Florida
Power
CORPORATION
Crystal River Unit 3
Docket No. 50-302

May 17, 1995
3F0595-08

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Subject: Response to NRC Staff Questions on Test of Mecatiss Fire Barrier Material in Morestel France, December 1994

Reference: A. FPC to NRC letter, 3F0395-11, dated March 6, 1995
B. NRC to FPC letter, 3N0495-10, dated April 7, 1995

Dear Sir:

Florida Power Corporation (FPC) provided our report of fire endurance tests conducted on barriers constructed of Thermo-lag and a combination of Thermo-Lag and Mecatiss to the NRC Staff for comment (Reference A). The purpose of this letter is to respond to questions on the test report posed by the NRC Staff (Reference B). Our responses to your questions and comments are included in Attachment 1.

In the past month, FPC Fire Protection Engineers have been walking down Crystal River Unit 3 (CR 3) Thermo-Lag fire barriers for the purpose of identifying configurations to be included in upcoming fire endurance tests. We have confirmed a barrier construction detail which may create a barrier failure mode not previously tested. The condition occurs where a non-essential cable, routed in aluminum conduit, enters a protected cable tray. In this case, the conduit would end at, and be attached to, the tray side rail, and the cable would join the other cables in the tray. The construction of a fire barrier around this configuration would consist of a fully enclosed tray with the conduit fully wrapped for 18" away from the tray. Beyond 18" there would be no further protection of the non-essential conduit.

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If this barrier were exposed to an ASTM E-119 fire test, it is probable that the unprotected portion of the conduit would burn through, potentially leaving an open path into the cable tray enclosure. It is expected that a barrier constructed like this would exceed test acceptance criteria sooner than a barrier without the added conduit. FPC is planning to test a barrier modification to eliminate this failure mechanism for CR-3 barriers during our upcoming barrier endurance test program. Existing compensatory measures in place to account for lower than required Thermo-Lag barrier resistance ratings adequately compensate for this additional failure mechanism.

FPC is continuing to develop the details of our Thermo-Lag/Mecatiss barrier test program for fire barrier performance and ampacity derating. Tests will be conducted at Underwriters Laboratory in Chicago. We anticipate testing to commence in late June or early July. Ampacity derating tests will be performed first and barrier performance rating tests shortly thereafter. Barrier performance rating tests will include 'standard' configurations and unique CR-3 configurations. FPC will submit detailed plans, procedures, and schedules to the NRC Staff for information as soon as they are available.

Please contact W. L. Rossfeld at (904) 563-4374 if you have any questions concerning this letter or the attachment.

Sincerely,

Gary Boldt

G. L. Boldt
Vice President
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GLB/SCP:ff

xc: Regional Administrator, Region II
NRR Project Manager
Senior Resident Inspector

Attachment A
Response to NRC Questions on Mecatiss Test Report

General Comments

NRC Question

1. Generic Letter (GL) 86-10, Supplement 1, "Implementation of Fire Protection Requirements," specifies test methods and acceptance criteria for determining the adequacy of fire barrier systems to satisfy NRC fire protection requirements. Alternative test methods and acceptance criteria proposed by licensees to demonstrate an equivalent level of protection will be reviewed by the staff on a case-by-case basis. The test method used for the Mecatiss/Thermo-Lag fire barrier assemblies deviated, in several instances, from the GL guidance and no supporting justification is provided for the deviations. Please provide justification.

FPC Response

The information in this attachment provides justification for deviations from the test methods and acceptance criteria for tests of Mecatiss/Thermo-Lag fire barriers conducted by FPC. FPC has not identified any additional deviations beyond those enumerated by the NRC Staff in the following questions.

NRC Question

2. The GL also states that the fire test specimens should be representative of the construction for which the fire rating is desired as to materials, workmanship, and details such as dimensions of parts, and should be built under representative conditions. The fire test program should bound raceway sizes and the various sizes of horizontal and vertical runs of cable trays, conduits and junction boxes, etc. This information was not included in the submittal. Please provide this information.

