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James Knubel
Senior Vice President and
Chief Nuclear Officer

October 30, 2000
JPN-00-041

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station PI-137
Washington, DC 20555

SUBJECT: James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
Request for Exemption From
10 CFR 50, Appendix R, III.G.2.c
Requirement For a One-Hour Rated Fire Barrier Wrap

REFERENCES: 1. NRC Letter G.S. Vissing to J. Knubel, dated September 8, 1999 regarding "Proposed Meeting to Discuss Kaowool Fire Barriers"

Dear Sir:

In accordance with the provisions of 10 CFR 50.12(a), the New York Power Authority requests an exemption from the requirements of 10 CFR 50, Appendix R, as it applies to the James A. FitzPatrick Nuclear Power Plant for Fire Area 1C. Attachment 1 summarizes the bases for this exemption request and Attachment 2 provides a detailed evaluation of the installed fire barrier wrap and its application.

If approved, the exemption would allow the use of a fire barrier wrap, for which there is insufficient test evidence that the one-hour fire-rating criterion of Appendix R Section III.G.2.c is met. An evaluation has been prepared which documents the adequacy of the existing fire barrier wrap to maintain the circuit of concern functional during a fire, thereby meeting the underlying purpose of 10 CFR 50, Appendix R to attain and maintain safe shutdown in the event of a fire.

This exemption is requested as a result of the Authority's recent review of the technical issues identified in SECY 99-204.

A006

There are no new commitments made by the Authority in this letter. If you have any questions, please contact Ms. C. D. Faison.

Very truly yours,

Jim Knubel
Chief Nuclear Officer

STATE OF NEW YORK
COUNTY OF WESTCHESTER
Subscribed and sworn to before me
this 30th day of Oct 2000.

Eileen E. O'Connor

cc: Next page

EILEEN E. O'CONNOR
Notary Public, State of New York
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Qualified in Westchester County
Commission Expires January 21, 2002

cc: Regional Administrator
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Attachments:

1. Request For Exemption From 10 CFR 50, Appendix R, Regarding Use of a Fire Barrier Wrap That May Not Meet the Acceptance Criteria For a One-Hour Rated Fire Barrier Wrap

2. Evaluation of Kaowool FP-60 Fire Barrier Wrap in Fire Zone CT-1, West Cable Tunnel

Attachment 1 to JPN-00-041

Request for Exemption From 10 CFR 50, Appendix R, III.G.2.c Requirement For a One-Hour Rated Fire Barrier Wrap

James A. FitzPatrick Nuclear Power Plant
New York Power Authority
Docket No. 50-333

Evaluation Pursuant to 10 CFR 50.12 Criteria

Exemption Requested

In accordance with the requirements of 10 CFR 50.12(a), the New York Power Authority requests exemption to the requirements of 10 CFR 50, Appendix R, Section III.G.2.c to the extent that a fire barrier wrap used to protect a safe shutdown power cable, lacks sufficient evidence to demonstrate that it meets the acceptance criteria for a rated one-hour fire barrier wrap.

Physical Arrangement and Fire Protection Features

Fire Area Boundaries

Fire Area 1C contains Fire Zone CT-1, or the west cable tunnel which is a cable tunnel through which the majority of Division I cables from the control room complex to the reactor building are routed. (Figure 1)

Fire Area 1C is separated from the adjoining plant areas by three-hour rated fire barriers (non-rated exterior barriers not considered).

The north and east walls of the west cable tunnel (CT-1) are three-hour rated fire barriers separating it from the east cable tunnel (CT-2). The remainder of the east wall and a portion of the south wall of the west cable tunnel are three-hour rated barriers separating the west cable tunnel from the Radwaste Pipe Tunnel (RW-1). Part of the south wall separates the west cable tunnel from the Steam Tunnel (Fire Area 1E). The ceiling of the west cable tunnel is a three-hour rated fire barrier separating it from the Turbine Building, the Administration Building and the Emergency Diesel Generator Switchgear Room (Fire Zone EG-5/Fire Area 5).

A portion of the west cable tunnel (CT-1) enters the Reactor Building below Elevation 272'-0" of Fire Zone RB-1B. The floor of RB-1B is a three-hour rated fire barrier at this interface. The portion of the floor of the west cable tunnel that passes over the Steam Tunnel is a three-hour rated fire barrier; the remainder of the floor is a base slab, and therefore an exterior barrier. The west wall is an exterior barrier except for a small portion which is separated from Fire Zone EG-3/Fire Area 6. In addition, the stairwell at the south end of the west cable tunnel at Elevation 272'-0" is separated from the remainder of the Administration Building by three-hour fire barriers.

There is no exposed structural steel in or supporting fire rated barriers in the west cable tunnel (CT-1).

Fixed Combustibles and Ignition Sources

The majority (over 90 percent) of the in-situ combustible loading in the west cable tunnel (CT-1) is cable. This zone has no significant in-situ ignition sources other than the cables themselves.

The equivalent fire severity for the entire zone is 61 minutes. The combustible loading that contributes to this fire severity is spread out over the entire 13,400 square foot area. The nature

and configuration of combustibles in the immediate area of the fire barrier wrap is expected to limit the fire severity to significantly below 61 minutes. Transient combustibles are controlled by administrative procedure.

Fire Detection Capabilities

The west cable tunnel (CT-1) is provided with automatic area-wide early warning smoke detection. A postulated fire in the zone is expected to involve electrical cable insulation and is expected to be a slowly developing, high smoke-generating event. The smoke detection system will alarm during the incipient stages of a fire involving electrical cable insulation and will provide an alarm in the control room.

The detection system was designed and installed in accordance with National Fire Protection Association standards NFPA-72D, 1979, Proprietary Signaling Systems and NFPA-72E, 1978, Automatic Detectors. Where the detection system deviates from the guidance provided in the NFPA guidelines, evaluations have been performed and it has been determined that the system meets the intent of the standard and there is no adverse impact on the operability of the system.

Fire Suppression Capabilities

The west cable tunnel (CT-1) is protected by an automatic area-wide wet pipe sprinkler system. The sprinkler system utilizes 165^{0}F rated sprinklers and is designed to suppress a floor based transient exposure fire. The sprinkler system meets the design requirements of NFPA-13, 1991, Installation of Sprinkler Systems.

In addition, an in-tray automatic wet pipe water spray system, utilizing 135^{0}F spray nozzles, is designed to suppress a tray based fire. The water spray system meets the design requirements of NFPA-15, 1990, Water Spray Systems.

Water hose lines and portable fire extinguishers are available in the zone to support manual suppression activities.

