August 1, 2000

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

FROM: Suzanne C. Black, Deputy Director ***/RA by J. Zwolinski Acting for/***
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: NRR RESPONSE TO TASK INTERFACE AGREEMENT (TIA) 99-028, SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 - RESOLUTION OF PILOT FIRE PROTECTION INSPECTION FIRE BARRIER QUALIFICATION ISSUES (TAC NO. MA7235)

By memorandum dated November 23, 1999 (TIA 99-028; ADAMS Accession Number ML003671052), you requested technical assistance from the Office of Nuclear Reactor Regulation (NRR) regarding two potential issues identified during a pilot fire protection inspection (IP 71111.05) conducted at the Shearon Harris Nuclear Power Plant from November 1 - 5, 1999. The two issues were related to: (1) the fire resistance ratings and qualification testing of Thermo-Lag; and (2) Heymc 1-hour and Promatec “MT” 3-hour fire barrier systems not being qualified to meet safe shutdown separation requirements.

NRR has completed its review of TIA 99-028, as documented in the attached response. For the first issue, the use of Thermo-Lag as a fire barrier separation between Switchgear Room B, Cable Spreading Room A and Cable Spreading Room B, NRR concluded that:

> The licensee has not clearly demonstrated that the as-installed Thermo-Lag fire barriers and associated penetration seals are adequate to withstand the hazards associated with the area(s) to protect important equipment from fire damage. The use of Thermo-Lag in this application appears to conflict with the NRC’s fire protection requirements as specified in GDC 3. The licensee’s evaluation did not provide the staff with an adequate technical basis on which to conclude that the change to the current licensing basis will not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire as required by the plant’s fire protection license condition.

For the second issue, the adequacy of Heymc 1-hour and Promatec “MT” 3-hour fire barrier systems, NRR concluded that:

> 1. The information documented in Final Report CTP 1026 is insufficient to qualify the Hemyc fire barrier system as a 1-hour-rated electrical raceway fire barrier system.
>
> 2. The information documented in Final Report CTP 1100A was acceptable to qualify select “MT” fire barrier systems as 3-hour-rated cable tray fire barrier systems, provided the installed plant configurations were bounded by those used in the testing.

3. The information documented in Final Report CTP 1071 is insufficient to qualify “MT” fire barrier systems as 3-hour-rated conduit fire barrier systems.

NRR is evaluating the potential generic implications of the second issue. No action is required from the licensee at this time, based on this evaluation. If the issue has generic implications, the NRC will address them through the normal processes for generic issues. If the issue has no generic implications, the NRC will pursue appropriate action with the licensee.

This completes NRR’s review of TIA 99-028 and closes TAC No. MA7253.

Docket No. 50-400

Attachment: As stated

cc w/attachments: A. R. Blough, Region I
G. E. Grant, Region III
K. E. Brockman, Region IV

CONTACT: R. Laufer, DLPM/PDII
301-415-1373

3. The information documented in Final Report CTP 1071 is insufficient to qualify "MT" fire barrier systems as 3-hour-rated conduit fire barrier systems.

NRR is evaluating the potential generic implications of the second issue. No action is required from the licensee at this time, based on this evaluation. If the issue has generic implications, the NRC will address them through the normal processes for generic issues. If the issue has no generic implications, the NRC will pursue appropriate action with the licensee.

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Accession Number ML003736721

* no major changes to responses
** see previous concurrence

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OFFICIAL RECORD

RESPONSE TO REGION II TASK INTERFACE AGREEMENT (TIA) 99-028

REVIEW OF FIRE BARRIER QUALIFICATION ISSUES

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

1.0 BACKGROUND

During a pilot fire protection inspection (NRC Inspection Report IP 71111.05), Region II inspectors identified two technical issues associated with the design, installation, and fire-resistive performance of fire barriers installed at the Shearon Harris Nuclear Power Plant (SHNPP). By memorandum dated November 23, 1999, Region II staff submitted TIA 99-028, and requested that the Office of Nuclear Reactor Regulation (NRR) review these issues.

2.0 APPLICABLE REGULATORY DOCUMENTS

Firewalls and Electrical Raceway Fire Barrier Systems (ERFBSs) are installed at SHNPP to protect circuits needed to achieve and maintain post-fire safe shutdown. The licensee installed these fire protection features as a part of the plant's design and licensing basis. The SHNPP construction permit was issued on January 27, 1978. The plant was licensed for commercial operation on January 12, 1987. SHNPP operating license condition 2.F states, "Carolina Power & Light Company shall implement and maintain in effect all provisions of the approved fire protection program as described in the Final Safety Analysis Report (FSAR) for the facility as amended and as approved in the Safety Evaluation Report (SER) dated November 1983 (and Supplements 1 through 4), and the Safety Evaluation dated January 12, 1987, subject to the following provision below. The licensees may make changes to the approved fire protection program without prior approval of the Commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire." The September 13, 1983, Fire Protection SER states, "The Chemical Engineering Branch reviewed the Fire Protection Program through FSAR Amendment 3 for conformance with the Standard Review Plan (NUREG-0800) Section 9.5.1, dated July 1981. This document includes Branch Technical Position (BTP) ASB 9.5-1 and Appendix R to 10 CFR 50. Because the licensee has compared its program to the latter guidelines, our report also references these guidelines." The September 13, 1985 SER states, "The cable spreading room is separated from the balance of the plant by 3-hour-fire-rated walls and floor/ceiling assemblies. All penetrations through fire-rated barriers are fitted with 3-hour-fire-rated dampers and/or 3-hour-rated penetration seals." Similarly, "The Division A and Division B switchgear rooms are separated from each other and from other plant areas by 3-hour-fire-rated walls and floor/ceiling assemblies."