FPC Response

The fire barrier test assemblies were constructed at Crystal River Unit 3 (CR-3) using materials, procedures, workmanship, and quality assurance that is representative of the construction of permanent Thermo-Lag barriers in the plant.

The majority of Thermo-Lag material used to construct the test assemblies was from original stock purchased by FPC during 1984/1985 when the in-plant barriers were installed. Approximately 20 feet of pre-formed half-round material rated for 1 hour application was removed from an actual plant installation. This material was carefully removed from its original installed location and used to construct one of the 3/4" test articles. Approximately 18 feet of pre-formed half-round material rated for 3 hour application did not come from our stock, but was obtained from NEI test stock manufactured in 1993. Trowel grade material was purchased from Thermal Science Incorporated current production material since it has a limited shelf life.

The Thermo-Lag barriers were as described in the Final Report, Section 2, "Description of Samples" submitted to the NRC Staff on March 6, 1995. Additional construction details are as follows and are representative of typical CR-3 fire barrier construction. Butt joints used between pre-formed panel sections were pre- and post-buttered with trowel grade material. Radial bends were installed

using the score and fold technique with trowel grade material used to fill these joints to maintain material thickness. Both stainless steel banding material and tie wires were installed to hold the preformed sections together. Their spacing was typical of CR-3 installations. All installations were covered with a layer of trowel grade material to a thickness of 1/8 inch (+/- 1/16), which is typical of CR-3 installations.

The construction of Thermo-Lag test assembly barriers was performed by craftsmen who were part of the original installation crews. The work instructions included Thermal Science Incorporated installation instructions and drawings from the original installation modification package. A current revision of the Florida Power Corporation Maintenance Procedure that was used originally was also employed during test item construction. Attachment of the conduits to unistrut supports was in accordance with typical construction used at CR-3.

The test articles construction and instrumentation was witnessed by FPC Quality Control Inspectors, and by an Underwriters Laboratory staff member. A Quality Control Inspection Plan was included in the work instruction package which implemented the requirements of the FPC Fire Protection Quality Assurance Program.

In consideration of the bounding criteria established in the "NEI Application Guide for Evaluation of Thermo-Lag 330 Fire Barrier Systems," the Thermo-Lag / Mecatiss barrier combinations bound the following additional configurations:

Tested Configuration	Bounded Configurations
3/4" conduit straight section (horizontal & vertical)	3/4" - 6" conduit straight sections (horizontal & vertical)
3/4" conduit radial bend	3/4" - 6" conduit radial bend
3/4" conduit 90° elbow	3/4" - 6" conduit 90° elbow
3/4" - 1.5" ganged conduit straight section (horizontal & vertical	straight sections of ganged conduits with relative diameters in a ratio of 2 to 1 or less and width of conduit array not exceeding 14.5" across* (horizontal & vertical)
3/4" - 1.5" ganged conduit radial bends	radial bends of ganged conduits with relative diameters in a ratio of 2 to 1 or less and width of conduit array not exceeding 14.5" across

* The ganged conduit test configuration contained conduits of 3/4" diameter to 1.5" diameter, a ratio of 2 to 1. 14.5" was the width of the tested conduit array before Thermo-Lag installation. No structural failures of the ganged array were seen, which are common for tray configurations.

Conduct of the Fire Tests

NRC Question

1. The test report states that the ambient temperature at the beginning of the 1 hour test was 45.9°F. ASTM E-119 states that the ambient air temperature at the beginning of the test shall be within the range of 50°F to 90°F. This deviation is expected to affect the test results for assemblies that meet the temperature acceptance criteria with little or no margin. The staff does not consider the 45.9°F temperature representative of ambient conditions at Crystal River.

FPC Response

The ambient temperature at the test facility was slightly below the temperature range specified in part 11 of the ASTM E-119 Standard. The standard states "The ambient air temperature at the beginning of the test shall be within the range of 50°-90°F (10°-32°C)." The range chosen by the ASTM E5 Committee for a starting temperature had no technical basis according to Committee Chairman Howard Grisack.

