulating material will produce better results. Without definitive information in the test reports, the test results cannot be translated into qualified plant designs.

Conclusion: On the basis of the erroneous data/information in the test reports, the staff does not agree with the licensee's "opinion that the Kaowool installed as the raceway fire protection barrier at FNP will perform its intended design function, is based on an understanding of Kaowool and its performance characteristics derived from significant amounts of testing conducted by numerous fire protection experts across the nation, and from discussions, presentations, and meetings with manufacturer and other industry experts, and the use of engineering judgement by qualified fire protection engineers."

***RAI (4.1.4)*: For the FNP Kaowool raceway fire barriers installed after the effective date of Appendix R, provide the cable functionality**

analysis and subsequent testing, which demonstrates that the protected post-fire safe shutdown cables are capable of performing their intended functions during and after a postulated fire (refer to Generic Letter 86-10, Interpretation 3, "Fire Damage").

Discussion: SNC stated, "The test acceptance criteria used by FNP were based on circuit functionality." SNC did not supply any analysis or additional testing. Circuit-continuity monitoring does not equate to circuit functionality. Furthermore, a number of the tests submitted by SNC (e.g., Reference E.4) show that cable damage occurred during the fire test.

Conclusion: The staff concludes that SNC has not demonstrated that its protected cables will remain free of fire damage (i.e., functional), as required by the regulations.

***RAI (4.1.5)*: Provide the tests/analyses which technically assess the required protection to raceway supports and the required protection of intervening items into the Kaowool fire barrier system.**

Discussion: SNC response referenced FSAR Appendix 9B, Attachment B, Section 40. Section 41.2 states, "The following raceways have been protected by a fire barrier enclosure having a 1-h fire rating." As discussed above, the representative FNP designs have not been qualified to a 1-hour rating. In addition, although the FSAR evaluation concluded that the unprotected supports should remain in place, the question regarding "thermal shorts" (i.e., supports, other metallic raceways, or obstructions that could conduct heat into the ERFBS and cause failure of the protected circuits) was not addressed.

Conclusion: The staff concludes that SNC has not demonstrated that the FNP Kaowool ERFBSs are qualified as 1-hour rated assemblies. Although previously approved exemptions conclude that the raceway supports will remain in place and carry the raceway's load, the exemptions did not address the question of thermal shorts. Therefore, the potential adverse effects of thermal shorts on the fire resistance rating of the barriers, or their ability to protect the safe shutdown components is not known.