Safe Shutdown Capabilities

For a postulated fire in the west cable tunnel (CT-1), safe shutdown compliance strategy credits the High Pressure Coolant Injection (HPCI) for reactor coolant makeup and Train B of Residual Heat Removal (RHR) for suppression pool cooling. Cold shutdown is achieved using train B Alternate Shutdown Cooling (ASD).

Excluding motor operated valves powered from the LPCI bus, the loss of the protected cable for a postulated fire in the west cable tunnel directly results in the loss of all essential Division B 600 Volt AC power for the above described shutdown strategy. Loss of 600 Volt AC power will either immediately or subsequently cause the loss of 120 Volt AC power and 125 Volt DC power.

The cable protected by the fire barrier wrap is a 500 MCM power cable between the 4160 switchgear (71H06) and the L-16 transformer (71T-14).

The protected cable is essential to support the relied upon shutdown strategies described above.

Fire Barrier Wrap Capabilities

Fire test results are available to demonstrate that the installed fire barrier wrap will provide 30 minutes of fire endurance when exposed to the standard ASTM E-119 time/temperature fire. Using guidance provided in Generic Letter 86-10 and Supplement 1, a cable functionality analysis has been performed to demonstrate that the fire endurance rating of the installed fire barrier wrap is 52 minutes.

The installed configuration may provide a fire endurance rating of equal to or greater than one-hour however, there is insufficient evidence available to prove this point. Since the thermal mass per linear foot of the installed configuration is greater than the thermal mass per linear foot of the tested configuration, it is expected that the installed configuration would perform better than the tested configuration when exposed to the same fire. That is, the installed configuration would be expected to remain cooler than the tested configuration.

JUSTIFICATION FOR EXEMPTION

The requested exemption satisfies the 10 CFR 50.12 criteria as stated below:

The requested exemption is authorized by law

10 CFR 50.12(a) authorizes the Nuclear Regulatory Commission to grant this exemption.

The requested exemption does not present an undue risk to the public health and safety

Appendix R Section III.G.2.c

Appendix R Section III.G.2.c specifies acceptable methods of ensuring that during and after any postulated fire in the plant, one train of systems necessary to achieve and maintain hot shutdown remains free of fire damage. Section III.G.2.c in part relies on the use of a fire barrier having a one-hour rating. The fire barrier wrap used to protect a safe shutdown power cable, lacks sufficient evidence to demonstrate that it meets the acceptance criteria for a rated one-hour fire barrier wrap.

Similar Exemptions

The NRC issued an exemption dated April 20, 1999 (Reference 3) which permitted the use of a fire barrier wrap with a fire endurance rating of less than one-hour. The criteria for granting the exemption and concluding that the exemption would not pose an undue risk to the public health and safety was based on the availability of automatic detection and fire suppression systems and the fire hazard in the zone.

The fire hazard in the west cable tunnel has been evaluated and does not provide a significant exposure to the protected cable. The west cable tunnel is protected by both automatic detection and fire suppression. In addition, an in-tray water spray system is installed.

The reliance on a fire barrier wrap with a fire endurance rating of less than one-hour in the west cable tunnel, fire zone CT-1 is less severe, with in-tray suppression, when compared to the above referenced exemption. On a similar basis it should also be concluded, for the subject request, that the use of a fire barrier wrap with less than one-hour fire endurance rating in the

west cable tunnel would not unduly risk the public health and safety, as the conditions presented in the previously NRC approved exemption are bounding.

The requested exemption is consistent with the common defense and security

The common defense and security are not affected by this exemption request.

Special circumstances are present as defined in 10 CFR 50.12(a)(2)

10 CFR 50.12(a)(2) states, in part:

> *"The commission will not consider granting an exemption unless special circumstances are present. Special circumstances are present whenever...(ii) Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or it is necessary to achieve the underlying purpose of the rule; or (iii) Compliance would result in undue hardship or other costs that are significantly in excess of those contemplated when the regulation was adopted, or that are significantly in excess of those incurred by others similarly situated."*

Underlying purpose of the rule

Achieve and Maintain Hot Shutdown – III.G.2.c

Compliance with the performance criteria of a one hour rated fire barrier wrap is not necessary to achieve the underlying purpose of the rule since safe shutdown conditions can be achieved and maintained with the use of a fire barrier wrap that does not meet that performance criteria, may have a fire endurance rating of less than one-hour but has been evaluated to be adequate for the hazards to which it is exposed.

Conclusion

This exemption request is warranted under the provisions of 10 CFR 50.12, in that it is authorized by law, does not present an undue risk to the public health and safety and is consistent with the common defense and security.

Special circumstances are present considering the lack of sufficient evidence that the fire barrier wrap meets the acceptance criteria for a rated one-hour fire barrier wrap (compliance with Section III.G.2.c). Safe shutdown conditions can be achieved and maintained with the installed fire barrier wrap protecting the safe shutdown power cable along with area wide automatic detection and suppression.

This exemption request is consistent with the ultimate objective of Appendix R, which is safe shutdown. There is no need to, or safety benefit associated with meeting the performance requirements of a one-hour fire rated barrier wrap since the use of the installed fire barrier wrap with a fire endurance rating less than one-hour has been shown to be a safe and effective means of protecting the cable and thereby achieving safe shutdown.

The information contained in this exemption request will permit the staff to complete its review of the FitzPatrick Appendix R fire protection program and issue a Safety Evaluation Report documenting their approval of the use of the installed fire barrier wrap to protect the safe shutdown capability of the plant.

The Authority has reviewed Appendix R exemptions issued by the NRC for FitzPatrick. The bases of these exemptions are not affected by this exemption request and will remain valid if the exemption is granted.

These actions support the resolution of the technical issues identified in SECY 99-204.