An initial temperature that is lower than the prescribed temperature creates a more severe test than an initial temperature at the top of the specified range. By starting the test at a temperature below that specified by the standard the test article was actually exposed to greater initial thermal and mechanical stress than it would have if it had been within the prescribed range. The change in temperature is the critical parameter and because the test article was below the prescribed temperature it was actually exposed to a more severe stress than necessary during the first part of the test.

If the test article had contained a large thermal mass, such as high cable loading, then a lower starting temperature could be viewed as non-conservative by providing a heat sink. This was not the case with these test articles. The articles were constructed of aluminum conduit and the conduit contained only one #8 bare copper wire. The thermocouples used to assess test acceptance were on the outside of the conduit surface, thereby monitoring the temperature on the immediate inside of the barrier. The small thermal mass provided by the test articles combined with the lower starting temperature would have only minimal effect on the temperature rise on the inside of the barrier. For the thermal mass represented by the combination of a 3/4" conduit and bare #8 copper wire, the heat required to raise the thermal mass 4.1°F is approximately 0.6 BTU per foot of test article. This is insignificant when compared to the heat flux within the furnace.

The ambient temperature at the test site is not representative of the ambient temperature where Thermo-Lag barriers are installed at CR-3. However, there is no requirement in Generic Letter 86-10 Supplement 1 or ASTM E-119 to relate standard test conditions to local conditions. For the reasons stated in the preceding paragraphs, FPC considers the conditions of the test to be sufficiently equivalent to the standard conditions to be acceptable. FPC therefore requests a deviation from the requirement of the standard for the temperature at the beginning of the test to be between 50°F and 90°F, and requests acceptance of the ambient conditions as measured.

NRC Question

2. The test report states that the furnace pressure is controlled by manifold openings to achieve a slightly negative pressure with respect to atmospheric. This is in accordance with the criteria contained in ASTM E-119. The 1-hour test was conducted with the furnace maintained at a negative pressure with respect to ambient of approximately 16 pascal (.06" water), while the 3-hour test was conducted with the furnace at a negative pressure with respect to ambient of approximately 40 pascal (.16" water). A discussion of the reason for the difference in furnace pressures and any corresponding effects on the fire endurance of tested assemblies should be provided to the staff.

FPC Response

The requirement to control furnace pressure to achieve a slightly negative value with respect to ambient, was included in the test specification, in accordance with Section 2.4 and G-6.3 of NFPA 251, to provide assurance that there would be no air leakage, and hence, flame out of the furnace chamber during the test. Also in accordance with NFPA 251, no specific value of pressure was assigned. Thus , the fact that the pressure was negative in both cases met the test specification requirement that assured there would be no leakage from the furnace.

As a result of discussions with meteorologists at the National Weather Service, it is considered reasonable in their view that the difference in ambient temperatures between the two days, 52.7°F for the 3-hour test and 45.9°F for the 1-hour test, and the atmospheric pressure difference caused by the local weather system, would be responsible for the difference in furnace pressure consistent with the reported magnitude. The average difference of -36.58 Pa during the 3-hour test and -14.71 Pa during the 1-hour test, amounts to an actual pressure differential of less than 5 parts in ten-thousand, which FPC considers insignificant.

Having reviewed the affects with the project consultant from Underwriters Laboratory, of the difference in furnace pressure on the fire endurance of the tested assemblies, it is their opinion that there would be no significant effects because the test articles were completely sealed, with respect to the environment, and did, in fact, represent a closed system. Thus, pressure would not be a forcing function that could drive the furnace environment either into or out of the test article, and therefore, would have no impact.

Therefore, FPC considers the furnace pressure differentials observed between the 1-hour and 3-hour tests had no effect on the performance of the fire barrier systems being tested.