The Standard Review Plan, NUREG-0800, Section 9.5.1, subsection 5, General Plant Guidelines, Safe Shutdown Capability, Position C5.b.1, requires one of the following means of ensuring that one of the redundant trains is free of fire damage:

a. Separation of cables and equipment and associated circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers should be protected to provide fire resistance equivalent to that required of the barrier;

b. Separation of cables and equipment and associated circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area; or

c. Enclosure of cables and equipment and associated circuits of one of the redundant trains in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

These are the same basic requirements as found in Section III.G.2 of Appendix R to 10 CFR Part 50.

3.0 REVIEW OF THERMO-LAG FIRE BARRIERS

3.1 Background

The licensee has installed Thermo-Lag fire barrier wall and ceiling assemblies to satisfy NRC fire protection requirements in the switchgear room “B,” cable spreading room “A,” and cable spreading room “B.” Unlike most Thermo-Lag configurations in the nuclear industry that enclose and protect electrical raceways within a single fire area, the configuration at SHNPP utilizes Thermo-Lag to partition the above compartments into separate fire areas. These barriers were originally installed to provide a fire resistance rating of 3 hours, and this performance expectation is reflected in the licensee’s FSAR and in the NRC’s SER for the plant dated November 1983 (NUREG-1038).

Based on fire testing performed subsequent to the issuance of Generic Letter (GL) 92-08, “Thermo-Lag Fire Barriers,” dated December 17, 1992, the licensee has concluded that the actual rating of the Thermo-Lag wall assemblies is 1 hour and 48 minutes, and that the rating of the Thermo-Lag ceiling assembly is 3 hours. To justify the existing plant configuration, the licensee has performed an evaluation that concluded that the protection provided by the Thermo-Lag fire barrier enclosures will ensure the plant’s ability to achieve and maintain safe shutdown conditions under postulated fire scenarios. The licensee’s evaluation states that the FSAR will be revised to change the rating of the barriers from 3 hours to 1 hour, which is “adequate” for the hazard.

The license condition for SHNPP states that the licensee shall implement and maintain in effect all provisions of the approved fire protection program as described in the FSAR for the facility as amended and as approved in the SER dated November 1983 (and supplements 1 through 4), and the SER dated January 12, 1987. The license condition allows the licensee to make changes to the approved fire protection program without prior approval of the NRC if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

The “current licensing basis” (CLB) for a facility as defined in GL 91-18, Rev. 1, “Information to Licensees Regarding NRC Inspection Manual Section on Resolution of Degraded and Nonconforming Conditions,” dated October 8, 1997, is the set of NRC requirements applicable to a specific plant, and a licensee’s written commitments for assuring compliance with and operation within applicable NRC requirements and in the plant-specific design basis that are docketed and in effect. This includes the plant-specific design basis information defined in the applicable parts of 10 CFR or the FSAR, orders, license conditions, exemptions, technical specifications, as well as licensee commitments documented in NRC safety evaluations or licensee event reports. As noted above, 10 CFR 50.48(a) and (e), General Design Criterion (GDC) 3 of Appendix A to 10 CFR Part 50, the stated license condition, the FSAR and the NRC SERs referenced above constitute the CLB for SHNPP.

The licensee has provided the following documentation for this review; CP&L calculations FP-0109 Rev. O, “Compartment Heat-up Analysis for Cable Spreading and ACP Rooms,” and FP-0110 Rev. O, “Evaluation of Thermo-Lag Fire Barrier Enclosures within the Cable Spreading and ACP Rooms,” and 10 CFR 50.59 Safety Evaluation ESR 95-00620 Rev. 1, Attachments C and D. The fire test reports issued by Omega Point Laboratories (14980-97261, 14980-97668 and 14980-98207) that were used as the basis for the licensee’s evaluation were not provided.

3.2 Discussion

As noted by the licensee, Position C.5.a.(1) (b) of Chemical Engineering Branch (CMEB) 9.5.1 states that fire barriers with a minimum fire resistance rating of 3 hours should be provided to separate redundant divisions or trains of safety-related systems from each other so that both are not subject to damage from a single fire. In addition, Position C.7.c. of CMEB 9.5.1 states that cable spreading rooms should be separated from other cable spreading rooms and other areas of the plant by barriers with a minimum fire rating of 3 hours, and Position C.7.d states that switchgear rooms containing safety-related equipment should be separated from the remainder of the plant by barriers having a minimum fire resistance rating of 3 hours. Therefore, as noted by the licensee, the existing configuration in the cable spreading rooms and switchgear room deviates from the guidance specified in CMEB 9.5.1. GL 86-10, “Implementation of Fire Protection Requirements,” dated April 24, 1986, defines the term “fire area” to mean an area sufficiently bounded to withstand the hazards associated with the area and, as necessary, to protect important equipment within the area from a fire outside the area. The GL also defines the term “free of fire damage” to mean that the structure, system or component is capable of performing its intended function during and after the postulated fire, as needed.

