CP&L
A Progress Energy Company

AUG 2 1 2001

SERIAL: HNP-01-123

United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
ADDITIONAL FIRE BARRIER EVALUATION

Dear Sir or Madam:

A conference call was held between personnel at NRC NRR, Region II, and the Harris Nuclear Plant on May 10, 2001 to discuss the Unresolved Item associated with the Thermo-Lag fire barriers in the Cable Spreading and Auxiliary Control Panel rooms. During this call, HNP provided additional clarification related to the position that the fire barrier configurations meets the original intent of the three hour fire barrier design requirements based on withstanding 1.8 hours of ASTM E119 fire exposure, and through additional engineering analysis of the as-installed configurations (fire barrier plus a 1" air gap between the fire barrier surface and cable tray). The NRC stated that this combined approach of testing and engineering analysis to meet the three-hour requirement for a fire barrier design had not been clearly understood in previous transmittals of information and would require further evaluation by the NRC. In order to support the additional evaluation, the NRC requested the following additional information:

- Provide an engineering evaluation to address the structural differences between the tested configuration and the as-install configuration, specifically for 1) the angle iron size differences, 2) the difference in panel spans, and 3) penetration seal configurations.
- Provide an engineering evaluation to address the cooling effects on the metal structures from the hose stream application.
- Address where the as-installed configurations are bounded by the FP&L tests and provide an analysis for any deviations.

HNP has completed the additional evaluation requested above and a copy is included as Enclosure 1 of this letter. This evaluation provides justification to support the following conclusions:

1. The difference in steel sizes and number of penetration seal openings between the one-hour and three-hour test assemblies do not have an adverse effect on the overall fire barrier performance and does not prevent these tests from being considered duplicate test assemblies for hose stream testing purposes.

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2. The analysis also identifies that the panel spans for the three-hour fire test are bounded by the one-hour fire test and therefore the hose stream test would be applicable for both configurations. It should be noted that this evaluation concluded that the panel spans are different and greater than those mentioned in the NRC TIA Response dated February 26, 2001.
3. The difference in steel thickness of 3/8" vs. 1/4" between the one-hour and three-hour test assemblies was evaluated and identified that a slightly higher temperature profile (less than 40°F increase) occurred in the three hour test using the 1/4" steel as would be expected. However, the maximum steel temperatures at the one-hour point still only reached 250°F (three hour test assembly). Therefore, based on the overall low steel temperatures experienced for each test assembly at the one-hour point, even if the framework for the one-hour test had been constructed using 1/4" thick steel instead of the 3/8" thick steel, no significant differences in the cooling effects on the steel members would be anticipated from the hose stream application.
4. A list of the pertinent attributes was generated for the FP&L test assembly and was compared to the as-installed HNP configurations. Only minor deviations were identified and these differences were evaluated and found acceptable as part of this analysis.

In addition to providing this engineering evaluation, HNP also identified in the conference call that a FSAR change package would be generated to better clarify that credit is being taken for both the fire testing and engineering analysis to conclude that the barrier meets the original intent of the three hour fire barrier design requirements.

Your cooperation in this important matter is appreciated.

Sincerely,

R. J. Field
Manager, regulatory Affairs
Harris Nuclear Plant

MSE/mse

Enclosures:
1. Engineer Analysis HNP-M/MECH-1065

c: Mr. J. B. Brady, NRC Sr. Resident Inspector
Mr. R. J. Laufer, NRC Project Manager
Mr. L. A. Reyes, NRC Regional Administrator

ENCLOSURE 1 TO SERIAL: HNP-01-123

SHEARON HARRIS NUCLEAR POWER PLANT
NRC DOCKET NO. 50-400/LICENSE NO. NPF-63
ADDITIONAL FIRE BARRIER EVALUATION

ASSESSMENT OF TESTED AND AS-BUILT THERMO-LAG FIRE BARRIER CONFIGURATIONS

SYSTEM FILE NO.# 6175

CALC. TYPE DA

CATEGORY CODE B

CAROLINA POWER & LIGHT COMPANY

HNP-M/MECH-1065

(CALCULATION #)

FOR

ASSESSMENT OF TESTED AND AS-BUILT THERMO-LAG FIRE BARRIER CONFIGURATIONS

(TITLE INCLUDING STRUCTURE/SYSTEM/COMPONENT)

FOR

SHEARON HARRIS NUCLEAR POWER PLANT

NUCLEAR ENGINEERING DEPARTMENT

QUALITY CLASS: ☐ A ☐ B ☐ C ☒ D ☐ E

REV NO	RESPONSIBLE ENGINEER DATE	☒ DESIGN VERIFIED BY ☐ ENGINEERING REVIEW BY DATE	APPROVED BY RESPONSIBLE SUPERVISOR DATE
0	Steve Hardy STEVE HARDY 8/15/01	David E. McAfee DAVID E. McAFEE 08/17/2001	Eric McCartney Eric McCartney 8/17/01
REASON FOR CHANGE:			
REASON FOR CHANGE:			

LIST OF EFFECTIVE PAGES

PAGE	REV	PAGE	REV	ATTACHMENTS	
1-26	0			Number Rev	Number of Pages
				1, Rev. 0	1
				2, Rev. 0	1
				3, Rev. 0	1
				4, Rev. 0	3
				5, Rev. 0	1
				AMENDMENTS	
				Letter Rev	Number of Pages

TABLE OF CONTENTS

PURPOSE

The purpose of this evaluation is to provide additional technical basis to address comments raised by the NRC staff related to Thermo-Lag® 330-1 fire barriers forming fire area boundaries within the HNP Cable Spreading Rooms (CSR's) A & B and the Auxiliary Control Panel (ACP) Room. These comments are identified in the Supplemental NRR Response to Task Interface Agreement (TIA) 2000-16, dated February 26, 2001 (Ref. 3.1).

Specifically, this evaluation will:

- Demonstrate that the 1-hour rated Thermo-Lag wall fire barrier assembly qualified under Omega Point Laboratories (OPL) Project No. 14980-97261 (Ref. 3.2) can be considered a "duplicate specimen" in accordance with ASTM E119-88, to the Thermo-Lag wall fire barrier assembly subjected to a 3-hour fire endurance test under OPL Project No. 14980-98207 (Ref. 3.3). This will establish the basis for not performing a hose stream test for the wall assembly following the 3 hour fire test exposure.

- Demonstrate that the external means of support added during fire test exposure of a Thermo-Lag ceiling fire barrier assembly to mitigate deflection effects does not invalidate its qualification as a 3-hour rated barrier in accordance with ASTM E119 under OPL Project No. 14980-97668 (Ref. 3.4). Additionally, a rationale will be presented to demonstrate why performance of a hose stream test for the ceiling assembly was not required.

- Finally, although not specifically addressed as a comment by TIA 2000-16, this evaluation will demonstrate that the tested fire barrier assemblies described above fully bound the as-installed Thermo-Lag fire barrier configurations at HNP.

BACKGROUND

ESR 95-00620 (Ref. 3.5) documented a detailed review of Thermo-Lag® 330-1 fire barriers forming fire area boundaries within the HNP CSR's A & B and the ACP Room. ESR 95-00620 and its supporting analyses (Ref. 3.6, 3.7) concluded that although portions of these fire barriers are not qualified for a full 3-hour rating in accordance with ASTM E119-88 (Ref. 3.8), the as-installed fire barrier configurations are qualified to withstand 1.8 hours of ASTM E119 fire exposure, and through additional engineering analysis have been demonstrated to meet the original intent of the fire barrier design requirements. Therefore through fire testing and engineering analysis, the as-installed fire barrier configurations have been demonstrated to be capable of withstanding postulated fire scenarios thus ensuring the plant's ability to achieve and maintain safe shutdown conditions.

As detailed by ESR 95-00620, three (3) full-scale fire endurance tests, partially sponsored by CP&L, were used to assess the performance capability of the as-installed Thermo-Lag fire barriers at HNP. These fire endurance tests were performed in accordance with ASTM

E119 / NFPA 251 by OPL in San Antonio, Texas between September 1994 and April 1995. OPL is an independent and nationally recognized testing organization, specializing in the conduct of fire endurance testing. The objective and a brief summary of each test are provided in Attachment 4.

3.0 REFERENCES

3.1 Memorandum to Loren R. Pilsco, Director, Division of Reactor Projects Region II from Suzanne C. Black, Deputy Director, Division of Licensing Project Management, Office of Nuclear Reactor Regulation, "Supplemental NRR Response to Task Interface Agreement (TIA) 2000-16, Shearon Harris Nuclear Power Plant, Unit 1-Review of Fire Test Reports Provided by Licensee for Resolution of Fire Protection Inspection Fire Barrier Qualification Issues (TAC No. MB0056) dated February 26, 2001.

3.2 Omega Point Laboratories Project No. 14980-97261, "Fire Endurance Test of a Wall Assembly Clad with Thermo-Lag 330-1," dated November 7, 1994.

3.3 Omega Point Laboratories Project No. 14980-98207, "Fire Endurance Test of a Wall Assembly Clad with Thermo-Lag 330-1," dated May 23, 1995.

3.4 Omega Point Laboratories Project No. 14980-97668, "Fire Endurance Test of a Ceiling Assembly Clad with Thermo-Lag 330-1," dated May 18, 1995.

3.5 Engineering Service Request (ESR) 95-00620, "Evaluation of Area Enclosures Cable Spreading Rooms/Aux. Control Panel Room."