Fire Test Furnace

NRC Question

1. The details of the test furnace were not provided in the report submitted for staff review. The report references Mecatiss Test Report of MPF-180 Fire Barrier System Qualification, "Three Hour Test of MPF-180" Report No. 94 ED 0074, dated December 6, 1994; however, this was not submitted. Information on furnace dimensions, and the type of materials used in the construction of furnaces used for the qualification of fire barriers, should be provided to the staff.

FPC Response

The furnace is contained in a cinder block building with overall dimensions of 18′ X 17′ X 30′ (length X width X height). Also enclosed in this building is the furnace control and instrumentation room and propane fuel bottle storage area. The outside dimensions of the furnace are approximately 9.8′ X 4.6′ X 5.4′ and is constructed of reinforced steel plate. The inside furnace walls are insulated with a 6" thickness of ceramic wool. Test articles are constructed in a 'u' shape and are mounted through a steel deck that becomes the top of the furnace. The underside of the top deck of the furnace is insulated with 10" of ceramic wool. The inside cavity of the furnace measures 8.5′ X 3.6′ X 4.7′. Thermocouple leads for the test specimens are threaded out through the top of the test article.

NRC Question

2. The details concerning the burners used in the test furnace was not submitted for staff review. Information on type of burners used, number and location of burners, type of fuel used and rating of the burners should be provided to the staff.

FPC Response

There are three burners in the furnace located 1.6′ above the floor of the furnace at 1.5′, 4.3′, and 7.1′ from the front wall of the furnace. Burners are located at the wall on one side of the furnace along the longest dimension. Burners are controlled by individual flow control valves and are fitted with automatic safety shutoffs. Burners use electric ignition to ignite the propane gas. The gas supply bottles are mounted on a scale, and flow from the bottles can be measured by weighing the bottles during the test. For these tests gas consumption was measured at 10, 20, and 30 minutes and at each 30 minute interval thereafter.

NRC Question

3. The thermocouple instrumentation of the test furnace for monitoring the furnace temperature for the control of the furnace burners does not appear to be in accordance with the criteria contained in ASTM E-119/NFPA 251. The ASTM E-119/NFPA 251 standard requires a minimum of nine thermocouples symmetrically distributed to indicate the temperature near all parts of the sample. Only four "NFPA 251" thermocouples were installed and these were used for data only. An evaluation of the four thermocouples' adequacy to monitor furnace temperature uniformly across the sample should be provided to the staff.

FPC Response

It is understood that the Standard requires 9 thermocouples "symmetrically disposed and distributed to show the temperature near all parts of the sample." The Standard also requires that the temperature be fixed by the curve deemed to be the average of these thermocouple readings. Section 2-2.1, and g-6.1 of NFPA 251 further states that "no uniformity of the temperatures within the fire chamber is specified." Within the physical constraints imposed by the small furnace volume, the furnace temperature thermocouples were symmetrically disposed and distributed specifically for the purpose of obtaining a truly representative average of the furnace environment.

In large scale tests of floors, walls, and columns test assemblies must be at least 8 feet in size and have 180 square feet of exposed surface area. To accommodate such large structural assemblies very large furnaces are required. Typical furnaces with large internal volumes such as those seen at UL and Lawrence Livermore have a thermocouple to volume ratio of around one TC for each 160 to 360 cu. ft. of furnace volume. The test furnace at Morestel, because it was smaller in size had a ratio of one TC for about 39 cu. ft. of furnace volume.

Based on facility drawings contained in test reports for fire endurance tests conducted a the Omega Point Laboratory facility in Texas for NEI, the estimated volume of the furnace is approximately 550 ft^3. The criteria that at least nine thermocouples be used for furnace average temperature results in an average thermal volume sensed, per thermocouple, of approximately 61 ft^3. The volume of the furnace used for the subject tests at Mecatiss is approximately 154 ft^3. Therefore on the basis that one thermocouple has been shown to adequately and acceptably sense the thermal environment of 61 ft^3, the Mecatiss furnace would require no more than three thermocouples. In the interest of conservatism, four thermocouples, each sensing a thermal volume of slightly less than 39 ft^3 were deemed sufficient to adequately monitor furnace average temperature uniformly across the test sample, in accordance with the intent of the referenced standards. Therefore it can be concluded that an accurate measurement of temperature distribution within the furnace was maintained at Morestel with only four thermocouples.