The November 1983 SER states that interior walls and structural components, radiation shielding materials, and soundproofing and interior finishes are noncombustible, or are listed by a nationally recognized testing laboratory such as Factory Mutual (FM) or Underwriters Laboratories (UL), or have a flame-spread, smoke and fuel contribution of 25 or less. This criteria deviates from Position C.5.a.9 of CMEB 9.5.1, which states that interior wall and structural components, thermal insulation materials, radiation shielding materials and sound proofing should be noncombustible. The origin of the performance criteria reflected in the November 1983 SER appears to be Appendix A to APCSB 9.5-1, “Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to July 1, 1976.” The use of this criteria is acceptable if the application for SHNPP was docketed prior to July 1, 1976. Thermo-Lag is classified as a combustible material based on the results of American Society of Testing Materials (ASTM) E-136, “Standard Test Method for Behavior of Material in a Vertical Tube Furnace at 750 C,” tests conducted by the National Institute of Standards and Technology (NIST) for the NRC, which were published in Information Notice (IN) 92-82, “Results of Thermo-Lag 330-1 Combustibility Testing.” Thermo-Lag wall, floor or ceiling assemblies are not listed in either the

UL Fire Resistance Directory or the FM Approval Guide. The flame spread of 5/8-inch Thermo-Lag panels, based on ASTM E-84 “Surface Burning Characteristics of Building Materials,” tests sponsored by the NRC, ranged from 25 for panels without a topcoat to 37 for panels provided with a latex topcoat applied by the manufacturer. This information was provided to licensees in IN 95-32, “Thermo-Lag 330-1 Flame Spread Results,” dated August 10, 1995. The licensee’s evaluation did not address the use of topcoat on the installed barriers, or the conformance or nonconformance of the Thermo-Lag configuration with this aspect of the plant’s CLB reflected in the November 1983 SER.

GDC 3-Fire protection of Appendix A to 10 CFR Part 50 states that noncombustible and heat resistant materials shall be used, whenever practical, throughout the plant. As noted above, Thermo-Lag is classified as a combustible material. Alternative construction materials such as concrete, masonry and gypsum, which are noncombustible, are typically used for fire barriers in nuclear power plants, such as walls, floors, and ceilings, that separate fire areas within the plant. 10 CFR 50.48(a) requires that each plant have a fire protection plan that satisfies GDC 3. The licensee’s evaluation does not address this apparent nonconformance with GDC 3.

Thermo-Lag, when exposed to a fire environment, releases toxic products of combustion (e.g., ammonia and melamine, ref. 12/13/95 Report of Analysis, Examination and Comparison of Fifteen Samples of a Fire Resistive Material) that may be a hazard to plant personnel that are not equipped with self-contained breathing apparatus. The licensee’s evaluation did not evaluate the potential toxic hazard to personnel required to transit or perform actions in the fire area(s) separated from the fire-affected area by Thermo-Lag walls or ceilings. The toxicity concern is only associated with the use of Thermo-Lag in this atypical application to separate fire areas, not where Thermo-Lag raceway barriers are installed to separate redundant divisions or trains within a single fire area. In the latter configuration, the toxic products of combustion generated by the combustion of the Thermo-Lag material will not significantly alter the environmental conditions in the fire-affected area that has become untenable.

The November 1983 SER states that the applicant will provide penetration seals for all penetrations of fire-rated walls or floor/ceiling assemblies. The SER also states that the penetration seals have been subjected to qualification tests using the time-temperature curve specified by ASTM E-119, and meet the acceptance criteria in Section C.5.a.3 of the staff’s guidelines. The licensee’s evaluation states that HVAC ducts, piping, conduit and cable trays passing through the barriers are sealed with penetration seal material. Doors in the enclosures are securely attached to the structure or to the metal framing of the enclosure and are 3-hour-rated doors. The licensee also states that the fire test results demonstrated that the performance of the installed Thermo-Lag barriers would not be reduced by, or limited by, the presence of the through penetrations, which are sealed commensurate with the designs utilized in the test. The licensee’s evaluation does not address the impact, if any, of the Thermo-Lag fire barrier configuration on the performance of the installed penetration seals. Therefore, the performance of the penetration seals installed in the Thermo-Lag barriers has not been demonstrated by the licensee to be equivalent to the fire rating of the barrier in which they are installed, in accordance with the plant’s CLB.

The licensee states in the evaluation that, although the unexposed average surface temperature of the tested wall section exceeded the 250°F increase prescribed by ASTM E-119, the actual function of the installed barriers is to preclude a fire on one side of the barrier from damaging redundant trains of electrical cabling required for safe shutdown located on the unexposed side of the barrier. The licensee references GL 86-10, Supplement (S) 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains Within the Same Fire Area," dated March 25, 1994, as the basis for this statement. While this statement is correct for electrical raceway fire barrier systems, as stated in GL 86-10, S1, it is incorrect for wall and ceiling assemblies that separate fire areas. For ERFBS fire tests, thermocouple instrumentation is placed on the raceway itself to assess the ability of the barrier in maintaining the enclosed component (e.g., cable) free of fire damage. In this configuration, combustible materials are not in direct contact with the surface of the fire barrier assembly. For wall and ceiling assemblies, which are the configuration that is the subject of this evaluation, the purpose of the barrier is to remain intact and prevent the ignition of combustible materials in contact with the unexposed side of the barrier. Hence, the thermocouples are placed directly on the unexposed side of the barrier surface, as was done in the licensee's fire endurance tests. The licensee's evaluation does not address the presence of combustible materials that can be in contact with the barrier surface. The licensee states that a calculation was performed to determine the temperature rise on a tray side rail located a limiting distance of 1 inch from the unexposed surface of both the as-tested and as-installed configurations. The results of this calculation concluded that the maximum expected temperature rise of 187°F is well below the 250°F criteria specified in GL 86-10 S1 for electrical raceway barrier systems. As noted above, the cited performance criteria is not applicable to fire barriers that separate fire areas. Therefore, the use of this performance criteria in determining the ability of the barrier to withstand the hazards within the fire area is inappropriate.