References

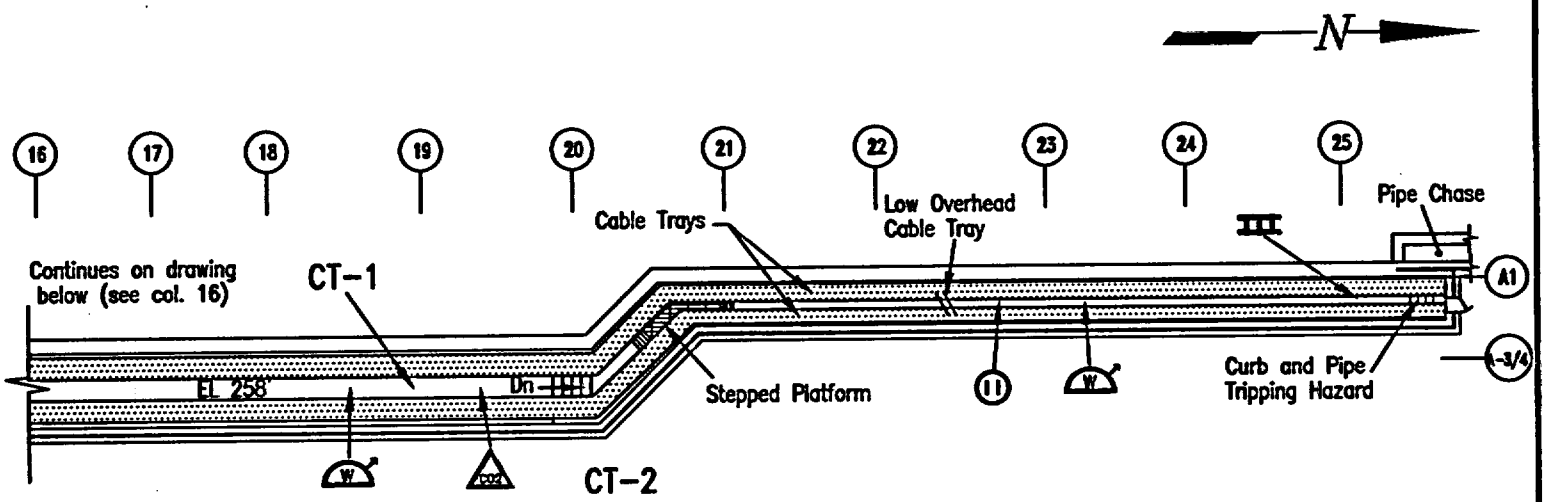
1. SECY 99-204, August 4, 1999, Kaowool and FP-60 Fire Barriers

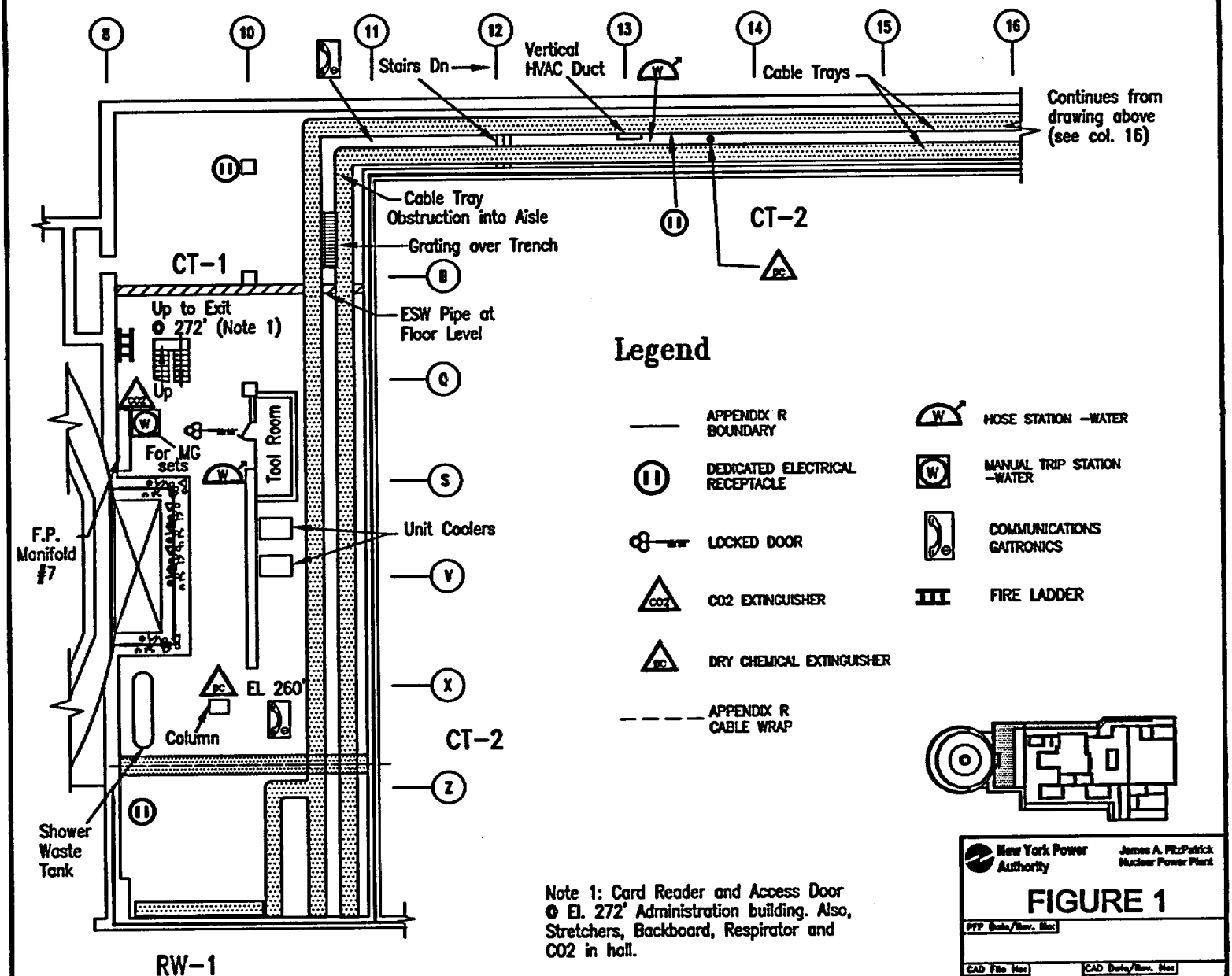
2. NRC Letter, G. Vissing to J. Knubel, September 8, 1999, Proposed Meeting to Discuss Kaowool Fire Barriers

3. NRC Letter and SER, T. Colburn to J. Langenbach (TMI) April 20, 1999, Three Mile Island Nuclear Generating Station, Unit 1, 10 CFR Part 50 Appendix R Exemption Request (TAC No. M97747)

West Cable Tunnel / Elev. 258'

Fire Area/Zone IC/CT-1





Note 1: Card Reader and Access Door @ El. 272' Administration building. Also, Stretchers, Backboard, Respirator and CO2 in hall.

New York Power Authority

James A. FitzPatrick Nuclear Power Plant

FIGURE 1

PTP Date/Rev. No:

CAD File No:

CAD Date/Rev. No:

Attachment 2
JPN-00-041

Evaluation of Kaowool FP-60 Fire Barrier Wrap in Fire Area CT-1 West Cable Tunnel

James A. FitzPatrick Nuclear Power Plant
New York Power Authority
Docket No. 50-333

1. Purpose:

The purpose of this evaluation is to document the fire resistive capabilities and adequacy of the Kaowool FP-60 fire barrier wrap installed in the west cable tunnel at the James A. FitzPatrick Nuclear Power Plant.