3.6 CP&L Calculation FP-0109, "Compartment Heat-Up Analysis for Cable Spreading and ACP Rooms," Rev. 0.

3.7 CP&L Calculation FP-0110, "Evaluation of Thermo-Lag Fire Barrier Enclosures Within the Cable Spreading and ACP Rooms," Rev. 0

3.8 ASTM E119-88 / NFPA 251, "Standard Methods of Fire Tests of Building Construction and Materials."

3.9 ASTM E814-81 "Standard Test Method for Fire Tests of Through-Penetration Fire Stops."

3.10 SFPE Handbook of Fire Protection Engineering, 2nd Edition, Chapter 4-9.

3.11 Southwest Research Institute Project No. 01-7900-016a, "Final Report CTP 1063, Three Hour Fire Qualification Test Promatec Formulated Products LDSE, HDSE, Radflex B for Electrical and Mechanical Penetration Seals," dated January 21, 1985.

3.12 Engineering Service Request (ESR) 95-00715, "Thermo-Lag Penetrations Upgrade."

3.13 "Steel Structures, Design and Behavior," C. G. Salmon and J. E. Johnson, 2nd Edition.

3.14 NFPA 252, "Fire Tests Door Assemblies," 1976 Edition.

3.15 Ebasco Specification CAR-SH-AS-54, "Fire and Control Doors and Hardware."

3.16 FPT-3500, "Fire Door Check, Daily Interval."

3.17 FPT-3505, "Fire Door Inspection RAB, Semi-Annual Interval."

3.18 ESR 94-00379, "As-Built Thermo-Lag Thickness Verification."

4.0 BODY OF CALCULATION

4.1 Methodology

This analysis is structured into three (3) sections as follows:

- A "Duplicate Specimen Matrix" will be compiled to list the pertinent attributes associated with the two (2) wall assembly fire endurance tests under review. This matrix and the accompanying evaluations referenced therein will provide the technical bases to establish that the 1-hour wall assembly (referred to as the "FPL Test") can be considered a duplicate specimen to the 3-hour wall assembly (referred to as the "CP&L Test") in accordance with ASTM E119.
- An "As-Tested to As-Installed Matrix" will be compiled to compare the pertinent attributes associated with the as-tested and as-installed wall fire barrier assemblies. This matrix and the accompanying evaluations referenced therein will provide the technical bases to demonstrate that the as-tested wall assembly configurations bound those of the as-installed HNP configurations.
- The technical bases for the acceptability of using an external support means to mitigate deflection effects during the 3-hour ceiling fire barrier assembly test will be presented. Finally, a rationale will be provided to demonstrate why performance of a hose stream test for the ceiling fire barrier assembly should not be required.

4.2 Duplicate Specimen Matrix

The following is a general comparison of the pertinent attributes associated with the fire endurance assemblies:

Attribute	1-Hour (FPL) Test	3-Hour (CP&L) Test	Duplicate Specimen Rationale
Steel Member Size (as related to hose stream impact and erosion effects)	3" x 3" x 3/8" Angle	3" x 3" x 1/4" 3" x 3" 3/8" (Edge Frame Only)	Equivalency Established See Section 4.2.1
Steel Member Temperature (as related to hose stream test cooling effects)	230ºF (153ºF single maximum point increase)	250ºF (190ºF single maximum point increase)	Equivalency Established See Section 4.2.2
Maximum Unsupported Panel Span / Overall Unsupported Panel Area	70" Vertical 40" Horizontal 19.4 sq. ft.	69" vertical 39" horizontal 18.7 sq. ft.	Equivalency Established See Section 4.2.3
Penetrations	(1) 24" x 24" Steel Blockout	(2) 24" x 24" Steel Blockouts	Equivalency Established See Section 4.2.4
Assembly Size	10' x 10'	10' x 10'	Equivalent
Thermo-Lag Fire Barrier Design	See Section 4.2.5	See Section 4.2.5	Equivalency Established See Section 4.2.5
Fire Exposure Side	Supporting Steel Side	Supporting Steel Side	Equivalent
Temperature Measurement Location	See Section 4.2.6	See Section 4.2.6	Equivalency Established See Section 4.2.6

4.2.1 Tested Steel Member Sizes (as related to hose stream impact and erosion effects)

As described in Attachment 4, the ASTM E119 requirements for a 2-1/2 minute (continuous) hose stream test duration for a duplicate test specimen were misinterpreted and the hose stream test for the 1-hour FPL wall assembly was administered in two stages. Specifically, immediately following the fire endurance portion of the test, the wall assembly was subjected to a hose stream test exposure for a 1-minute duration. After approximately 90 minutes, a second hose stream exposure was applied for a 1-1/2 minute duration, thus satisfying the ASTM E119 requirement for a total 2-1/2 minute hose stream test duration for a duplicate specimen of an assembly subjected to a 3-hour fire endurance test. Due to its nature, upon exposure to heat Thermo-Lag 330-1 materials soften and require mechanical support. Additionally, any unreacted or "virgin" substrate material not significantly affected by fire exposure readily absorbs water to the point of saturation. On this basis, the approximate 90-minute delay between hose stream test applications allowed the Thermo-Lag panels used to construct the FPL wall assembly to soak up water and continue to soften. It is for this reason that the 90 minute delay between the initial and subsequent hose stream applications may have resulted in a more severe test of the barrier to withstand the impact and erosion effects of the hose stream test. Additionally, following both portions of the hose stream test, no holes or breeches in the barrier system allowed projection of water through the unexposed surface.

As noted, the 1-hour FPL wall configuration was constructed using 3" x 3" x 3/8" steel angle for the supporting framework, seismic cross-brace and perimeter frame members. The subsequent 3-hour CP&L wall configuration utilized 3" x 3" x 1/4" steel angle for the framework and seismic cross-brace members and 3" x 3" x 3/8" angle for the perimeter frame. However, use of slightly thicker support steel for the FPL wall test does not detract from its consideration as a duplicate specimen to the 3-hour wall configuration for purposes of the impact and erosion effects of the hose stream test following a 1-hour fire exposure duration based on the following considerations:

- For mechanical support of the two (2) layers of prefabricated Thermo-Lag panels comprising these fire barriers, the important feature of the supporting steel is the 3" flange width of the angle members to which the 1/4" diameter bolts were installed to secure the panels in place. The 3" flange width and bolt arrangement was consistent for both the 1-hour and 3-hour configurations; therefore, each wall assembly had the same supporting ("backing") area and fastener mechanisms for structural support of the Thermo-Lag panels.

- Following the FPL test, up to 3/16" of unreacted Thermo-Lag material remained on the outer panel (nearest to the test furnace), and the entire 1/2" (nominal) thickness of the inner panel layer was unconsumed. The substantial quantity of unreacted Thermo-Lag material remaining after a 1-hour fire test exposure provides additional assurance that use of 1/4" thick support steel to construct the FPL test assembly would have resulted in no appreciable difference in the structural performance capability of the barrier when subjected to a 2-1/2 minute hose stream test following a 1-hour fire test exposure.

- Finally, as described in Section 4.2.3, the maximum unsupported Thermo-Lag panel span and total unsupported panel surface area employed for the 1-hour FPL test exceeded those of the 3-hour CP&L test assembly. Specifically, the maximum unsupported panel span for the 1-hour FPL test assembly was 70" with a corresponding maximum unsupported panel surface area of approximately 19.4 sq. ft. The maximum unsupported panel span for the 3-hour CP&L test assembly was 69" with a corresponding maximum unsupported panel surface area of approximately 18.7 sq. ft.

4.2.2 Steel Member Temperature (as related to hose stream test cooling effects)

Section 4.2.1 described that the support steel used to construct the 1-hour FPL wall assembly was 3" x 3" x 3/8" angle (ASTM A-36). The support steel used to construct the 3-hour CP&L wall assembly was 3" x 3" x 1/4" angle (ASTM A-36) for the framework and seismic cross-brace members and 3" x 3" x 3/8" angle for the framework perimeter. In order to assess the hose stream cooling effects associated with the difference in support steel thickness, the steel temperatures recorded at the 1-hour mark for both tests were compared. Attachment 1 details the positions of thermocouples used during both the 1-hour and 3-hour tests to record temperatures on the supporting steel members. The highest steel temperature recorded at the 1-hour mark for the FPL test was 230ºF (a 153ºF increase from initial ambient conditions). The highest steel temperature recorded at the 1-hour mark for the CP&L test was 250ºF (a 190ºF increase from initial ambient conditions). Temperatures of such low magnitude are not sufficient to induce markedly different effects on rolled ASTM A-36 carbon steel members during heat-up or cooldown conditions based on the following considerations:

- During fire exposure the primary effects on the carbon steel members are due to thermal expansion. The equation for the coefficient of thermal expansion of steel ($\propto$) taken from the SFPE Handbook (Ref. 3.10) can be used to compare anticipated differences in thermal expansion. This equation states that the coefficient of thermal expansion is $\propto = (6.1 + 0.0019T_s) \times 10^{-6}$ where T_s represents the temperature difference experienced by the steel. If an ambient temperature of 75ºF is assumed and the maximum steel temperature increase for each test is used, the difference in the coefficient of thermal expansion of the steel based on the temperatures recorded during the two tests at the 1-hour mark would only be 7.03×10^{-8} in/in. Based on the length of the longest steel members used to construct the test assemblies (120 in.), the expected thermal expansion effect would be on the order of 8.44×10^{-6} in. (i.e., 7.03×10^{-8} in/in x 120 in), which is not significant.

- During both portions of the hose stream test, a considerable quantity of the Thermo-Lag trowel grade material remained adhered to the protected steel members. Therefore, at temperatures in the range of 250ºF, the thermal conductivity of the remaining Thermo-Lag material, which is significantly lower than that of steel, would be expected to result in relatively uniform cooling rates during the hose stream test for rolled ASTM A-36 steel members of either 3/8" or 1/4" thickness. Specifically, per Ref. 3.7, the equivalent thermal conductivity of Thermo-Lag is 0.06 Btu/hr-ft-ºF compared to 26.20 Btu/hr-ft-ºF for steel.