The licensee, in describing the test results that are the basis for the safety evaluation, states that during the fire endurance test of a barrier that is "similar" to the configuration installed at SHNPP, that the recorded temperature on the unexposed side of the barrier was not sufficient to ignite cotton waste after a 3-hour exposure. The licensee states that this provides additional technical basis for the conclusion concerning the acceptability of the fire barrier assembly. The ignition of cotton waste is dependant on both the relative pressure on the interior of the furnace to the exterior of the furnace, and on the unexposed side surface temperature. For example, if the furnace is maintained at a negative or neutral pressure (a common practice) relative to the exterior, then the ignition of cotton waste is unlikely as the predominant air flow will be from the structure housing the furnace into the furnace itself. If the furnace is maintained at a positive pressure (not a common practice due to the potential hazard to laboratory personnel, but typical of actual fire events), then the cotton waste is relatively easy to ignite as the hot gases are forced from the interior of the furnace to the unexposed side of the test assembly. As the licensee did not address the relative pressure of the test furnace to the ambient environment in its evaluation, the significance of the failure to ignite cotton waste in assessing the performance of the barrier assembly could not be determined.

The licensee has included in its evaluation a drawing of the enclosure wall configuration in calculation FP-0110 cited above. This drawing indicates that the wall configuration is not symmetrical and that on one side of the barrier the fastener assemblies used to attach the Thermo-Lag panels have not been provided with trowel-grade Thermo-Lag protection. The calculation notes that for the wall and floor tests, the side of the barrier containing the steel members was exposed to the furnace environment. This is opposite the side with the unprotected fastener assemblies. The licensee's evaluation states that the effect of not protecting the fasteners was evaluated in calculation FP-0110; however, the effect, if any, of not providing trowel-grade material on the exposed fasteners for a fire on the same side as the exposed fasteners was not evaluated. As the barrier was not tested on both sides and the barrier is not symmetrical, the performance of the barrier during a fire exposure on the untested side is indeterminate. A drawing of the ceiling assembly was not included in the evaluation. The symmetry of the ceiling assembly and its potential impact on barrier performance were not assessed by the licensee.

The licensee states in the evaluation that the Individual Plant Examination of External Events (IPEEE) performed for SHNPP calculated the overall core damage frequency (CDF) from a fire originating in the switchgear room to be 4.0E-06 per year, and 5.6 E-08 per year for fires originating in the cable spreading rooms. The licensee’s IPEEE dated June 30, 1995, utilized the Fire-Induced Vulnerability Evaluation (FIVE) methodology developed by the Electric Power Research Institute (EPRI). A CDF for fire involving more than one of the fire areas separated by Thermo-Lag barriers was not calculated by the licensee, as fire propagation between fire areas was screened qualitatively in accordance with the fire compartment interaction analysis provided in the FIVE methodology. Therefore, the risk significance of a potential failure of a fire barrier that could result in fire propagation between different fire areas could not be determined.

The licensee describes the hose stream tests performed on a wall assembly following a 1-hour fire endurance test. The licensee states that the hose stream test procedure was not performed in accordance with the criteria specified in ASTM E-119, “Standard Methods of Fire Tests of Building Construction and Materials,” in that the entire duration of the hose stream test was not conducted immediately following the completion of the fire endurance test. Instead, the test personnel applied the hose stream for 60 seconds immediately following the fire exposure, and then allowed the test assembly to cool for approximately 90 minutes until applying the final 90 seconds of the hose stream test. No technical basis is provided for the licensee’s unique two-stage test procedure. The licensee states in their evaluation that this two-stage test may have been more severe than the test prescribed in ASTM E-119, and therefore satisfied the acceptance criteria prescribed by the standard. The ASTM E-119 standard states that the purpose of the hose stream test is to simulate the effects of cooling, impact and erosion. It is not clear how allowing the test specimen to gradually cool for 90 minutes following the initial hose stream application prior to the final application satisfies the ASTM E-119 criteria. As acknowledged by the licensee, the hose stream test did not follow the established ASTM E-119 protocol; therefore, the results of the hose stream test are indeterminate.

The licensee’s evaluation states that in the plant’s pre-fire plans the fire brigade members are directed to watch for indications of charring or other visible fire-induced degradation of the Thermo-Lag enclosures. Based on this assertion, the licensee concludes that the degradation of the Thermo-Lag barriers will be detected in time for the application of hose streams by the fire brigade prior to the failure of the barrier(s). As noted above, the hose stream test performed on the wall assembly did not follow the established protocol, and is therefore indeterminate. The application of a hose stream by the fire brigade may result in further degradation of the barrier assembly. However, in an actual fire condition, the smoke and heat generated by the burning combustibles located in the compartment, including the Thermo-Lag, will make a visual inspection of the barrier(s) unlikely. Therefore, staff does not concur with the licensee’s assertion concerning the ability of the fire brigade to preclude a failure of the Thermo-Lag barrier(s).

3.3 Conclusion

The licensee has not clearly demonstrated that the as-installed Thermo-Lag fire barriers and associated penetration seals are adequate to withstand the hazards associated with the area(s) to protect important equipment from fire damage. The use of Thermo-Lag in this application appears to conflict with the NRC's fire protection requirements as specified in GDC 3. The licensee's evaluation did not provide the staff with an adequate technical basis on which to conclude that the change to the current licensing basis will not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire as required by the plant's fire protection license condition.