This evaluation is being prepared in accordance with the guidance provided in Generic Letter 86-10 and Supplement 1.

2. Summary:

10 CFR 50, Appendix R, Section III.G, specifies acceptable methods of ensuring that during and after any postulated fire in the plant, one train of systems necessary to achieve and maintain hot shutdown remains free of fire damage. The option described in Appendix R, Section III.G.2.c; "Enclosure of cable and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating, in addition, fire detectors and an automatic fire suppression system shall be installed in the fire area", was relied upon in the west cable tunnel. A Kaowool FP-60 system was utilized as the one-hour rated fire barrier.

Evaluation of the original Kaowool FP-60 fire test and supporting documentation has revealed that there is insufficient evidence that the fire barrier wrap meets the acceptance criteria for a rated one-hour fire barrier wrap.

Evidence is available to demonstrate that the fire barrier wrap will maintain the protected cable free from fire damage for at least 30 minutes. In addition, by applying criteria provided by the staff in Generic Letter 86-10 (Reference 2), and Supplement 1 (Reference 3), a cable functionality assessment of the installed configuration in the west cable tunnel determined that the functionality of the installed cable would not be challenged until the temperature approached 482^{0}F. Review of the test data indicates the maximum measured temperature within the tested configuration did not reach this limit within the first 52 minutes.

Considering that the installed cable is a 500 MCM triplex cable and the tested configuration consisted of a 300 MCM single conductor cable, a seven conductor 12 AWG and a two conductor 16 AWG cable, whose total thermal inertia is approximately one half that of the 500 MCM triplex, it is reasonable to expect that the internal barrier temperatures would remain below the 482^{0}F operating limit for more than one hour.

In conjunction with other existing mitigating factors (e.g., automatic detection, wet pipe sprinklers and in tray wet pipe water sprays), the ability to achieve and maintain safe shutdown in the event of a fire in west cable tunnel is assured.

3. **Background:**

The underlying purpose of Section III.G of 10 CFR 50, 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 options for limiting fire damage so that one train of systems necessary to achieve and maintain hot shutdown remains free of fire damage.

In the west cable tunnel, compliance with Section III.G.2.c was achieved by the use of area fire suppression and fire detection along with a one-hour rated fire barrier wrap constructed of Kaowool FP-60 manufactured by Thermal Ceramics, Inc.

Approximately 60 linear feet of Kaowool FP-60 is installed as a fire barrier wrap which protects a 500 MCM power cable (1HOEBBH001) between the 4160 switchgear (71H06) and the L-16 transformer (71T-14).

Recently the NRC issued SECY 99-204 to inform the Commission about the results of NRC staff's review of Kaowool fire barriers. The staff found that although they had previously accepted Kaowool as a rated one-hour barrier, they could find no evidence that the staff that originally approved the barriers had reviewed the Kaowool fire test reports or the design basis for the barriers. The staff concluded that the fire rating of the Kaowool barriers is indeterminate, but less that one-hour.

In a previous analysis, Reference 5, NYPA documented the fire resistive capability of the configuration installed at JAF as a one-hour fire rated assembly. The staff used this analysis along with their own review of the fire endurance test report to close an Unresolved Item (URI) at JAF.

In Inspection Report 92-80 (Reference 7), the staff opened URI 333/92-80-07B which questioned the adequacy of the installed Kaowool system. The URI was subsequently closed in Inspection Report 50-333/92-14 (Reference 8). From IR 92-14, "Additional information on the UL test was received by the licensee from the engineering department of UL and documented in a licensee's memorandum dated September 10, 1992 (NED-SW-92-254). This UL engineering data was used by the licensee to support their decision to accept the UL test data and cable configuration for their cable design for a one-hour fire barrier. Based on the licensee's configuration of their one hour cable installation and a review of the UL test data, the inspectors closed this item."

As a result of the technical issues identified in SECY 99-204 concerning the fire resistive rating of Kaowool FP-60 fire barriers, the NRC met (Reference 10) with affected utilities to solicit an industry initiative to address these issues.

As a result of the meeting with the NRC, NYPA decided to revisit the technical issues and determine their applicability to JAF.

Further evaluation of the original fire test (Reference 15) and supporting documentation has revealed that there is insufficient evidence that the fire barrier wrap meets the acceptance criteria for a rated one-hour fire barrier wrap. This is due to anomalies in the test data, which cannot be proven beyond a reasonable doubt using engineering judgement. Absent sufficient evidence that demonstrates that the barrier meets the acceptance criteria for a rated one-hour fire barrier wrap, the barrier will be considered non-conforming.

Following is a discussion of the adequacy and ability of the configuration installed at JAF to meet the underlying purpose of 10CFR50, Appendix R.

4. Consequences of Cable Failure:

4160V emergency bus 71H06 (located in EDG switchgear room EG-6) supplies 600V load centers 71L16 (300' Reactor Building Northeast/Northwest Quadrants, RB-1C) and 71 L26 (east electric bay, SW-2) from a single breaker, 71-10660.

From the breaker at 71H06, the two power cables run together through the east cable tunnel (258' elevation) until the cable for 71L26 rises through the ceiling into the east switchgear room (286' elevation). The cable for 71L16 continues for the full length of the east cable tunnel, passes through a wall penetration into the west cable tunnel (fire zone CT-1), where it is wrapped with Kaowool FP-60. The cable then runs into the Reactor Building (RB-1A and then into RB-1C).

For a postulated fire in the west cable tunnel (CT-1), safe shutdown compliance strategy credits High Pressure Coolant Injection (HPCI) for reactor coolant makeup and train B of Residual Heat Removal (RHR) for suppression pool cooling. Cold shutdown is achieved using train B Alternate Shutdown Cooling.

Excluding motor operated valves powered from the LPCI bus, the loss of the protected cable for a postulated fire in the west cable tunnel directly results in the loss of all essential Division B 600 Volt AC power for the above described shutdown strategy. Loss of 600 Volt AC power will either immediately or subsequently cause the loss of 120 Volt AC power and 125 Volt DC power.

5. Configuration of Installed Cable:

Kaowool is a noncombustible, flexible ceramic-fiber blanket originally manufactured by Babcock and Wilcox. FP-60 is an upgraded version of Kaowool with aluminum foil laminated to both surfaces and is manufactured by Thermal Ceramics.