Fire Exposure

NRC Question

1. Both the 1-hour and 3-hour exposures appear to be outside the acceptable limits specified in ASTM E-119/NFPA 251. The furnace temperature readings for both the 1-hour and 3-hour tests, as measured by the "NFPA 251" thermocouples provided by Underwriters Laboratories, are below the standard time-temperature curve for the entire duration of both tests. For the 1-hour exposure, the area under the curve as measured by the "NFPA 251" thermocouples should be within 10% of the corresponding area under the standard time-temperature curve. However, furnace temperatures, as measured by the "NFPA 251" thermocouples, during the first 10 minutes of the exposure are 72% less than the standard time-temperature curve. The difference is within 10% midway through the exposure period and within 5% at the end of the 1-hour test. For the 3-hour exposure, the area under the curve should be within 5% of the corresponding area under the standard time-temperature curve. However, furnace temperatures during the first 10 minutes of exposure are 39% less than the standard curve. The difference is 4% midway through the exposure and 5% at the end of the 3-hour test. The staff considers these deviations to be significant in evaluating the relative performance of fire barrier assemblies.

FPC Response

It is recognized that there is a difference in both construction and thermal characteristics between thermocouples (TC's) made in accordance with ASTM E-119 / NFPA 251 (NFPA 251 TC's) versus those used to measure furnace temperature during the French Mecatiss tests. The TC's used in the French Mecatiss tests were fabricated in accordance with the ISO-834 standard (ISO TC's.) NFPA 251 TC's are made of heavier gage wire, encapsulated in a ceramic insulated stainless steel tube, and have a time constant of from 5 to 7.2 minutes. They are considered acceptable to accurately measure radiant heat within a test furnace. ISO TC's are made of lighter gage wire, sealed in small diameter tubing without thermal insulation, and respond quickly to temperature changes. These are well suited to measure flame temperature in a test furnace. These TC's allowed for virtually instantaneous control of the furnace temperature, should the temperature exhibit a runaway condition due to the heat load presented by a mass of uncovered Thermo-Lag material. Understanding the differences between the two TC types and recognizing the overriding need to maintain a safe test condition, it was decided to use the ISO TC's to control the test environment, and use the NFPA 251 TC's as both a backup and for comparison purposes.

The most significant differences in temperature readings between the two types of TC's occurs during the early stages of the fire test, with the ISO TC's reading somewhat higher than the NFPA 251 TC's. With these concerns in mind the project consultant from UL was contacted to determine the impact on the test program from using the faster response ISO TC's backed up by the NFPA 251 TC's with their 5-7 minute response time.

In the opinion of the UL representative, although the NFPA 251 TC's were required by the test standard, where a real concern existed with safe operation and control of the furnace, it should be considered acceptable to use the ISO TC's to determine furnace temperature. This would acceptable as long as the test were continued beyond the minimum time period to account for differences in time response. By exposing the samples to a longer period at measurably higher

temperatures, the concern would be alleviated that true radiant heat was not being measured by the ISO TC's. Furthermore, by monitoring both types of TC's an accurate determination of the differences in time response between them could be determined. Once the time response difference had been determined, that value could be used to offset the temperature curve controlled by the ISO TC's, by the measured difference, to assure a correct exposure of the test articles.

It was suggested by the UL representative and accepted that several (four) NFPA 251 TC's be included in the test to determine exactly how much difference existed between the two types of TC's and what effect the difference in time response would have on the area under the time-temperature curve.

Prior to using these thermocouples in the test furnace, a pre-test burn in a calibration furnace was performed for both types of TC's (8 ISO TC's and 4 NFPA 251 TC's.) This test was used to make a comparison of performance and determine their relative time response. The results of this pre-test shows agreement occurs between the two TC types in about 30 minutes. Specifically, after 30 minutes of test time, at an overall temperature of 843.5°C, the standard deviation for all 12 TC's was 7.01°F. By the end of the test, 120 minutes later, at an average temperature of 1027°C, the standard deviation had decreased to just 3.58°F. The data from this test also confirmed the difference in time response to be within the 5 to 7 minute range.