- Based on standard graphs of temperature effects on A-36 steel (Ref. 3.10, 3.13) temperatures in the range of 250ºF are not sufficient to significantly alter the physical properties of ASTM A-36 steel such as yield or tensile strength, or imposition of stress, strain, deflection, etc. Additionally, significant changes in the crystalline structure of ASTM A-36 steel, such as lamination effects, occur only at temperatures in excess of 1100 to 1200ºF (Ref. 3.10).

Based on the low steel temperatures for each assembly at the 1-hour mark, if the framework for the FPL wall assembly had been constructed using 3" x 3" x 1/4" angle and exhibited the (slightly higher) temperature profile recorded during the CP&L test, no significant differences in the cooling effects on the steel members would be anticipated. On this basis, the differences in support steel size used for the respective wall assembly tests do not detract from the FPL wall assembly being considered as a duplicate specimen to the 3-hour CP&L wall configuration for purposes of the cooling effects of the hose stream test following a 1-hour fire exposure duration.

4.2.3 Maximum Unsupported Panel Span / Overall Unsupported Panel Surface Area

This section assesses differences between the 1-hour FPL wall test assembly and the 3-hour CP&L assembly with regard to maximum unsupported Thermo-Lag panel spans and overall unsupported panel surface areas. As described below, the actual unsupported panel spans are significantly greater than stated in the Supplemental NRR Response to Task Interface Agreement (TIA) 2000-16 (Ref. 3.1). Specifically, the Supplemental TIA Response stated that these spans were approximately 26" for the 1-hour FPL assembly and approximately 31" for the 3-hour CP&L assembly.

Attachment 2 depicts the steel framework utilized for the 1-hour FPL wall test assembly. Attachment 3 reflects the steel framework utilized for the 3-hour CP&L test assembly. A comparison of the steel framework configurations reflected by Attachments 2 and 3 show that the maximum unsupported panel spans and overall maximum unsupported panel surface areas occur at the large rectangular openings fitted with a seismic cross-brace member. The center-to-center dimensions of this opening for the 1-hour FP&L test assembly were 76" (H) x 46" (W), and for the 3-hour CP&L test assembly were 75" (H) x 45" (W). It must be noted that for each fire endurance test, the respective wall assemblies were exposed to the test furnace from the steel support member side. Equally important is the fact that the Thermo-Lag panels used to cover these openings were installed "behind" the 3" x 3" seismic cross-brace members and were not physically attached to the cross-brace member. Therefore, from the perspective of the impact force of the hose stream test applied to the 1-hour FPL assembly, the two layers of Thermo-Lag panels covering the 76" x 46" opening were not supported by the seismic cross-brace member.

To determine the specific (maximum) unsupported Thermo-Lag panel spans, the dimensions across the inside edges of the opposing 3" x 3" angle members are considered. Specifically, the 1-hour FPL assembly maximum unsupported panel spans were 70" vertically and 40" horizontally for the panels covering the large rectangular opening. Similarly, the 3-hour CP&L assembly maximum unsupported panel spans were 69" vertically and 39" horizontally for the panels covering the large rectangular opening. On this basis, the maximum unsupported panel spans for the 1-hour FPL assembly exceeded those of the 3-hour CP&L assembly. Relative to maximum overall unsupported panel surface areas, the area of the panels covering the large rectangular opening for the 1-hour FPL assembly was approximately 19.4 sq. ft. The unsupported panel surface area for the 3-hour CP&L assembly was approximately 18.7 sq. ft. The maximum unsupported panel spans and overall maximum unsupported panel surface area of the 1-hour FPL assembly bounds those of the 3-hour CP&L assembly; therefore, supporting the two configurations as being duplicate test specimens.

4.2.4 Penetrations

The 1-hour FPL wall assembly was tested with one (1) 24" x 24" blockout containing a steel sleeve penetration. The 3-hour CP&L assembly was tested with two (2) 24" x 24" blockouts with steel sleeve penetrations. In the 1-hour FPL test, the steel sleeve was covered with Thermo-Lag panels for a distance of approximately 9" from the exposed surface of the wall, with approximately 3" of the steel sleeve remaining exposed. In the 3-hour CP&L test, the entire inside and outside surfaces of the sleeves were covered with a 3/4" (nominal) thickness of Thermo-Lag trowel grade material. The upper penetration was sealed with a 4" depth of Promatec low-density silicone elastomer (LDSE) followed by installation of 1" thick M-Board damming on the exposed side only. In the event that this design was incapable of maintaining acceptable temperatures on the unexposed side of the seal (commensurate with the performance capability of the wall itself), the lower penetration utilized an upgraded seal design consisting of a 9" depth of LDSE and 1" thick M-Board damming on the exposed side only. Finally, for each penetration, the interface regions between the Thermo-Lag coverage on each penetration sleeve and the panels surrounding each penetration were upgraded with external stress skin reinforcement and a skim coat of trowel grade material.

Introduction of the second penetration and the design upgrades applied to both penetrations for the 3-hour CP&L test does not detract from consideration of the 1-hour FPL wall assembly as a duplicate specimen. This is based on the following:

- The presence of the second penetration or the design upgrades applied to both penetrations did not significantly affect the thermal performance of the 3-hour CP&L wall test assembly. The limiting thermal performance characteristic of the tested wall assemblies was transmission of heat through the Thermo-Lag panels in lieu of the through penetrations. For example, the highest temperatures experienced on the unexposed surface of the test assemblies at the 1-hour mark were not recorded at the penetration locations. Specifically, for the FPL test assembly temperature the highest increases of 123ºF and 132ºF were recorded at approximately 1 and 3 feet away from the penetration. Likewise, from the same penetration location in the CP&L test assembly the highest temperature increases at the 1-hour mark (211ºF and 217ºF) were also located between 1 and 3 feet from the penetration. Therefore, in neither test configuration did the location of the penetration nor the addition of a second penetration make a significant difference in overall thermal performance of the barrier during the first hour.

- From a structural performance perspective, the second penetration was positioned such that the 3-hour CP&L assembly still included the large (75" x 45") rectangular opening described in Section 4.2.3. As noted previously, the 1-hour FPL test utilized unsupported Thermo-Lag panel spans and an overall unsupported panel surface area larger than those in the 3-hour CP&L test to cover the large rectangular opening. Therefore, since the FPL wall assembly successfully withstood the hose stream test with larger unsupported panel spans and a greater overall unsupported panel surface area, inclusion of a second penetration in the 3-hour CP&L wall test assembly does not challenge the validity or results of the hose stream test applied to the FPL assembly.

4.2.5 Thermo-Lag Fire Barrier Design

With the exception of the slightly different thickness of the supporting steel angle members and the number of penetrations as described above, the same basic Thermo-Lag fire barrier design was utilized for each test. Specifically, both wall assemblies were constructed in the following manner. The steel angle members were welded "back to back" as shown by Attachment 1. To allow for attachment of the Thermo-Lag panels to the framework, 5/16" diameter holes were drilled through the flanges of the steel angles on 12" centers. Bolts (1/4" diameter x 2-1/2" long, A-307) were placed through each hole with the threaded ends protruding on the unexposed side of the wall and the bolt hex heads were tack-welded to the angle flanges. The steel framework was then coated with Thermo-Lag 351 primer. Thermo-Lag 330-1 V-ribbed panels having a 1/2" (nominal) thickness were utilized with integral stress skin monolithically adhered to the V-rib face of the panels. The panels were cut as necessary to fit the steel framework and the V-ribs were hammered flat prior to installation. The panels were installed on the framework in a "back to back" arrangement, i.e., stress skin side facing out on both sides. The panels were fit over the 1/4" diameter bolts and secured with fender washers (1-1/2" O.D.) and nuts. Thermo-Lag 330-1 trowel grade material was then applied over the panel joint areas, the exposed nuts and washers and on the steel angle framework.

With the exceptions of the steel thickness and number of penetrations as evaluated above, the basic Thermo-Lag fire barrier designs utilized to construct the two wall test assemblies were consistent and support the 3-hour CP&L configuration as a duplicate of the 1-hour FPL configuration .

4.2.6 Temperature Measurement Location

The methods used to record the temperature on the unexposed surface of the barrier for both the 1-hour FPL and 3-hour CP&L tests met the requirements prescribed by ASTM E119, which states:

"Temperature readings shall be taken at not less than nine points on the surface. Five of these shall be symmetrically disposed, one to be approximately at the center of the specimen, and four at approximately the center of its quarter sections. The other four shall be located at the discretion of the testing authority to obtain representative information on the performance of the construction under test."

Specifically, for the 1-hour FPL test, five (5) thermocouples were symmetrically disposed with one (1) thermocouple positioned at the approximate center of the assembly and four (4) additional thermocouples located at the approximate centers of the assembly's quarter sections. Nine (9) more thermocouples were located near the geometric center of each Thermo-Lag panel. These 18 thermocouples (located on the unexposed side of the barrier) were covered with 6" x 6" felted mineral pads and were used for test acceptance purposes. Four (4) thermocouples were positioned on the 3" x 3" steel angle support members (prior to covering the members with Thermo-Lag panels) to record steel temperatures on the unexposed side of the barrier. Attachment 1 details the location of the thermocouples on the steel support members. Five (5) additional thermocouples were positioned on the unexposed side of the barrier directly over joint locations between adjacent Thermo-Lag panels. These thermocouples were covered with pads as described above but were notched for clearance over the Thermo-Lag trowel grade material covering the panel mounting studs. Finally, one (1) thermocouple was positioned on the unexposed side approximately 1" from the penetrating steel sleeve and covered with a 2" x 2" pad as described above.