Approximately 60 linear feet of Kaowool FP-60 is installed as a fire barrier wrap in the west cable tunnel which protects a 500 MCM power cable (1HOEBBH001) between the 4160 switchgear (71H06) and the L-16 transformer (71T-14). The wrap was installed by modification F1-85-065 and protects the entire length of the cable in the west cable tunnel.

The following from specification APO-77 (Reference 12) is a summary of the physical characteristics of the cable that is wrapped, mark number NFF-50:

• Number of conductors/size:	3 conductors/500 MCM
• Manufacturer:	Okonite Company
• Conductor material:	aluminum
• Insulation material:	cross-linked polyethylene
• Insulation type:	thermosetting
• Binding tape:	flame resistant neoprene
• Jacket:	galvanized steel (armored)
• Temperature rating:	90^0C normal 130^0C emergency rating 250^0C short-circuit rating

The cable is wrapped with six, one-half inch layers of Kaowool FP-60 for a total thickness of three inches. An outer cover of Zetex FP-1000 is provided as a protective wrap. The Zetex fabric is held together by the use of steel fastening clips. The wrapped armored cable is laid in an open ladder back cable tray.

With the exception of the use of the steel fastening clips on the Zetex fabric, in lieu of steel banding, the field installation follows the manufacturer's recommended installation guidelines as endorsed by American Nuclear Insurers (Reference 14).

This deviation from the manufacturer's recommendation is not expected to have a detrimental affect on the fire barrier system since the clip material is similar to that of the banding, and the function of both the clips and the banding is the same, to hold together the Zetex outer protective layer. The use of the outer covering of Zetex FP-1000 is an optional enhancement to the design, and is provided to protect against physical damage in high traffic areas.

All supports in the cable tray containing the wrapped armored power cable are wrapped in their entirety with four, one-half inch layers of Kaowool FP-60 for a

total thickness of two inches. Some of the wrapped supports are provided with Zetex FP-1000 and some are not, leaving the aluminum foil laminate exposed in certain areas.

6. Review of the Fire Qualification Test:

A nationally recognized, independent testing organization, Underwriters Laboratories Inc., performed a one-hour fire exposure and hose stream test on the Thermal Ceramics Kaowool FP-60 ceramic fiber blanket. The test was performed on September 26, 1984 and was documented in File R11044-1, Project 84NK8356, dated March 22, 1985 (Reference 15). The test was performed in accordance with Underwriters Laboratories Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems (Reference 16), which closely resembles the requirements of ASTM E-119.

The temperature of the test furnace was controlled by sixteen thermocouples, symmetrically disposed and distributed. The furnace temperatures followed the ASTM E-119 standard time/temperature curve.

A hose stream test was performed consistent with the requirements described in ASTM E-119. The hose stream test was made on the specimen subjected to the fire endurance test immediately following expiration of the fire endurance test and removal from the test furnace.

The fire endurance test consisted of eight different tested configurations placed in the furnace and exposed to the standard time/temperature curve and subsequent hose stream. The tested configuration most closely resembling the installed configuration is identified in the test report as System No. 8.

The System No. 8 tested configuration consists of an air-drop protected by six, one-half inch layers of Kaowool FP-60. No outer covering (hardware cloth) was provided. Note, this compares with the installed cable which is protected by six, one-half inch layers of Kaowool FP-60 along with Zetex FP-1000 as a protective outer covering laid in an open back cable tray.

There were three cables protected within the tested configuration. One single copper conductor 300 MCM power cable with PVC jacket and XLPE insulation; one seven copper conductor No. 12 AWG control cable with PVC jacket and XLPE insulation; and one two copper conductor No. 16 AWG control cable with PVC jacket and XLPE insulation. Note, this compares with the installed cable, which is a 3 aluminum conductor, armored jacket, XLPE insulated 500 MCM power cable.

The tested cable tray supports were trapeze type with a single channel and 3/8" diameter threaded steel rods with washers and lock nuts. The channel is 1-5/8"

wide web with 1-5/8" high flanges formed from 0.093" (12 gauge) galvanized steel. The tested supports were wrapped with two, one-half inch layers of Kaowool FP-60, secured with steel tie wire. At the interface of the supports and the ceiling, loose ceramic fiber was packed between the layers of blanket. Again, no outer protective covering (Zetex FP-1000) was provided. The installed supports are trapeze type wrapped in their entirety with four, one-half inch layers of Kaowool FP-60 for a total thickness of two inches, all have bulk fiber packed between the layers of blanket. Some of the installed supports are provided with Zetex FP-1000 and some are not, leaving the aluminum foil laminate exposed in certain areas, similar to the tested configuration.

7. Acceptance Criteria:

In their Generic Letter 86-10, Supplement 1, the staff provided clarification of acceptance criteria applicable to fire endurance and functionality test results. These criteria include:

1. The average internal temperature of the fire barrier system, as measured on the exterior surface of the raceway or component, shall not rise more than 250^{0}F above its initial temperature or any single thermocouple shall not exceed 30% of the maximum allowable temperature rise (i.e., 250^{0}F + 75^{0}F = 325^{0}F); and

2. A visual inspection of the protected cable or components shall reveal no signs of degraded conditions from the thermal effects of the fire exposure; and

3. The fire barrier system shall remain intact during the fire exposure and hose stream tests without developing any openings through which the protected component, raceway, or cables are visible

8. Review of Test Results:

The Underwriter's Laboratories Inc. test yielded the following results:

8.1 Test Results for Acceptance Criteria No. 1:

The fire endurance test results indicate that several thermocouple readings did exceed the 325^{0}F criteria during the fire exposure portion of the test.

8.1.1 Review of Test Results for Acceptance Criteria No. 1

Guidance provided in GL 86-10, Supplement 1 requires that both the single point (325^{0}F rise above ambient) and average temperature (250^{0}F rise above ambient)

be met. In the context of cable functionality assessments, single point cable failures are most likely therefore reliance on the single point failure method is considered conservative and appropriate. The average temperature rise criteria ($250^0F + 75^0F$ ambient = 325^0F) will be applied to the single point methodology for the following reasons.

In GL 86-10, Supplement 1, the staff states: "The basic premise of the NRC fire resistance criteria is that fire barriers which do not exceed 163^0C (325^0F) cold side temperature and pass the hose stream test provide adequate assurance that the shutdown capability is protected without further analyses."

The selection of 325^0F as acceptance criteria is based on ignition of cotton waste from NFPA 251. In fact GL 86-10 states: "The resulting 325^0F cold side temperature criterion is used for cable tray wraps because they perform the fire barrier function to preserve the cable free of fire damage. It is clear that cable that begins to degrade at 450^0F is free of fire damage at 325^0F."