4.0 REVIEW OF "HEMYC" 1-HOUR AND PROMATEC "MT" 3-HOUR RATED ELECTRICAL RACEWAY FIRE BARRIER SYSTEMS (ERFBSs)

4.1 Background

During the November 1999, pilot fire protection inspection at SHNPP, the NRC inspectors requested the fire tests that qualify the 1- and 3-hour rated ERFBSs. The licensee responded that the 1-hour systems are "Hemyc" fire barriers qualified by Promatec Final Report CTP 1026, dated June 1, 1982. The 3-hour systems are "MT" fire barriers qualified by Promatec Final Report CTP 1071 dated January 6, 1986, and CTP 1100A dated June 4, 1986. The licensee acknowledges that the testing was performed to the American Nuclear Insurers (ANI) criterion and not ASTM E 119. This testing criterion relied on low voltage DC current and not temperature rise within the enclosure. The licensee also stated that, "Based on review of the applicable Promatec fire endurance test data, CP&L concluded that a satisfactory basis existed to substantiate use of Hemyc and MT wrap systems to achieve the required 1- or 3-hour level of protection required by paragraph C.5.b of CMEB 9.5.1 (NUREG-0800)." (See CP&L response to Question "GRW 12" from the November 1999, inspection.)

4.2 Discussion

Using cable continuity as an acceptance criteria for ERFBSs is not sufficient to determine that the barriers will ensure the protected cables remain free of fire damage for the required 1- or 3-hour fire rating. The problems and false readings associated with this method of acceptance criteria have been previously discussed in Supplement 1 to GL 86-10, which states "The use of circuit integrity monitoring during the fire endurance test is not a valid method for demonstrating that the protected shutdown circuits are capable of performing their required function during and after the test fire exposure." Region II forwarded the three test reports to NRR for this review. Each of the three Promatec tests have been reviewed by the staff from a technical adequacy standpoint to determine if the tests can support the fire barriers required rating. Limitations and bounding conditions of each test have also been reviewed. The results of this review are listed below for each test.

4.2.1 HEMYC 1-hour test report No. CTP 1026

This test was performed in 1982 at the Central Nuclear de Asco, Tarragona, Spain. The test was authenticated and monitored by Bureau Veritas. This report covered the following tests:

TEST 1

This test contained two 12-inch ladder-back cable trays stacked with 8-inches of air gap between the trays. The top tray had 100% cable fill consisting of one-third 300mcm, one-third 7/C #12AWG and one-third 2/C #16 AWG cables. The lower cable tray had a single layer of cable with the same ratio and types of cable as the top tray. Both cable trays were enclosed in a single, common fire barrier enclosure consisting of a single layer of 1-1/2-inch Kaowool blanket mounted over a steel frame work with minimum 2-inch air gaps. The inside of the Kaowool has a layer of fiberglass cloth, while the outside has a layer of Siltemp fabric. These materials constitute the basic “Hemyc” fire barrier system.

<u>TEST 2</u>

a. This test contained a 12-inch ladder-back cable tray with a single layer cable fill consisting of one-third 300mcm, one-third 7/C #12AWG and one-third 2/C #16 AWG cables. The tray was enclosed in a single, fire barrier enclosure consisting of a single layer of 1-1/2-inch Kaowool blanket mounted over a steel frame work with minimum 2-inch air gaps . The inside of the Kaowool has a layer of fiberglass cloth, while the outside has a layer of Siltemp fabric.

b. Two 4-inch diameter conduits with a 100% cable fill enclosed in a common enclosure.

c. An airdrop cable consisting of approximately 10 cables wrapped with single layer of 1-1/2-inch Cerablanket and Siltemp fabric.

<u>TEST 3</u>

a. This test contained a 12-inch ladder-back cable tray with a 100% cable fill consisting of one-third 300mcm, one-third 7/C #12AWG and one-third 2/C #16 AWG cables. The tray was enclosed in a single, fire barrier enclosure consisting of a single layer of 1-1/2-inch Kaowool blanket mounted over a steel frame work with minimum 2-inch air gaps. The inside of the Kaowool has a layer of fiberglass cloth, while the outside has a layer of Siltemp fabric.

b. A single 4-inch conduit with a 100% cable fill. The fire barrier system consisted of 2-inch Cerablanket and Siltemp fabric. The design was held in place with 3/4-inch standard finger straps.

c. An airdrop cable consisting of approximately 10 cables wrapped with single layer of 1-1/2-inch Cerablanket and Siltemp fabric held in place with clips to a mounting metal bracket the length of the cable.

The “Hemyc” fire barrier systems were installed as discussed in the details of the test report. The NRR staff has reviewed the test report. The following is a list of the staff’s concerns with the test report.