Similarly, for the 3-hour CP&L test, five (5) thermocouples were symmetrically disposed with one (1) thermocouple positioned at the approximate center of the assembly and four (4) additional thermocouples located near the approximate centers of the assembly's quarter sections. Five (5) more thermocouples were located near the geometric center of Thermo-Lag panels. These 14 thermocouples (located on the unexposed side of the barrier) were covered with 6" x 6" felted mineral pads and were used for test acceptance purposes. Two (2) thermocouples were positioned on the 3" x 3" steel angle support members (prior to covering the members with Thermo-Lag panels) to record steel temperatures on the unexposed side of the barrier. Attachment 1 details the location of the thermocouples on the steel support members. Seven (7) thermocouples were used to monitor the performance of each of the two penetration seal assemblies. For each penetration, two (2) thermocouples were positioned on the unexposed face of the Thermo-Lag trowel grade material covering the interior of the steel sleeve, 1" away from the LDSE seal material. Two (2) thermocouples were located on the unexposed face of the LDSE seal material, 1" away from the walls of the penetration sleeve. The remaining three (3) thermocouples were placed in the field of the unexposed side of the seal. All thermocouples used to record temperatures associated with the penetration assemblies were covered with a 2" x 2" pad as described above.

Therefore, the means whereby temperature data was obtained and recorded for both the 1-hour FPL and 3-hour CP&L wall assemblies were equivalent and supportive of the FPL test assembly being considered as a duplicate specimen.

4.3 As-Tested to As-Installed Matrix

The following is a general comparison of the pertinent attributes associated with the fire endurance assemblies and the as-installed configuruations:

Attribute	As-Tested	As-Installed	Bounding Rationale
Steel Member Size	3" x 3" x 3/8" Angle 3" x 3" x 1/4" Angle	3" x 2-1/2" x 1/4" Angle 3" x 3" 1/4" Angle 4" x 4" 1/4" Angle 4" x 4" x 3/8" Angle WT 4 x 15.5 C8 x 11.5	Testing Bounds Installed See Section 4.3.1
Maximum Unsupported Panel Span / Overall Unsupported Panel Area	70" 19.4 sq. ft.	71" 11.8 sq. ft.	Testing Bounds Installed See Section 4.3.2
Penetration Interfaces and Seal Designs	See Section 4.3.3	See Section 4.3.3	Testing Bounds Installed See Section 4.3.3
Access Doors	Access doors not included in wall fire tests	Seven (7) access doors of various sizes, see Section 4.3.4	Acceptable per Evaluation See Section 4.3.4
Fire Barrier Design	See Section 4.3.5	See Section 4.3.5	Testing Bounds Installed See Section 4.3.5
Unexposed Barrier Surface Temperature After 3-hour Fire Test Exposure	Unexposed surface temperatures recorded using felt pads as if protected commodity was in direct contact with barrier	Protected commodities not in direct contact with unexposed surface of barrier	Acceptable per ESR 95-00620 Evaluation See Section 4.3.6
Fire Barrier Symmetry	Support steel surface of barrier subjected to fire endurance & hose stream tests	Support steel surface and exposed tie bolts located within enclosures	Testing Bounds Installed See Section 4.3.7
Steel Member Loads	N/A: Applied load during fire test not required by ASTM E119	4 ksi (heaviest loaded member per ESR 95-00620)	Acceptable per ESR 95-00620 Evaluation See Section 4.3.8

4.3.1 Steel Member Size

One steel angle member used for the framework of the ACP Room Thermo-Lag enclosure has a dimension slightly less than that tested (3" x 2-1/2" x 1/4" vs. 3" x 3" x 1/4"). The 2-1/2" flange of this member is attached directly to the adjacent concrete structure with anchor bolts, and the Thermo-Lag panels are bolted to the 3" flange of the angle, consistent with the tested configurations. Additionally, the size of the panels bolted to the 3" flange measure 60" (H) x 27" (W), which is considerably smaller than the largest tested panel sizes. Therefore, this 3" x 2-1/2" x 1/4" member provides a level of structural support to the attached panels commensurate with the tested frame members.

Additionally, 3" x 3" x 3/8" members were used for the perimeter frame for the tested assemblies. For the installed configurations, the smallest perimeter angle member used is the 3" x 2-1/2" x 1/4" member described above. The smallest angle members used in perimeter framework applications for the remainder of the in-plant enclosures are 3" x 3" x 1/4". However, in all cases, the perimeter members are anchored to supporting concrete surfaces (i.e., walls, floor or ceiling). The slight difference in perimeter steel member thickness between tested and installed configurations will be offset by the heat sink effect of the surrounding concrete. Additionally, in each case the surface area of the attached Thermo-Lag panels, and corresponding loads imposed on the perimeter members are bounded by the tested panel sizes. Therefore, the one instance where a 3" x 2-12" x 1/4" member is used in a perimeter framework application, and the remaining instances where 3" x 3" x 1/4" steel angle is used are effectively bounded by the tested configurations.

With the two exceptions described above, the sizes of the steel framing members used to construct in-plant configurations meet or exceed those utilized for the tested configurations.

4.3.2 Maximum Unsupported Panel Span / Overall Unsupported Panel Area

As described in Section 4.2.3, the maximum unsupported Thermo-Lag panel span tested was the 70" span across the vertical dimension of the large rectangular opening in the 1-hour FPL assembly. The maximum overall unsupported panel surface area tested was the approximate 19.4 sq. ft. panel covering the large rectangular opening.

The largest unsupported Thermo-Lag panel span utilized for in-plant fire barrier enclosures is a single Thermo-Lag panel with a 71" vertical span installed as part of the full height enclosure in Cable Spreading Room (CSR) B. However, the width of the panel containing the 71" span is only 24" compared to a width of 40" for the 1-hour FPL test assembly. Therefore, the total unsupported panel surface area for the installed panel is approximately 11.8 sq. ft. Additionally, the bottom edge of the 71" (H) x 24" (W) panel is bolted to a 3" x 3" x 1/4" steel perimeter frame member which is anchored directly to the concrete floor of the CSR which provides substantial support.

Based on the significantly smaller surface area of the largest installed panel compared to the largest tested panel (11.8 sq. ft. vs. 19.4 sq. ft.) and its interface with the CSR concrete floor, the largest unsupported panel span and unsupported panel surface area for in-plant configurations are bounded by those tested. The remaining Thermo-Lag panels used to construct the in-plant barrier configurations (approximately 180 panels) all have unsupported spans of 60" or less and are therefore bounded by the tested 70" panel span.

4.3.3 Penetration Interfaces and Seal Designs

As described in Section 4.2.4, the 1-hour FPL test assembly included one (1) 24" x 24" blockout with steel sleeve penetration. However, the method used to seal the penetration was not representative of standard CP&L designs used to seal through openings in fire barriers. In the FPL test, the sleeve was sealed with a 6" thick depth of Promatec 45B silicone elastomer material in the plane of the barrier, the interior cavity was completely filled with Kaowool fiber, followed by installation of 1" thick M-Board damming on both ends.

As part of the 3-hour CP&L test, two (2) 24" x 24" blockouts with steel sleeve penetrations were employed. One of the objectives of the 3-hour test was to assess the performance capability of two (2) different designs for sealing penetrations through Thermo-Lag barriers. Therefore two different seal designs, representative of those commonly used for in-plant applications were used. The upper penetration was sealed with a 4" depth of Promatec low-density silicone elastomer (LDSE) followed by installation of 1" thick M-Board damming on the exposed side only. The lower penetration utilized a 9" depth of LDSE and 1" thick M-Board damming on the exposed side only. A 3/4" thick (nominal) application of Thermo-Lag trowel grade material was used to cover the inside and outside surfaces of the steel sleeve penetrations. The interface region between the Thermo-Lag coverage on each sleeve and the panels surrounding each penetration was upgraded with external stress skin reinforcement and a skim coat of trowel grade material.

The seal design utilized for the upper penetration (4" depth of LDSE) maintained individual temperature increase parameters within the limitations prescribed by ASTM E814 for a 171-minute duration. The seal design utilized for the lower penetration (9" depth of LDSE) maintained individual temperature increase parameters within the limitations prescribed by ASTM E814 for the entire 180-minute test duration. Therefore, the rated performance capability of the two penetration seal designs exceeded that of the Thermo-Lag wall assembly.

The LDSE penetration seal designs utilized in the 3-hour test have been independently qualified by fire endurance and hose stream tests when installed in significantly larger openings in concrete floor configurations (Ref. 3.11). Moreover, it is recognized that the structural integrity of penetration seals installed in horizontal (floor) configurations is more challenged during hose stream tests than those installed in through wall applications. The designs utilized to seal in-plant penetrations through Thermo-Lag barriers (Typical Details EL-1 and HL-1) both utilize a 4" (min.) depth of LDSE, but are superior to the tested designs in that 1" of M-Board damming is installed on both sides of the seal. The interface regions between penetrating commodities and the in-plant Thermo-Lag enclosures were upgraded with external stress skin and additional trowel grade material commensurate with the tested configurations under ESR 95-00715 (Ref. 3.12). As part of ESR 95-00715, an assessment was performed for each type of through penetration and seal design associated with the installed Thermo-Lag enclosures. The evaluation documented under ESR 95-00715 concluded that designs utilized to seal penetrations through installed Thermo-Lag barrier enclosures are commensurate with tested designs, and exceed that of the Thermo-Lag wall assembly.