Since the single point failure criteria alone is applied herein, a single thermocouple reading above the acceptance criteria of 325^0F will be considered the point at which the test will fail. It is clear that at 325^0F the protected cable will remain free from fire damage. This is conservative and appropriate.

It is recognized that using the single point failure criteria in GL 86-10, Supplement 1, ($325^0F + 75^0F$ ambient = 400^0F) would result in a fire-rating of greater duration.

The application of the average temperature rise criteria ($250^0F + 75^0F$ ambient = 325^0F) to a single point methodology demonstrates that the cable remains free from fire damage up to that point.

A total of 23 thermocouples (nos. 184 through 206) were used to record temperatures of the wrapped air drop assembly during the fire exposure test. The thermocouples were located on the surface of the protected cables and were placed approximately every 12 inches along the cable and adjacent to penetrations.

Data from thermocouple no. 201 is missing from the final report. Several other thermocouples (nos. 187, 190, 191, 192, 193, 197 and 199) recorded decreasing temperatures during the test. Underwriter's Laboratories (Reference 19) has attributed this to either thermocouple wires within the plug being crossed or the two wires within the plug were touching each other. Once this condition was corrected, the measured temperatures increased. For the purpose of this evaluation, these thermocouple readings have not been relied upon to support any conclusions. This is acceptable since the data from these thermocouples indicates lower than expected temperatures and their inclusion would be non-conservative.

This leaves data from 15 thermocouples to be evaluated. Although the remaining thermocouples are not located every 12 inches along the cable as required by GL 86-10, Supplement 1, the temperature data is considered valid and can be used to support the conclusions herein since the 325^{0}F criteria is applied to any single thermocouple measurement.

Thermocouple no. 200 recorded a temperature in excess of 325^{0}F (377.7^{0}F) at 30 minutes and 50 seconds into the fire exposure test. At 32 minutes and 50 seconds, this same thermocouple read 302.2^{0}F, a decrease of 75.5^{0}F. The readings from thermocouple 200 continue to oscillate with time during the fire exposure test. Thermocouple no. 200 was located adjacent to where the air-drop penetrated the floor/ceiling assembly.

Since no data is available to discount the accuracy of thermocouple no. 200 or to demonstrate that it was not operating properly, the data associated with it will be considered valid. It is noteworthy that adjacent thermocouples did not read temperatures above 325^{0}F until about 50 minutes into the test.

Two other thermocouples (nos. 194 and 206) were installed at the same location. Thermocouple 194 readings never exceeded 325^{0}F for the duration of the test. Thermocouple no. 206 recorded a temperature in excess of 325^{0}F at 50 minutes and 49 seconds (341.4^{0}F).

8.1.2 Conclusion Regarding Acceptance Criteria No.1

This provides demonstrable evidence that the configuration of Kaowool FP-60 installed in the west cable tunnel protecting the power cable provides at least 30 minutes of fire resistive capability and will maintain the protected cable free of fire damage for that period.

8.2 Test Results for Acceptance Criteria No. 2

Cable damage did occur upon examination of the tested System No. 8 after the hose stream test was performed (Reference 17).

8.2.1 Review of Test Results for Acceptance Criteria No. 2

GL 86-10 states: "...justification should be provided for use of material which does not meet the 325^{0}F criterion. This may be based on an analysis demonstrating that the maximum recorded temperature is sufficiently below the cable insulation ignition temperature." In addition, Supplement 1 recognizes that "Thermosetting electrical conductor insulation materials usually retain their electrical properties under short term exposures as high as 260^{0}C (500^{0}F)"

The tested assembly included one single copper conductor 300 MCM power cable with PVC jacket and XLPE insulation; one seven copper conductor No. 12 AWG control cable with PVC jacket and XLPE insulation; and one two copper conductor No. 16 AWG control cable with PVC jacket and XLPE insulation.

Post-test observations indicated that 80% of the cable bundle was melted and charred, but the 300 MCM cable was almost undamaged. The markedly different performance of the 300 MCM cable and smaller 12 AWG and 16 AWG cable is attributed to the substantially greater thermal inertia of the conductor of the larger cable.

The conductors of the smaller cables were not able to absorb sufficient energy to prevent the jacket from reaching a temperature where damage was sustained. The conductor of the 300 MCM cable had sufficient thermal inertia to absorb the thermal energy entering the jacket and hold the PVC jacket temperature below the temperature at which significant melting could occur and pyrolysis begin. As the 300 MCM cable did not melt and was essentially undamaged, it is believed the PVC jacket temperature remained below its melting point. Based on generic data (Reference 31) it is expected the jacket temperature remained below 350^{0}F.

The installed cable is a 500 MCM triplex cable with approximately twice the thermal inertia of the 300 MCM cable (Reference 28). It is expected that the insulation temperatures of the 500 MCM cable would have been maintained below the 350^{0}F value had the 500 MCM cable been installed in the test specimen. This is substantially below the short circuit rating of the XLPE insulation of the installed cable. Further, this value is below the temperature (392^{0}F) that the jute fibers in the binding tape would begin to decompose releasing combustible gases inside the system (Reference 27). Consequently, cable functionality can be reasonably expected to have been maintained for the entire one-hour period.

The point at which the cable insulation will retain its electrical properties under short-term exposure to elevated conductor temperatures is defined as the short circuit rating of the cable (Reference 23). This short circuit temperature limit has been applied to justify that the cable will remain functional up to the time that this temperature limit was reached. The manufacturer's short circuit rating of the installed Okonite cable is 250^{0}C (482^{0}F).

A review of the temperature data from thermocouples measuring temperatures on the surface of the cable indicates that the tested jacket was not exposed to temperatures of 482^{0}F during the fire exposure test after 52 minutes and 49 seconds.

Even conservatively applying this jacket surface temperature to the entire jacket/insulation (a temperature gradient would be expected between the jacket and insulation as heating is from an external source), cable functionality would

not be jeopardized until after this time as this temperature is below the short circuit rating of the insulation.

The installed configuration may in fact have a fire endurance rating of equal to or greater than one-hour. However, since there is no demonstrable evidence to prove this the fire barrier wrap has been evaluated to provide 52 minutes of fire resistive capability.

8.2.2 Conclusion Regarding Acceptance Criteria No. 2

Applying the criteria provided by the staff in GL 86-10, and Supplement 1, the above cable functionality assessment estimates that the fire barrier wrap will provide 52 minutes of fire resistive capability when exposed to the standard time/temperature fire.

8.3 Test Results for Acceptance Criteria No. 3

The hose stream test met the staff's acceptance criteria since post test observations indicated that the Kaowool product, installed on System No. 8, remained intact with no visible openings through which cable could be seen (Reference 18).