The testing was conducted to ANI/MAERP “Standard Fire Endurance Test Method to Qualify a Protective Envelope for Class 1E Electrical Circuits.” As stated in the “Introduction” to this insurance standard, “In an effort to provide, <u>for insurance purposes only,</u> a reasonable and reliable method of “protecting-in-place” these vital circuits, without limiting our Insureds to conventional methods, and giving them the option of using products/materials not normally seen in this type of application, we have developed this test method.” In the 1980 time frame, the NRC specified ASTM E119 as the testing method as documented in GL 86-10. Testing to the insurance standard and not ASTM E 119 presents the following concerns:

a. ASTM E 119 is specific as to the type of thermocouples used in the testing, specifically fusion-welded No. 18 AWG Chromel-Alumel wire. Review of Final Report CTP 1026 states that they used “Pt., Pt-Rd” thermocouples. (Note: It is assumed that “Pt.” is abbreviated “Platinum” and “Pt-Rd” is Platinum-Rhodium” type thermocouples.) This could affect the time delay and accuracy of the measurement when coupled with protective tubing used to determine the furnace temperature profile.

b. ASTM E 119 requires a minimum of nine thermocouples distributed through the furnace to control the test fire curve. The thermocouples must also be mounted in minimum 12-inch-long protective tubing and distributed throughout the furnace. This is necessary to confirm that the furnace has a uniform heat flux and is exposing all faces of the test article. Test CTP 1026 only used one thermocouple and one “reserve” thermocouple, both of which are located in the back of the furnace to control the furnace test curve. This was done by averaging the reading of the two thermocouples. Without the multiple thermocouples as required by ASTM E 119, the uniform thermal environment used in CTP 1026 test is undetermined, especially in areas such as the front of the furnace (See the test report p. “Anexo 2.1").

c. ASTM E 119 requires the minimum furnace be sized to test a 100-square-foot sample. The furnace used in the test was 1400 x 2200 x 1700mm (4.59 x 7.22 x 5.58 foot). This equates to a 33.14-square foot area. Thus, the catenary furnace used in the testing is a small-scale test furnace, not the full-scale furnace as required by ASTM E 119.

d. ASTM E 119 requires thermocouples located on the cold side surface, measuring at least nine separate points. Test 1 used only 6 thermocouples, Test 2 used 9 thermocouples, and Test 3 used 10 thermocouples. There were not enough thermocouples in the test assemblies to provide a realistic thermal profile of the raceway. The data provided in the test report, Test 1 thermocouples T1 thru T6, all recorded less than the allowable temperature rise (ΔT) of 250^{o}F. This could be expected for the following reasons:

- There were two cable trays inside the fire barrier system with a very heavy cable loading. This acted as a large thermal heat sink for a single fire barrier.

- The test report does not state exactly where the thermocouples were attached. Review of the sketches appear to show the thermocouples on the inside of the cable trays attached to cables. One thermocouple in particular, T5, is buried in the 100% filled tray. Cable insulation is also a good thermal insulator and would provide lower temperatures than if the thermocouple was attached to a metallic raceway.

Test 2 had thermocouples T1,T2, and T3, installed on cables located in the bottom of the tray. These thermocouples exceed the average allowable temperature rise ($\Delta T \leq 250^{o}F$) at approximately 38 minutes. For thermocouples T4, T5, T6, located on cables in the top of the tray, the temperature plot stops at 55 minutes, which corresponds to a ΔT of $250^{o}F$. Thermocouples T4' and T5' located on the inside of the 4-inch conduit pair exceed the allowable ΔT of $250^{o}F$ at approximately 42 minutes. By ASTM E 119 criteria, even though the raceways were tested at their least conservative arrangement, (i.e., from a heat transfer standpoint, the full raceways provided a large thermal mass to absorb energy, reducing the overall recorded temperatures) the test assemblies could still not achieve acceptable temperatures.

In test 3, the single 4-inch conduit exceeded the maximum allowable temperature rise at approximately 42 minutes. The report tries to explain a data recorder problem that involved switching thermocouples. Thermocouples in the 12-inch cable tray all remained below the maximum allowable; however, it is noteworthy that one of the nine thermocouples, #T4, indicated a decrease in temperature between 30 minutes and 55 minutes before rising and falling again at the end of the test. This type of temperature response is not credible based on the fact that the furnace continues to increase temperature as the test progresses. Test 3 also contained an air drop cable. The report states this air drop cable “lost continuity and its insulation.” It is assumed this means that the cable’s insulation failed due to the thermal insult of the furnace and the inability of the fire barrier to protect the cable.

Raceway supports appeared to be beyond the scope for all three of the tests, as the report does not discuss their interface and protection requirements. There were no thermocouples on or near supports to determine their impact on the temperature rise inside the fire barrier systems.

4.2.1.1 Conclusion for 1-hour test CTP 1026

After review of Final Report CTP 1026, the staff determined that the results of the testing are inconclusive to qualify the fire barrier system as a 1-hour rated fire barrier for Appendix R requirements. While some assemblies may appear to meet qualifying temperatures, there is concern as to the size of the furnace, its accuracy, and the type, location and number of thermocouples used both in the furnace and on the test assembly to provide this data. The assemblies were not bounding in the fact that the cable trays were heavily loaded in some cases with a non-realistic arrangement of cable (300 MCM and 16AWG in the same tray). Also, experience has shown that testing large conduits (4-inch) does not bound smaller sizes (less than 4-inch). In fact, the opposite has been demonstrated in numerous fire tests (i.e., small conduits heat up much more rapidly and obtain higher end temperatures than larger conduits with the same fire barrier system). Based solely upon this test report, the fire resistance rating of the Hemyc barriers is indeterminate.

4.2.2 Three-Hour Fire Qualification Test of Promatec ‘MT’ Barrier Wrap System Electrical Cable Tray Circuits Report No. 1100A

This test was performed in 1986, at Southwest Research Institute, San Antonio, Texas. The report covered the following test configurations:

Cable Tray ‘A’: This assembly consisted of a 4-inch by 18-inch cable tray arranged in a “U” shape. One-half was a ladder back, the other half solid back. The cable fill was: 20 300MCM, 36 7/C #12AWG, and 82 2/C #16AWG. This assembly also had an airdrop consisting of 1 300MCM, 2 7/C #12AWG, and 8 2/C #16 AWG. This equates to a 100% visual/50% actual cable fill.