4.3.4 Access Doors

The tested Thermo-Lag wall assemblies did not include access doors, as do the in-plant configurations. Specifically, a total of seven (7) doors, ranging in size from approximately 4'-0" (H) x 2'-5" (W) to 6'-0" (H) x 2'-9" (W) are provided for access into the Thermo-Lag enclosures. These door and frame assemblies are qualified for a 3-hour fire resistance rating and are labeled, listed or approved as such by Underwriter's Laboratories (UL), Warnock Hersey or Factory Mutual (FM). On this basis, the doors have satisfied the fire endurance and hose stream test acceptance criteria prescribed by NFPA 252 (Ref. 3.14). Fire endurance testing protocol for fire door assemblies does not invoke an unexposed surface temperature increase limitation. The fire endurance qualification of fire doors is based on limitations on the presence of flames on the unexposed side during prescribed time intervals and limitations on the door's movement within its frame assembly when subjected to the hose stream test. Fire doors are not required to be tested within the specific type of barrier or opening in which they are installed, such as walls constructed of masonry, gypsum or Thermo-Lag 330-1 materials.

The access doors are 1-1/2" thick and constructed of two 16 gauge rolled steel plates, internally reinforced with steel stiffeners running the full height of the door at 6" intervals (Ref. 3.15). The frame of each access door is secured to 4" x 4" x 1/4" steel angle members or adjacent concrete surfaces with 3/8" diameter machine screws or anchor bolts. To mitigate heat transmission through the doorframesthe inside surface of the steel angles are covered with a 1" (nominal) thickness of Thermo-Lag trowel grade material and the outside surface of the steel angles are covered with a 3/4" (nominal) thickness of trowel grade material. Although not included within the tested Thermo-Lag wall assemblies, inclusion of access doors within the in-plant barrier configurations is acceptable based on the following considerations:

- The access doors and frame assemblies are qualified for a 3-hour rating in accordance with NFPA 252.
- The size of the steel members to which doorframes are attached (4" x 4" x 1/4" angle) is significantly larger than the tested steel member sizes (3" x 3" x 3/8" and 3" x 3" x 1/4" angle) and therefore will result in an improved thermal performance.
- Thermo-Lag trowel grade material applied to the 4" x 4" x 1/4" angles is of equivalent or greater thickness than that applied to the tested steel members. Therefore, the method of protection for the larger 4" x 4" x 1/4" members is bounded by the members tested.
- No combustible materials, such as exposed cabling, are in direct contact with the surfaces of the access doors.

- The doors are inspected and administratively controlled in accordance with HNP operating procedures (Ref. 3.16, 3.17).

4.3.5 Fire Barrier Design

The design utilized to construct the tested Thermo-Lag wall fire barrier assemblies was described in Section 4.2.5. This section will address the differences between tested barrier configurations and those installed at HNP.

Vertical members forming the steel framework for the in-plant wall barrier configurations are generally spaced 19" to 28" on center and are reinforced in some cases with seismic cross-brace members. The acceptability of the smallest installed steel member sizes was addressed in Section 4.3.1. One (1) prefabricated 5/8" thick (min.) Thermo-Lag panel with monolithically adhered stress skin was installed on each side of a layer of 1/4" thick metal lath, with the stress skin side facing out. The metal lath and Thermo-Lag panels were secured to the steel framework at 12" intervals with 1/4" diameter welded studs bolts, nuts and washers. Additionally, the panels were bolted to each other through the metal lath with 1/4" diameter tie bolts, spaced at 24" intervals. Thermo-Lag trowel grade material was applied over the nuts and washers securing the panels to framing members. Trowel grade material was also applied over the heads of the tie bolts on the outside surface of the enclosures. A 1" (min.) thickness of trowel grade material was used to cover these fasteners. The nuts and washers associated with the tie bolts are not covered with Thermo-Lag trowel grade material on the inside surface of the enclosures. Trowel grade material was installed on the outside and inside surfaces of the steel framing members to a thickness of 0.75"±0.06" and 0.65"±0.06" respectively. The inside surfaces of 4" x 4" x 1/4" angle members to which access doorframes are attached were covered with Thermo-Lag trowel grade material having a nominal thickness of 1".

The differences between the as-installed and as-tested configurations are as follows:

- The as-installed fire barrier assemblies utilize 1/4" thick expanded metal lath between the two layers of Thermo-Lag panels. Due to the thickness of the expanded metal lath, its presence will substantially increase the overall rigidity of the installed wall assemblies. Therefore, the in-plant configurations would be expected to exhibit better structural performance than the tested assemblies.

- The as-installed fire barrier assemblies utilize 1/4" diameter tie bolts between the panels and metal lath spaced at 24" intervals. On the outside surface of the barrier, the tie bolt heads are covered with a 1" (min.) thickness of trowel grade material. Use of tie bolts to secure the two panel layers to the expanded metal will provide additional resistance against sag and deflection of the panels during fire exposure which would be expected to result in better thermal and structural performance than the tested assemblies.
- The as-installed fire barrier assemblies secured the Thermo-Lag panels to the steel angle support members with welded studs, which do not penetrate through the support members. The Thermo-Lag panels for the test assemblies were secured to the steel support members with bolts, which necessitated drilling holes through the support

members. The heads of the bolts on the exposed side of the test assemblies were covered with Thermo-Lag trowel grade material, however presence of the bolt heads on the exposed side resulted in a more severe thermal challenge to the unexposed side than would occur for as-installed welded stud configurations. Therefore, the as-installed configurations would be expected to exhibit better thermal performance than the tested assemblies.

- The as-installed fire barrier assemblies utilize Thermo-Lag panels having greater thickness than the tested assemblies. Specifically, ESR 94-00379 (Ref. 3.18) verified that the total prefabricated Thermo-Lag panel thickness was 1.6", not including the 1/4" thick metal lath between the panel layers. The thickness of the Thermo-Lag materials used to construct the test assemblies was 1.5". The increased barrier thickness for the in-plant configurations would be expected to result in better overall thermal performance than the tested assemblies.

In summary, based on the above differences between the tested and installed Thermo-Lag wall configurations, the in-plant configurations would be expected to exhibit better overall thermal and structural performance capability than the tested assemblies.

4.3.6 Unexposed Barrier Surface Temperature After 3-hour Fire Test Exposure

As described in Section 4.2.6, temperatures were recorded for test acceptance purposes by thermocouples covered with 6" x 6" felt pads. While ASTM E119 requires use of thermocouple pads, this practice effectively measures temperatures directly on the unexposed surface of the barrier. However, 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. As described by ESR 95-00620, for in-plant configurations, no electrical cables are positioned in direct contact with barrier surfaces. Specifically, it was determined that a minimum air gap of 1" exists between barrier surfaces and the side rail portion of the closest cable tray. Therefore, temperatures actually experienced by cables required for safe shutdown would be significantly lower than those recorded on the unexposed surface of the tested wall assemblies. Calculation FP-0110 (Ref. 3.7) was performed to evaluate the temperature increase that would be anticipated on the side rail of a cable tray located 1" from the unexposed side of a wall fire barrier enclosure. In performing this calculation, two different barrier configurations were evaluated. However, each of the model scenarios utilized the average temperature recorded on the unexposed surface of the CP&L assembly at the completion of the 3-hour fire exposure test (458ºF). The first scenario modeled the tested wall design configuration (1.5" Thermo-Lag thickness and no metal lath between the panels). The result of this scenario was that a temperature increase of 187ºF would be expected on the cable tray side rail surface which is located a minimum of 1" away from the surface of the fire barrier wall assembly. The second scenario modeled the installed wall design configuration (1.6" Thermo-Lag thickness and presence of metal lath), and conservatively assumed that the "target" cable tray was located inside the wall enclosure and positioned immediately adjacent to the exposed portion of a tie bolt. This configuration was determined to represent the most severe thermal exposure to the "target" cable tray.

The result of this scenario was that a temperature increase of 106ºF would be expected on the surface of the cable tray side rail which is located a minimum of 1" away from the surface of the fire barrier wall assembly.

Using the average temperature recorded directly on the unexposed surface of the tested barrier after 3 hours of fire exposure in combination with the existing minimum 1" air gap between the surface of the fire barrier wall assembly, the as-installed fire barrier wall assembly was evaluated to be adequate to maintain electrical cables required for safe shutdown free from fire damage.

4.3.7 Fire Barrier Symmetry

It is recognized that the wall fire barrier configurations are not symmetrical in that one side of the barrier has support steel members protected with Thermo-Lag trowel grade material and in most instances the opposing side does not require support steel members. However, from a fire exposure perspective, the barrier surface with protected support steel members represents the "worst case" since the Thermo-Lag trowel grade material used to cover the steel members is approximately 0.75 in. thick, while the total prefabricated panel thickness on the opposite face is approximately 1.6". Additionally, the tie bolt configuration is not symmetrical in that the tie bolts are covered with trowel grade material on the outside surface of the enclosures and are exposed on the inside surface of the enclosures. However, as described in Section 4.4.6, this fact was considered when the results of the 3-hour CP&L test were applied in Calculation FP-0110.

Therefore, CP&L has utilized the test results and applied supplemental analyses to conclude that the fire barrier symmetry having the least conservative attributes has been adequately addressed.

4.3.8 Steel Member Loads

As part of ESR 95-00620, Calculation FP-0110 (Ref. 3.7) assessed the capability of steel members used to support the Thermo-Lag enclosures to withstand design basis load conditions at elevated temperatures. ESR 95-00620 concluded that structural steel members forming part of or supporting installed Thermo-Lag fire barriers will provide a fire resistance capability at least equivalent to that of the barriers themselves.

4.4 3-Hour Ceiling Test Assembly

This section will address the comments associated with the 3-hour ceiling test described by the Supplemental NRR Response to Task Interface Agreement (TIA) 2000-16 (Ref. 3.1). A general description of this test is provided in Attachment 4.