8.3.1 Review of Test Results for Acceptance Criteria No. 3

The hose stream test was performed on Kaowool FP-60 without an outer protective covering of Zetex FP-1000. The configuration installed in the plant uses the Zetex FP-1000 outer protective covering which will provide enhanced impact protection during a hose stream exposure. It is expected that the field installation would perform equal to or better than the tested configuration during a hose stream exposure.

8.3.2 Conclusion Regarding Acceptance Criteria No. 3

It is concluded that the installed configuration meets the staff's acceptance criteria and no further action is required.

9. Unprotected Cable Tray:

The wrapped cable is run in an unprotected open ladder back 30 inch wide cable tray made of galvanized steel. The tray is supported nominally every 4 feet with trapeze type supports wrapped with two inches of Kaowool FP-60. The cable tray runs the entire width of the west cable tunnel (approximately 60 feet).

It is commonly recognized that substantial weakening of structural steel members does not occur until the average temperature within the steel reaches around

1000^{0}F (Reference 27). In the event of an unmitigated fire in the tunnel it is expected that the steel cable tray would potentially be jeopardized during an unsuppressed fire. However, the west cable tunnel is provided with area-wide wet pipe sprinklers and in-tray wet pipe water sprays. The operation of these systems is expected to limit the exposure temperatures to well below the failure temperature of the steel tray thereby limiting the challenge to the cable tray itself.

Conservatively, in the event of cable tray failure, the spacing of the fire wrapped supports is such that the deflection of the wrapped cable would be minimized and it is expected that the fire barrier wrap and the power cable would remain functional.

10. <u>Ampacity Derating:</u>

Internal heating of a fire wrap system, due to ampacity effects can have an adverse affect on system performance by:

1. Internally adding energy to the protected item, decreasing the time at which the critical temperature is reached;
2. Preheating the protected item, such that the pre-fire temperature is initially closer to the critical temperature limit, thereby decreasing the time and energy required for the protected item to sustain damage;
3. Causing the steady state temperature of the cable to be sufficiently high to exceed short term or long term EQ limits

For the case under consideration, preheating of the cable/fire barrier wrap system due to ampacity effects is not a significant consideration. The subject cable is rated for 425 amps when installed in free air (Reference 23). The actual loading on the cable is 43 amps. The power dissipation within the cable is proportional to the square of the amperage consequently the actual energy dissipation requirements are two orders of magnitude below the rated energy dissipation capability.

All energy released in the cable by ampacity effects could be dissipated through the cable insulation and fire wrap system with a cable centerline temperature less than 10^{0}F above ambient (Reference 28).

Similarly, the light amperage loading of the cable significantly decreases the rate of temperature rise of the protected cable due to internal heating. Assuming all energy released in the cable remains in the cable the heat-up rate would less than 5^{0}F during the one-hour fire exposure (Reference 28).

Due to the relatively low amperage (compared to actual cable rating) of the affected cable, the combination of the above two effects is small compared to the allowable increase in cold side temperature allowed by guidance contained in

Generic Letter 86-10. Consequently this would have an insignificant affect on fire wrap system rating and can be neglected.

With respect to the affect on the EQ limits, the 10^0F increase in conductor temperature above ambient conditions is well below the EQ limits of the cable for long term operation. This limit is not challenged similarly the short term operating limits will not be exceeded.

11. Fire Hazards and Other Mitigating Factors:

The equivalent fire severity of the fire zone CT-1 is 61 minutes (Reference 22). The in-situ combustible loading is spread out over 13,400 square feet. The major contributor (over 90%) to the combustible loading in the zone is electrical cable insulation. Other than power cables, there are no significant ignition sources in the fire zone.

The nature and configuration of the in-situ combustibles in the immediate area of the fire barrier wrap and the administrative controls on transient combustibles are expected to limit the fire severity to significantly below 61 minutes.

Transient combustibles are controlled by administrative procedure (Reference 26). This procedure establishes limits on the amounts and location of combustibles. Combustibles are prohibited 5 feet horizontally and 15 feet vertically from cable trays.

Following are the administrative limits for combustibles in the area:

Work site attended at all times:
- 25 pounds ordinary combustibles or plastic
- 15 gallons Class II or III combustible liquids in approved containers
- 16 ounces (one pint) flammable liquids in approved containers
- one 14 ounce aerosol can

Work site not attended at all times:
- 10 pounds ordinary combustibles or plastic
- 15 gallons Class II or III combustible liquids in safety cans
- combustible liquids shall not be unattended more than one shift

Amounts in excess of these established limits are required to be evaluated and to have a combustible control permit.

The west cable tunnel is provided with automatic area-wide early warning smoke detection. The design/installation of the automatic detection system deviates from the guidelines of the codes of record, NFPA-72D, 1979, Proprietary Signaling Systems and NFPA-72E, 1978, Automatic Detectors. Deviations have

been identified, evaluated and resolved (Reference 29). Subsequently, the design/installation of the system meets the intent of the code and there is no adverse impact on the operability of the system.

A postulated fire involving electrical cable insulation is expected to be a slow growing, high smoke generating event. The smoke detection system is expected to alarm during the incipient stages of a fire involving electrical cable insulation. The system will provide an alarm in the Control Room and an operator will be dispatched to investigate the cause of the alarm. Verification of a fire will result in the dispatch of the fire brigade. The brigade is expected to respond to the fire zone within 15 minutes after receiving an alarm.

The tunnel is also provided with an automatic area-wide wet pipe sprinkler system. The sprinkler system utilizes 165^{0}F rated sprinklers and is designed to suppress a floor based transient exposure fire. The sprinkler system meets the design requirements of NFPA-13, 1991, Installation of Sprinkler Systems.

The cable trays are also protected by an in-tray wet pipe water spray system. The in-tray spray system utilizes 135^{0}F directional spray nozzles and is designed to suppress a tray-based fire. The in-tray water spray system meets the design requirements of NFPA-15, 1990, Water Spray Systems.

Application of water on the exterior of the fire barrier wrap as well as the surrounding area will limit the exposure temperature and the challenge to the fire barrier material. The exposure temperatures as a result of a postulated fire are expected to be significantly below those experienced in the standard fire test using the ASTM E-119 time/temperature curve.

Manual suppression is available through the use of installed hose stations and portable fire extinguishers.