Cable Tray ‘B’: This assembly consisted of a 4-inch by 18-inch cable tray arranged in a “U” shape. One-half was a ladder back, the other half solid back. The cable fill was 8 300MCM, 12 7/C #12AWG, and 16 2/C #16AWG. This equates to a single layer of cable fill.

Cable Trays ‘C’ and ‘D’: This assembly consisted of two cable trays (C & D), both 4-inch by 24-inch cable tray arranged in a “U” shape. One-half of each was a ladder back, the other half solid back. Both cable trays were protected in a common fire barrier enclosure. The cable fill for Tray ‘C’ was 14 300MCM, 18 7/C #12AWG, and 40 2/C #16AWG. This equates to a single layer of cable fill. The cable fill for Tray ‘D’ was 30 300MCM, 48 7/C #12AWG, and 100 2/C #16AWG. This equates to a 100% visual fill.

The “MT” fire barrier systems were installed as described in the test report. The cable tray supports were protected for a minimum 18-inches with a total of 4-inch-thick fire barrier material.

The testing was performed in an acceptable ASTM E 119 furnace.

For acceptance criteria, the test relied upon the ANI continuity criteria and thermocouples attached directly to cable jackets. The report states, “Temperatures of the cable jacket/air interface inside the test assembly are measured with No. 20 B&S gage, type K (Chromel-Alumel) welded thermocouples, held down with glass fiber adhesive tape to prevent direct contact with the internal cable tray surfaces.” The report states that the ambient temperature at the start of the test was 89^{o}F, which yields 414^{o}F as the maximum single point allowable temperature. This is based on the single point maximum rise of 325^{o}F. All the reported temperatures were below this with the solid back tray in cable tray ‘B’ reporting the highest at 334^{o}F. The report does not state any averaging of thermocouples across an assembly as required by ASTM E 119. As previously discussed in this TIA, temperatures measured on cable jackets have minimal value in determining the acceptability of the fire barrier system. However, the report does have some relevant thermocouple data located in the Appendix of the report. The cable trays had “engineering” thermocouples installed on their side rails and one thermocouple installed on the rung under the tray for a total of 16 thermocouples on each tray. Cable Tray ‘A’ highest reading was 361^{o}F (TC E-70) at the end of the test (180 minutes). Cable tray ‘B’ highest reading was 314^{o}F (TC E-86) at the end of the test. Cable tray ‘C’ highest reading was 308^{o}F (TC E-117) at the end of the test. Cable tray ‘D’ highest reading was 362^{o}F (TC E-112) at the end of the test. These were all below the maximum allowable single point temperature of 414^{o}F. A survey of the averages suggests that the maximum average temperature rise was below the 250^{o}F allowable temperature rise (ΔT).

4.2.2.1 Conclusion for 3-hour cable tray test CTP 1100A

Based on this information, this test may be used to qualify the following cable tray configurations protected with the “MT” fire barrier system installed as described in the test report:

1. Steel, solid or ladder-back cable trays with a minimum dimension of 4-inch by 18-inch and a minimum cable mass (weight) equivalent to, or greater than, the mass of 8 300MCM, 12 7/C #12AWG, and 16 2/C #16AWG. The fire barrier system, including the installation techniques, must as a minimum meet the requirements of those described in the test report.

2. Two steel, solid or ladder-back cable trays in a stack with minimum dimensions of 4-inch by 24-inch and a minimum cable mass (weight) equivalent to, or greater than, the mass of 14 300MCM, 18 7/C #12AWG, and 40 2/C #16AWG. The two stacked cable trays are in a common fire barrier enclosure installed to meet the requirements of that described in the test report.

3. Structural steel supports, maximum 1/4" x 2 ½" x 2 ½" and smaller, protected a minimum 18-inches with fire barrier material as described in the report.

4. Cable air drops with a cable mass equal to, or greater than, 1 300MCM, 2 7/C #12AWG, and 8 2/C #16 AWG protected with a fire barrier enclosure that meets the requirements of that described in the test report.

Other cable tray sizes, construction, cable mass, configurations, and components (e.g., tees/ crosses) are not bounded by this test report.

In order to ascertain the acceptability of the plant’s installed configurations, one needs to determine if the 3-hour rated Promatec ‘MT’ ERFBSs installed at SHNPP are within the above parameters.

4.2.3 <u>Three Hour Fire Qualification Test of Promatec ‘MT’ Barrier Wrap System Electrical Conduit Circuits Report No. 1071</u>

This test was performed in 1986, at Southwest Research Institute, San Antonio, Texas. The report covered the following test configurations:

<u>Conduit ‘A’</u>: This assembly consisted of a 4-inch steel conduit arranged in a “U” shape. The cable fill was 3 300MCM, 5 7/C #12 AWG, and 16 2/C #16 AWG, which equates to 100% visual loading.

<u>Conduits ‘B & C’</u>: This assembly consisted of two 4-inch steel conduit arranged in a “U” shape and protected by a single fire barrier. The cable fill for conduit ‘B’ was 3 300MCM, 5 7/C #12 AWG, and 16 2/C #16 AWG, which equates to 100% visual loading. The cable fill for conduit ‘C’ was 1 300MCM, 2 7/C #12 AWG, and 5 2/C #16 AWG, which equates to a light load of one layer of cable.
<u>Conduit ‘D’</u>: This assembly consisted of a 4-inch steel conduit arranged in a tight “U” shape using conduit LB’s to form a tight 90^{o} bend with a 10" x 10" x 24" junction box in the center of the run. The cable fill was 3 300MCM, 5 7/C #12 AWG, and 16 2/C #16 AWG, which equates to 100% visual loading. The fire barrier system was attached to the test deck on one side.