4.4.1 Use of External Means of Support During Fire Test

This test was performed by Omega Point Laboratories (OPL) for CP&L and two other sponsoring utilities to assess the performance of three (3) separate fire barrier designs for ceiling and/or structural beam members constructed or protected using Thermo-Lag 330-1 materials. To accommodate the three different utility test assemblies, OPL's 12 ft. x 18 ft. x 7 ft. deep horizontal furnace was used to simultaneously subject the individual test specimens to a 3-hour ASTM E119 fire exposure. The CP&L floor/ceiling assembly, which measured 12 ft long x 5 ft 9 in. wide, was positioned at one end of the test furnace, which meant that it was simply supported by the furnace perimeter along three of its four edges. The fourth, which ran across the 12-ft. dimension of the assembly, was positioned toward the center of the furnace and interfaced with the test assembly of one of the other utilities. Positioned in this manner, the fourth edge of the assembly was not supported by the furnace perimeter.

The floor/ceiling assembly satisfied the temperature increase parameters of ASTM E119 for the entire 3-hour duration of fire exposure. Specifically, the average temperature increase recorded on the unexposed surface of the barrier was only 157ºF, compared to the 250ºF allowed by ASTM E119. However, at approximately 27 minutes into the test the assembly began to exhibit sag along the 12 ft. unsupported edge, due to structural failure of the adjacent test assembly. This deflection had not been anticipated and the magnitude of deflection along the unsupported edge continued to increase. Therefore, at approximately the one hour mark, a chain fall was installed near the midpoint of the unsupported edge to prevent continued deflection of the assembly from jeopardizing continuation of the test, especially in light of the shared nature of the test.

Use of the chain fall to support the free edge of the test assembly is not considered to adversely affect CP&L and OPL's determination that the assembly satisfied the test acceptance criteria. The bases for this determination are outlined below.

- ASTM E119 requires that a floor/ceiling test assembly be at least 180 sq. ft. in size, with no dimension less than 12 ft. However, ASTM E119 states "if the conditions of use limit the construction to smaller dimensions, a proportionate reduction may be made in the dimensions of the specimens for a test qualifying them for such restricted use." The CP&L assembly was constructed such that four (4) 3 in. x 3 in. x 1/4 in. steel angle cross-members, spaced 2 ft. 6 in. on center, spanned across the 5 ft. 9 in. dimension of the assembly. For in-plant configurations, the largest distance between cross-members is 2 ft. 4 in. and the largest cross-member span is 5 ft 3 in. Therefore, the dimensions of the CP&L assembly satisfied ASTM E119 requirements and bound installed barrier configurations.

- The unsupported edge along the 12 ft. dimension of the test assembly resulted from the unique arrangement of three utility test specimens within the same test furnace. If the CP&L assembly had been tested separately, support around the entire perimeter of the configuration similar to the as-installed assembly would have prevented the unexpected deflection from occurring.

- For the as-installed configurations, both ends of each cross-member are structurally supported. Specifically, one end of each member is welded to support members secured to concrete walls via anchor bolts or welded to embedded plates. The other end is attached to vertical steel support members, which in turn are supported from concrete floor/ceiling structures. Therefore, to simulate in-plant conditions, the unsupported 12 ft. edge of the test assembly would have been supported at each of the four (4) cross-member locations.

- As a conservative measure, ESR 95-00620 assessed the installed barrier configurations as though portions of the enclosures may be partially unrestrained from thermal expansion effects. However, based on the methods of support described above, the installed barrier configurations should be classified as fully restrained against the effects of thermal expansion by the concrete walls and the vertical support members. For conduct of fire endurance testing of ceiling/floor specimens that are restrained from thermal expansion, ASTM E119 requires subjecting the specimen to their maximum loaded condition during the fire test. ASTM E119 does not require that specimens be physically restrained against thermal expansion effects during fire exposure testing. Based on the test methods of ASTM E119, a restrained assembly is generally expected to possess greater fire endurance capability than an unrestrained assembly. Therefore, the as-installed configuration would be bounded by the tested configuration.

- Although the ceiling assembly was not tested under loaded conditions, the loads experienced by the cross-brace members for in-plant configurations are not significant in relation to the extent of the overall support system. Specifically, as described above the maximum distance between cross-brace members for in-plant barrier configurations is 2 ft. 4 in. Moreover, unlike the tested configuration, one end of each installed cross-members is welded to members attached to concrete walls via anchor bolts or welded to embedded plates. The other end of each cross-member is attached to vertical members supported from concrete floor/ceiling structures. Therefore, based on the strength of the overall supporting framework (which has been qualified under dynamic/seismic as well as dead weight loading conditions), the loads imposed on the fire barrier cross-members are not significant and therefore were not imposed under fire test conditions.

- As a test standard for generic building construction and materials, the ASTM E119 requirement for imposition of maximum loaded conditions under fire test conditions is intended for structural load bearing floor and roof systems. This is due to the fact that the loaded conditions of floor and roof systems within buildings can change over time due to changes in occupancy or use. The nature of the installed Thermo-Lag fire barrier enclosures is a unique case not explicitly contemplated by ASTM E119.

Specifically, the barrier support members do not carry building structure loads, and the loads imposed on the barrier supports by the Thermo-Lag barrier enclosures, cable trays, etc. will not significantly change over the life of the plant. In the event that significant changes to loading conditions occur, the resulting impact of such changes will be evaluated.

Based on the above considerations, use of the chain fall during the fire test simply simulated support mechanisms that are present under normal plant operating conditions.

4.4.2 Hose Stream Test

The HNP licensing basis for qualification of fire-rated assemblies is ASTM E119. For fire endurance tests associated with floor/ceiling assemblies, ASTM E119 does not require a hose stream test and none was performed following the 3-hour fire exposure for the subject ceiling assembly.

Hose stream testing is only included as a condition of acceptance for *certain* fire resistive elements when tested in accordance with ASTM E119. Hose stream tests are not required for structural elements such as columns and beams or floors and ceilings that perform as barriers or for protective membranes in wall, partition, floor or roof assemblies. Each of these elements may be qualified by ASTM/NFPA test methods as "fire resistive" without being subjected to a standard hose stream test.

CP&L has sufficient assurance that in the event that a hose stream test were applied to a duplicate ceiling test specimen, following a 1-hour fire endurance exposure, the assembly would withstand the impact, erosion and cooling effects of the hose stream test. This is based on the fact that the design of the 3-hour CP&L ceiling configuration was substantially more robust than that of the FPL wall test assembly, which successfully withstood a 2-1/2 minute hose stream test following one hour of fire exposure. The following differences existed between the FPL wall test assembly and the CP&L ceiling test assembly:

- The FPL wall test assembly utilized two (2) layers of Thermo-Lag Panels and stress skin without expanded metal lath. The CP&L ceiling test assembly utilized 1/4 in. thick expanded metal lath welded to the perimeter framework and to the 3 in. x 3 in. x 1/4 in. angle cross-members. The bottom two layers of Thermo-Lag panels (with integral stress skin) were bolted to the expanded metal lath. The top surface of the expanded metal was covered with another layer of stress skin and buildup of trowel grade material. The presence of the expanded metal and additional layer of stress skin for the ceiling assembly would be expected to result in better structural performance capability than the FPL wall assembly when subjected to the hose stream test after a 1-hour fire endurance exposure.

- The Thermo-Lag material thickness used to construct the FPL wall assembly was less than that used for the ceiling assembly. ESR 94-00379 verified the minimum thickness of in-plant ceiling barrier configurations to be 1.75 in. The Thermo-Lag material thickness used to construct the FPL wall assembly was 1.50 in. The effectiveness of the increased Thermo-Lag material thickness for the ceiling assembly is evidenced by the fire endurance test results. Specifically, at the conclusion of the 3-hour CP&L ceiling test, the average temperature increase recorded on the unexposed surface of the assembly was 157ºF and the largest individual point temperature increase was 291ºF. The maximum allowable average and individual point temperature increase parameters specified by ASTM E119 are 250ºF and 325ºF respectively.

Therefore, based on the results of the 1-hour FPL wall assembly test and the 3-hour CP&L ceiling assembly test, the additional Thermo-Lag material thickness, use of expanded metal lath and three layers of stress skin provide reasonable assurance that a duplicate ceiling test specimen would withstand the effects of a 2-1/2 minute duration hose stream test following a 1-hour fire exposure.