Part of the data reduction process included a determination of the point in time when the test was considered to have started and ended. Briefly stated, the start time was determined to be that point at which the furnace temperature significantly increased from ambient, and the end time was selected as that point at which the interior furnace temperature showed a significant decrease from it's operating temperature. On this basis the 1-hour test duration was 70 minutes and the 3-hour test duration was 191 minutes. These times are sufficient to allow for the furnace time-temperature curve to be defined on the basis of the 4 NFPA 251 TC's, even with the 5 to 7 minute difference in time response while still providing a margin of conservatism.

Re-plotting the time-temperature curves to include a six minute delay results in the 1-hour curve being more severe than the standard E-119 curve. Re-plotting the area under the curve yields an area that is 17% greater than the standard at the beginning of the test and to within 5.5% for the remaining 64 minutes of exposure. Similarly, the 3-hour curve was more severe than the standard, with the area under it likewise considered conservative by being nearly 12% greater than the standard at the beginning and within 3-1/2% throughout the remaining 185 minutes of exposure. Both cases are therefore conservative with respect to the ASTM E-119 / NFPA 251 acceptance limits.

Discussion with ASTM E-5 Chairman Howard Grisack on this matter pointed out that the fire exposure that the test specimen is subjected to is represented by the total area under the fire test curve during the time period specified. Points along the curve before and after the period specified are to be used as exposure guidelines and not as absolute benchmark. Thus on the basis of the above discussions, the relative performance of the Mecatiss covered Thermo-Lag fire barriers should be considered acceptable.

FPC requests that the use of the ISO TC's for furnace temperature measurement be approved for this test. We also request that the time-temperature profile corrected for ISO TC time response be accepted as equivalent to the exposure specified by ASTM E-119.

Results

NRC Question

1. The 3-hour test of the 3/4-inch conduit with a Thermo-Lag and Mecatiss fire barrier system exceeded the maximum allowable average temperature criteria specified in Supplement 1 to Generic Letter 86-10. Licensees that intend to use fire endurance test results that deviate from the acceptance criteria as the bases for qualifying and installing fire barrier configurations, should request a deviation from the acceptance criteria based on an engineering evaluation acceptable to the staff, such as demonstration of cable functionality.

FPC Response

The average of thermocouple readings on the exterior of the 3/4" conduit protected with Thermo-Lag and Mecatiss exceeded the Generic Letter 86-10 Supplement 1 acceptance criteria at 2 hours 56 minutes into the test, based on the curve corrected to the NFPA 251 thermocouple readings. At the conclusion of the test at 3 hours 3-1/2 minutes the average temperature had exceeded the acceptance criteria by only 8°F. The single thermocouple acceptance criteria was not exceeded within 3 hours of exposure. The thermocouple readings on the bare copper conductor inside the 3/4" conduit never exceeded the average temperature criterion or the single thermocouple criterion during the entire test period of over 3 hours. This is indicative of the difference in conditions to which the protected cable would actually be exposed, as opposed to the more conservative measurement on the exterior surface of the conduit.

The cable used for instrumentation, control, and power circuits for safe shutdown equipment at CR-3 is IEEE-383 cable qualified to remain free of insulation damage to 700°F. Based on the protection demonstrated by the combination of Thermo-Lag and Mecatiss on the individually wrapped 3/4" conduit in the 3-hour test, and the specific cable used at CR-3, FPC believes that this combination is a viable 3-hour rated barrier system for CR-3 applications. FPC requests a deviation from the Generic Letter 86-10 Supplement 1 acceptance criteria for average thermocouple readings on the exterior of a protected conduit for this test, and requests that this test be accepted as demonstration of a 3-hour rated barrier system for a 3/4" aluminum conduit.