Additional data regarding the fire resistive capability of the fire barrier wrap is contained in recent fire test results performed by the industry in an attempt to quantify the fire rating of Kaowool (Reference 30). Those results are consistent with the UL test data described in this evaluation in that the thermal protection provided by both Kaowool (without aluminum foil laminate) and Kaowool FP-60 (with aluminum foil laminate) will prevent cold side temperatures from reaching 325^{0}F for nominally 30 minutes. This is a result of the thermal insulation capabilities of the product and the time required for the thermal wave to propagate through the material when exposed to the standard time/temperature test fire.

12. Fire Scenario:

A fire in this zone is postulated to be a slowly developing cable fire, with possible ignition sources being transient combustibles. Exposure of the protected envelope to fire is possible through the ignition of cable insulation.

If a fire were to occur in the vicinity of the Kaowool FP-60 envelope in this fire zone, indication of the fire would be received in the control room, through the area-wide ionization smoke detection system. If necessary, the fire brigade would be dispatched soon thereafter. Fire brigade response to this fire zone upon receipt of an alarm has been estimated to be within 15 minutes. Manual fire fighting equipment (i.e., fire extinguisher and hose station) is available in this zone.

The fire zone is protected by an area-wide automatic wet pipe sprinkler system designed to suppress a floor based fire and an automatic in-tray wet pipe spray system designed to suppress a tray based fire. The wet pipe sprinkler system uses 165^{0}F sprinklers and the spray system uses 135^{0}F spray nozzles.

With the above considerations, reasonable assurance exists that the Kaowool FP-60 protected cable will remain free from fire damage.

13. Conclusion:

It has been demonstrated by fire test, that the fire barrier wrap of Kaowool FP-60 installed in the west cable tunnel will provide at least 30 minutes of fire resistive capability when exposed to the standard time/temperature curve fire, and will maintain the protected cable free from fire damage for that period.

Evidence is available to demonstrate that the fire barrier wrap will maintain the protected cable free from fire damage for at least 30 minutes. In addition, by applying criteria provided by the staff in Generic Letter 86-10 (Reference 2), and Supplement 1 (Reference 3), a cable functionality assessment of the installed configuration in the west cable tunnel determined that the functionality of the installed cable would not be challenged until the temperature approached 482^{0}F. Review of the test data indicates the maximum measured temperature within the tested configuration did not reach this limit within the first 52 minutes.

Considering that the installed cable is a 500 MCM triplex cable and the tested configuration consisted of a 300 MCM single conductor cable, a seven conductor 12 AWG and a two conductor 16 AWG cable, whose total thermal inertia is approximately one half that of the 500 MCM triplex, it is reasonable to expect that the internal barrier temperatures would remain below the 482^{0}F operating limit for more than one hour.

The installed configuration may in fact have a fire endurance rating of equal to or greater than one-hour. However, since there is insufficient evidence to prove this the fire barrier wrap has been evaluated to provide 52 minutes of fire resistive capability.

The west cable tunnel is provided with fire protection features that will contribute to the early detection and suppression of postulated fires. The nature of the in-situ combustibles and the administrative control of transient combustibles limit the fire hazard in the area of the wrap such that a postulated fire is not expected to challenge the integrity of the fire barrier wrap.

It is expected that the protected cable would remain free from fire damage and would be able to perform its intended design function in the event of a fire in the west cable tunnel and that the ability to achieve and maintain safe shutdown is assured.

14. References:

1. 10 CFR 50 Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979"

2. NRC Generic Letter 86-10, April 24, 1986, "Implementation of Fire Protection Requirements"

3. NRC Generic Letter 86-10, Supplement 1, March 25, 1994, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains Within the Same Fire Area"

4. Thermal Ceramics Fire Test Report 84NK8356, March 22, 1985, "Electrical Circuit Protective Materials"

5. JAF-ANAL-FPS-00636, September 16, 1992, "Fire Barrier Analysis, Thermal Ceramics (Babcock & Wilcox) FP-60 Electrical Circuit Protective System

6. SECY 99-204, August 4, 1999, "Kaowool and FP-60 Fire Barriers"

7. NRC Region 1 Inspection Report 50-333/92-80, April 15 1992

8. NRC Region 1 Inspection Report 50-333/92-14, February 3, 1993

9. Task Interface Agreement (TIA) 96-023, "Response by the Office of Nuclear Reactor Regulation Kaowool Raceway Fire Barriers Joseph M. Farley Nuclear Plant, Units 1 and 2"

10. Letter to James Knubel from Guy Vissing (NRR), September 8, 1999, "Proposed Meeting to Discuss Kaowool Fire Barriers"

11. Memorandum to Paul Brozenich from Jack Balla, October 1, 1999, "Operability Review of Kaowool FP-60 Fire Barrier Wrap"

12. APO-77, Specification for Furnishing and Delivery of 5,000 Volt Power Cable, October, 16, 1970

13. Modification F1-85-065, "Fire Wrapping of Selected Electrical Conduits and Cables, Appendix R"

14. Letter to Charles Chaille (Babcock & Wilcox) from William Bornhoeft (ANI), July 2, 1986 regarding acceptance of Kaowool installation guide for a one-hour rated fire barrier wrap

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18. FAX from Alec Hauser (UL) to Jack Balla (NYPA), January 4, 2000, regarding inspection of Kaowool FP-60 enclosing System No. 8, air-drop after hose stream test.

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20. Factory Mutual Technical Report, "Electrical Cables – Evaluation of Fire Propagation Behavior and Development of Small-Scale Test Protocol, January 1989

21. SFPE Fire Protection Engineering Handbook, 2nd edition

22. JAF Fire Hazard Analysis, Revision 1

23. Okonite Company, Bulletin EHB 81, Engineering Data, Copper and Aluminum Conductor Electrical Cables

24. SWEC Calculation, 14620-08-E-3, Ampacity of 3/C, 500 MCM Stranded Aluminum Cable Wrapped with B&W Kaowool Ceramic Blanket

25. NYPA letter to NRC, Response to 10CFR50.54(f) Request for Additional Information Regarding Fire Barrier Manufactured by Thermal Ceramics, Inc., dated August 27,1993 (JPN-93-064)

26. AP-14.02, Combustible and Flammable Material Control

27. NFPA Fire Protection Handbook, Eighteenth Edition

28. JAF-CALC-FPS-04023, Rev. 1, Calculation of the Affect of Ampacity on Internal Fire Barrier Heating

29. JAF-RPT-FPS-01532, Rev. 10, NFPA Code Conformance Review Project summary of Open Items

30. South Carolina Electric and Gas, V.C. Summer Nuclear Station, TR07870-001, Rev. 0, Kaowool Triple Wrap Raceway Fire Barrier Test for Conduits and Cable Trays, 5/24/2000

31. Lange's Handbook of Chemistry, Twelfth Edition, McGraw-Hill