5.0 CONCLUSIONS

Based on the rationale presented herein, the following conclusions can be drawn:

- For purposes of the hose stream test, the 1-hour FPL wall test assembly can be considered a duplicate specimen to the 3-hour CP&L wall test assembly

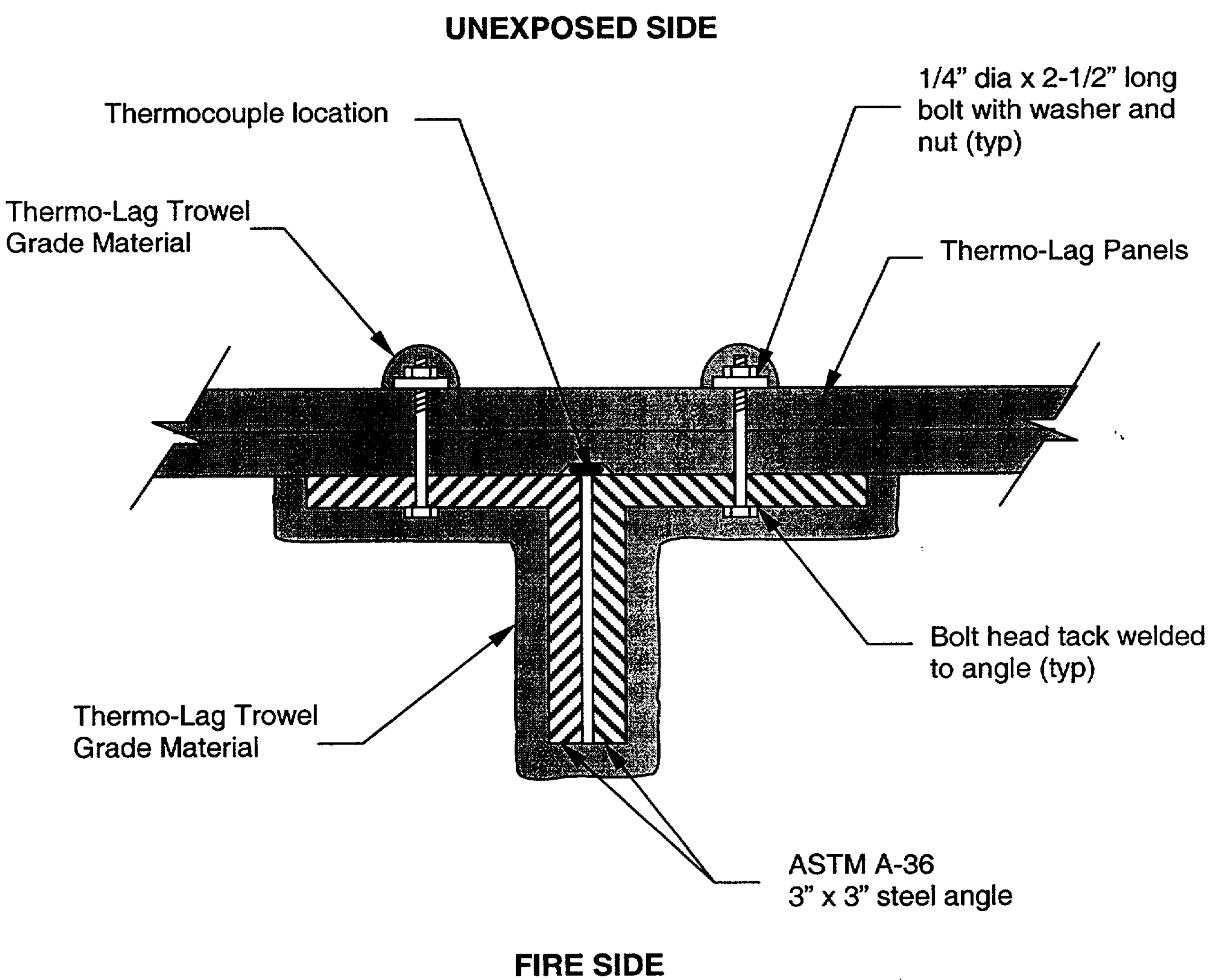
- The tested wall assemblies, as supplemented by evaluations presented and/or referenced herein, bound all significant attributes of the HNP Thermo-Lag wall enclosures.

- Use of a chain fall to provide support to the CP&L ceiling assembly during the 3-hour fire test simply simulated support mechanisms that are present under normal plant operating conditions and the validity of the fire test should not be in question.

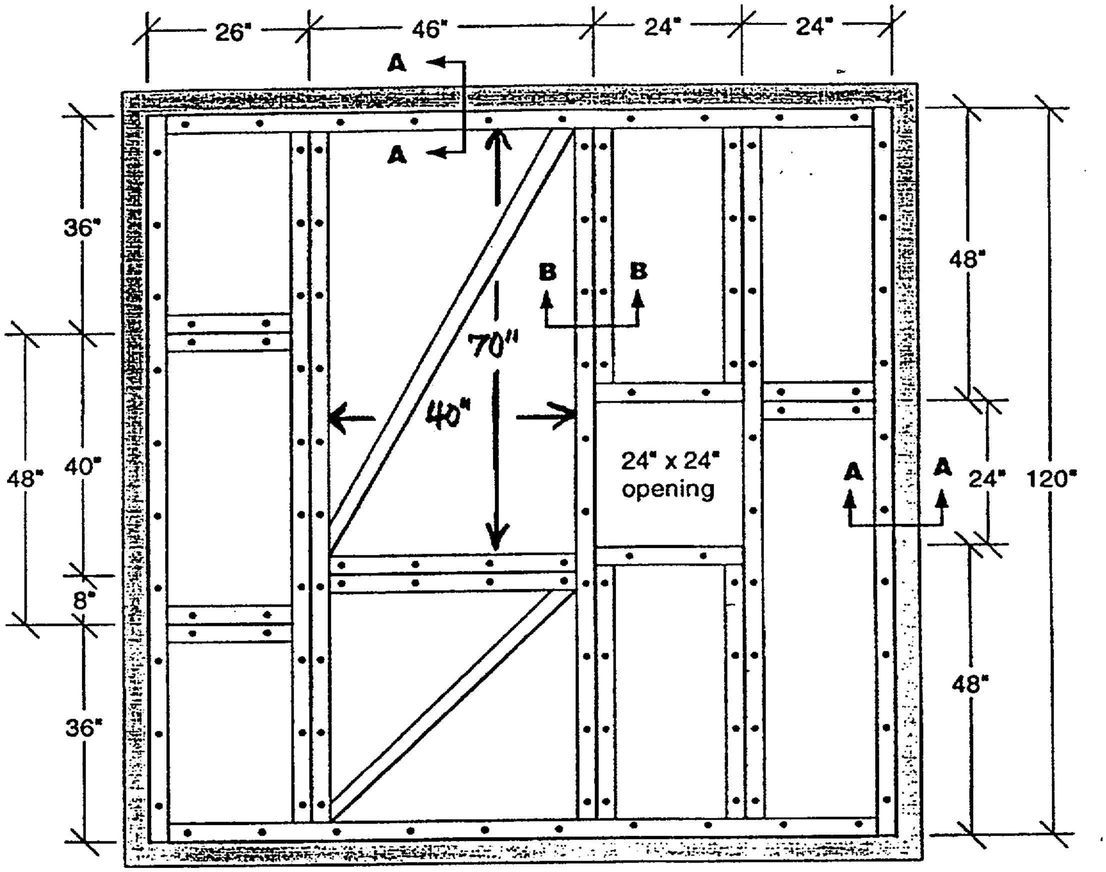
- The HNP licensing basis for qualification of fire-rated assemblies is ASTM E119, which for floor/ceiling test specimens has no requirement to conduct of a hose stream test following a fire exposure test.

- CP&L has reasonable assurance that a duplicate ceiling test specimen would withstand the effects of a 2-1/2 minute duration hose stream test following a 1-hour fire exposure.

Attachment 1
Thermocouple Location on Steel Members



ATTACHMENT 2
1-Hour FPL Test Assembly Frame Detail



ELEVATION VIEW
FROM UNEXPOSED SIDE

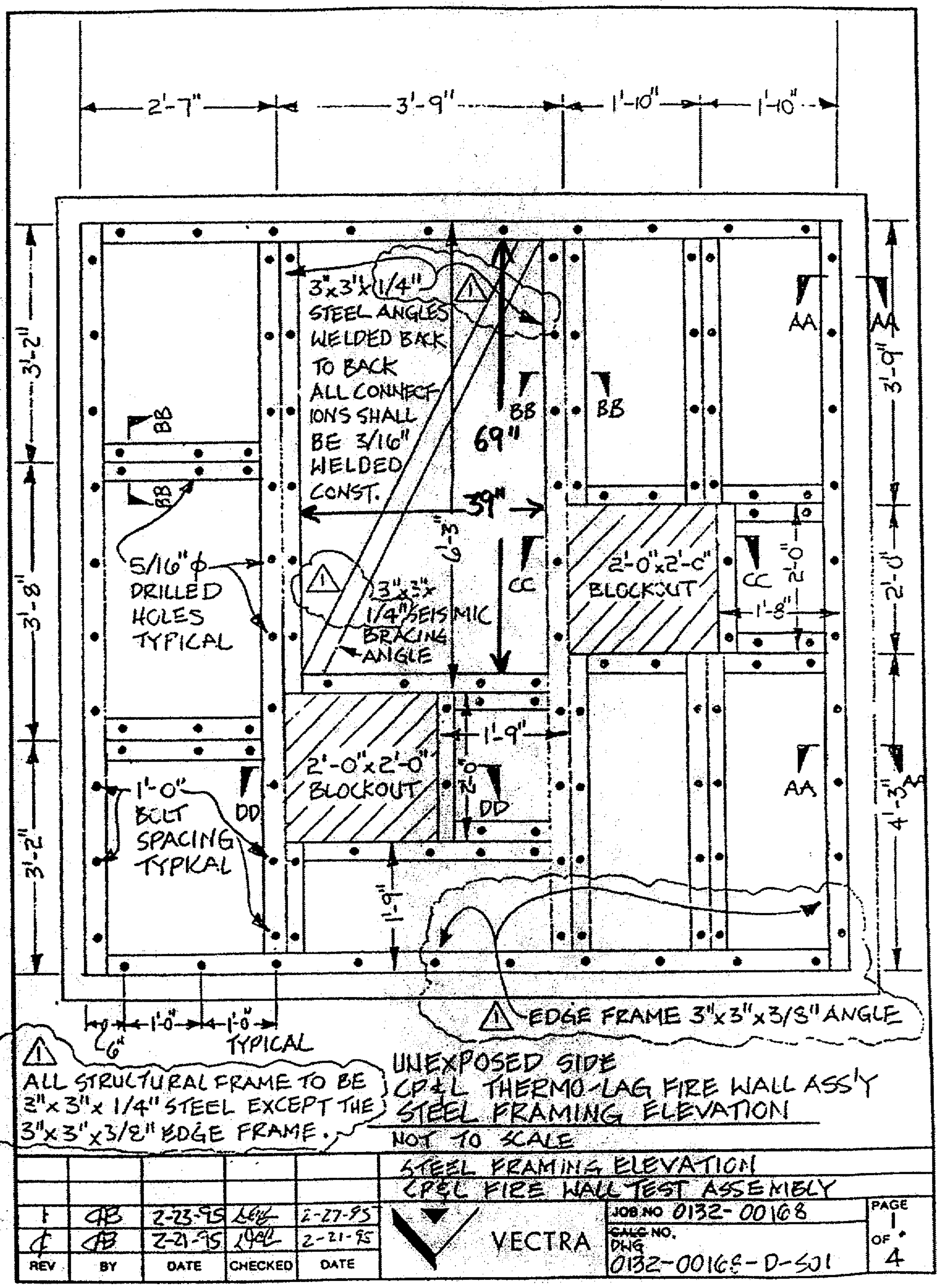
NOTE:
All structural steel shown on this drawing consisted of 3" x 3" x 3/8" steel angle, including the seismic bracing angles. Where two angles are shown back to back, they were welded along the joint on their flat sides (unexposed surface of the wall) with nominal 3/16" fillet welds. The 24" x 24" opening contained a 24" x 24" steel duct section, passing through the wall horizontally, at a 45° angle to the wall plane (not shown on this drawing).