<u>Conduit ‘E’</u>: This assembly consisted of a 4-inch steel conduit arranged in a “U” shape with a conduit “Tee” in the center of the run. An airdrop was attached to this Tee. The cable fill in the

conduit was 2 300MCM, 3 7/C #12 AWG, and 11 2/C #16 AWG. The airdrop consisted of 1 300MCM, 2 7/C #12 AWG, and 5 2/C #16 AWG.

The “MT” fire barrier systems were installed as discussed in the details of the test report. The testing was performed in an acceptable ASTM E 119 furnace.

For acceptance criteria, the test relied upon the ANI continuity criteria and thermocouples attached directly to cable jackets. The report states, “Temperatures of the cable jacket/air interface inside the test assembly are measured with No. 20 B&S gage, type K (Chromel-Alumel) welded thermocouples, held down with glass fiber adhesive tape to prevent direct contact with the internal conduit surfaces.” The report states that the ambient at the start of the test was 89^{o}F, which yields 414^{o}F as the maximum single point allowable temperature. This is based on the single point maximum rise of 325^{o}F. All the reported temperatures with the exception of Conduit B were below this limit. Conduit ‘B’ reported the highest temperature at 428^{o}F. The report does not state any averaging of thermocouples across an assembly. As previously discussed in this TIA response, temperatures measured on cable jackets have minimal value to determining the acceptability of the fire barrier system. The report does have some additional thermocouple data located in the Appendix of the report. However, the thermo junctions of these additional thermocouples were located between layers of the fire barrier material and not on the conduit surfaces. Due to their location, they recorded high temperatures, and the temperature of the conduit was not determined.

The report states that circuit integrity checks were made before and during the test with an intermittent short detected between 175 and 180 minutes. However, as previously discussed, continuity testing is of little value to determine the cables remain free of fire damage. Likewise, the report states that Megger tests were conducted 15 hours after completion of the test, and “Except for the model in Conduit C, all models showed leakage between conductors and to ground. The white wire in Conduit B was shorted to ground.” Again, this is of minimal value since the primary area of concern is determining the cables are free of fire damage during the thermal excursion and not 15 hours after it has ended.

4.2.3.1 Conclusion for 3-hour conduit test CTP 1071

After review of Final Report CTP 1071, it was determined that the results of the testing are inconclusive to qualify the fire barrier system as a 3-hour rated fire barrier for satisfying Appendix R requirements. While the limited thermocouples may appear to meet qualifying temperatures, there is concern as to the type, location and number of these thermocouples used on the test assembly to provide the data. The assemblies were not bounding in the fact that the 4-inch conduits were heavily loaded in some cases with a non-realistic arrangement of cable (300 MCM and 16AWG in the same raceway). Testing heavily loaded raceways (i.e., large mass) does not bound similar raceways with less cable mass. Also, experience has shown that testing large conduits (4-inch) does not bound smaller sizes (less than 4-inch). In fact, the opposite has been demonstrated in numerous fire tests (i.e., small conduits heat up much more rapidly and obtain higher end temperatures than larger conduits with the same fire barrier system). Based solely upon this test report, the fire resistance rating of the 3-hour “MT” conduit fire barriers is indeterminate.

4.2.4 NRC Pilot-Scale Fire Endurance Tests of Fire-Barrier Mats, Blankets, and Panels

In 1994, the NRC conducted a series of small-scale, two-dimensional fire tests on fire barrier materials. The tests were performed as scoping tests to evaluate the generic fire-endurance characteristics of available materials. One test involved Hemyc-style material described as "a ceramic-fiber core within a glass-cloth (SiO_2) pillow case. The thickness of the blanket was nominally 28 mm (1.5 in).

The testing was performed at the National Institute of Standards and Technology (NIST) small scale furnace. One side of the sample was exposed to the furnace environment, the other side was exposed to the open laboratory environment (unexposed side of the barrier). Three thermocouples were placed on the unexposed side of the barrier. The sample was exposed to ASTM E 119, standard time/temperature curve.

4.2.4.1 Conclusion for 1-hour NRC Pilot-Scale Test

For scoping purposes, the ASTM E 119 acceptance criteria were used. The first thermocouple to rise a minimum 250^{o}F occurred at 21.2 minutes into the test. All three thermocouples met or exceeded this value at 23.2 minutes. The maximum single-point temperature rise of 325^{o}F occurred at 24.8 minutes. No flaming or burn through occurred in the sample at 60 minutes.

The pilot-scale test suggested that a thicker layer, or multiple layers, of the material could be used in the construction of a 1-hour-rated ERFBS, provided the appropriate design, engineering and full-scale fire testing was performed.

4.3 SUMMARY

The staff concluded that the information documented in Final Report CTP 1026 is insufficient to qualify the Hemyc fire barrier system as a 1-hour-rated ERFBS.

The staff concluded that the information documented in Final Report CTP 1100A was acceptable to qualify select "MT" fire barrier systems as 3-hour-rated cable tray fire barrier systems, provided the installed plant configurations were bounded by those used in the testing.

The staff concluded that the information documented in Final Report CTP 1071 is insufficient to qualify "MT" fire barrier systems as 3-hour-rated conduit fire barrier systems.