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261
Florida Power & Light
Fig. 1 Test Article – ELEVATION VIEW
Drwn by: D.N. Priest Date: 8/30/94 App'd by: [signature] Date: 8/30/94
Vectra Approval: [signature] Date: 8-30-94

Scale: 1/2"=1'

OMEGA POINT LABORATORIES

ATTACHMENT 3
3-Hour CP&L Test Assembly Frame Detail



Thermo-Lag Fire Test Summary

1-Hour Wall Test (Ref. 3.2)

The objective of this test was to assess the thermal and structural performance capability of a vertical "wall" element when subjected to a 1-hour ASTM E119 fire exposure followed by a hose stream test. Additionally, for purposes of the hose stream test, this wall assembly was to serve as a duplicate specimen in support of a future 3-hour test of an equivalent wall configuration. Specifically, ASTM E119 allows subjecting a duplicate specimen to a fire exposure test for a period equal to one half of that indicated as the fire resistance period, but not for more than 1 hour, followed by subjecting the duplicate specimen to the impact, erosion, and cooling effects of the hose stream test.

The 10 ft x 10 ft framework for the wall assembly consisted of a matrix of 3 x 3 x 3/8 in. steel angle to which two (2) layers of 1/2 in. thick (nominal) prefabricated Thermo-Lag 330-1 panels were bolted. A single steel sleeve penetration was also included in the test assembly.

Florida Power & Light (FPL) was the primary sponsor of this test, and as such, the design utilized to construct the fire barrier wall assembly was representative of configurations installed at St. Lucie. Accordingly, certain additional design features employed to construct fire barrier wall configurations at HNP, such as 1/4 in. thick expanded metal lath between the two layers of Thermo-Lag panels and slightly thicker Thermo-Lag materials were not incorporated into the tested design.

The tested wall assembly successfully withstood the fire endurance test without passage of flame and the unexposed surface temperature increase parameters prescribed by ASTM E119 were not exceeded throughout the 1-hour fire test exposure. Immediately following fire exposure, the assembly was subjected to a hose stream test in accordance with ASTM E119 for a 1-minute duration. However, for purposes of the hose stream test, crediting the 1-hour rated wall assembly as a duplicate specimen for the future 3-hour wall test, ASTM E119 requires a 2-1/2 minute duration of hose stream application. Therefore, upon discovery of this oversight, a second 1-1/2 minute hose stream application was conducted approximately 90 minutes after the initial application. The tested wall assembly did not allow projection of water through the unexposed surface of the barrier during application of either hose stream test.

3-Hour Wall Test (Ref. 3.3)

The objective of this test was to assess the overall thermal performance capability of a wall fire barrier assembly, having equivalent construction as the 1-hour rated configuration, when subjected to a 3-hour ASTM E119 fire exposure such that in-plant barrier configurations could be suitably evaluated. Since the previously qualified 1-hour wall assembly was considered a duplicate specimen, and it satisfactorily withstood a 2-1/2 minute hose stream test, no hose stream test was planned or performed for the 3-hour wall assembly following the fire test. Another objective of this test was to evaluate the performance of different penetration seal designs used to seal steel sleeves that penetrated through the barrier.

Consistent with the 1-hour assembly, a 10 ft x 10 ft framework constructed using 3 in. x 3 in. angle members was utilized. However, the thickness of the steel angle members used for this test was 1/4 in., in lieu of 3/8 in. thick members for the 1-hour assembly. Additionally, evaluation of two different penetration seal designs necessitated including two (2) penetrations through the wall assembly, in lieu of a single steel sleeve penetration for the 1-hour assembly.

As with the 1-hour wall test, FPL was a co-sponsor of the 3-hour test. Therefore, to maintain the construction features of the test assembly consistent with those used at St. Lucie, and the previously tested 1-hour assembly, the supplemental design features previously described used for HNP in-plant configurations were not included.

The tested wall assembly satisfied the ASTM E119 temperature acceptance criteria for a 108-minute duration. The barrier withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste for the entire duration of the 3-hour test. The performance of the penetration seal designs exceeded the rated capability of the wall assembly.

3-Hour Ceiling Test (Ref. 3.4)

The objective of this test was to determine the extent that horizontal "ceiling" elements used to form bottom surfaces of as-installed two-sided barrier configurations could meet ASTM E119 temperature acceptance criteria when subjected to a 3-hour fire test exposure. Since ASTM E119 does not invoke performance of a hose stream test as a condition for acceptance for floor/ceiling assemblies, no hose stream test was planned or performed for the ceiling fire barrier.

IES Utilities, AEP and CP&L jointly sponsored this test; with each utility having site specific designs for ceilings and/or structural beam members constructed or protected using Thermo-Lag 330-1 materials. To perform the test OPL's 12 ft x 18 ft x 7 ft deep horizontal furnace was used to simultaneously subject all three (3) test specimens (one representing each utility configuration) to a standard ASTM E119 fire test exposure. The 18-ft dimension of the furnace was subdivided into three (3) sections and gaps between the individual test articles were sealed with refractory fiber insulation.

The CP&L ceiling fire barrier assembly was constructed consistent with the HNP configurations using a framework consisting of 3 x 3 x 1/4 in. steel angle. The overall dimensions of the framework were 12 ft long x 5 ft 9 in. wide. Four (4) cross-member angles were welded to the framework across the width of the assembly. Sections of 1/4 in. thick expanded metal lath were spot welded to the perimeter framework and to the cross-angle members. Two (2) layers of site fabricated Thermo-Lag 330-1 panels were bolted to the underside of the metal lath. The top surface of the metal lath was covered using Thermo-Lag trowel grade material with an embedded layer of stress skin. Therefore, the expanded metal lath was embedded within Thermo-Lag 330-1 material having an overall minimum thickness of 1.75 in. The steel angle members were covered with Thermo-Lag trowel grade material having a thickness of approximately 3/4 in.

The ceiling test assembly withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste for the 3-hour test duration. Additionally, the temperatures recorded on the unexposed side of the barrier were well below the ASTM

E119 acceptance parameters, however, at approximately 27 minutes into the test the assembly began to sag along its 12 ft. unsupported edge. This portion of the assembly was located along the interface region between the CP&L ceiling assembly and an adjacent configuration being tested for one of the co-sponsoring utilities. Therefore, this framing member was not supported by the perimeter of the test furnace. To mitigate the deflection effects, at approximately the 1-hour mark, a chain fall was attached to the framing member to support it for the remainder of the test. As described in Section 4.4, use of this external support means to mitigate deflection of a barrier frame member does not invalidate qualification of the ceiling assembly for a 3-hour rating in accordance with ASTM E119.

REV. 0

Design HNP-M/MECH-1065 Revision 0

ASSESSMENT OF TESTED AND AS-BUILT THERMO-LAG FIRE BARRIER CONFIGURATIONS

The signature below of the Lead Reviewer records that:

- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☒ **Design Verification Review** ☐ Engineering Review ☐ Owner Review

☒ Design Review

☐ Alternate Calculation

☐ Qualification Testing

☐ **Special Engineering Review**________________

☐ YES ☒ N/A **Other Records are attached.**

David E. McAfee/David E. McAfee 08/17/2001 **Fire Protection/HESS** **07/20/1001**
Lead Reviewer (print/sign) **Discipline** **Date**

Item No.	Deficiency	Resolution
1)	Pg. 5; DO NOT spell out Omega Point Lab again it is already defined on page 4. Use acronym.	Incorporated
2)	Pg. 9, Last bullet; Provide additional details/explanation as to why this is acceptable. Be explicit, Stand Alone.	Incorporated
3)	Pg. 10, Section 4.2.2, 1st Bullet; Provide an actual figure for the difference in the longest length of angle member.	Incorporated
4)	Pg. 10, Section 4.2.2, 2nd Bullet; What are the thermal conductivity numbers for the T-Lag vs. Steel for comparison.	Incorporated
5)	Pg. 10, 3rd Bullet; Provide detailed explanation since some readers may not have easy access to Reference 3.13. Stand Alone.	Incorporated
6)	Pg. 12, Section 4.2.4, 1st Bullet; The second penetration changed the structural arrangement of the tested configuration. Why did it not change the thermal performance of the test? Stand Alone.	Clarification Incorporated
7)	Pg. 12, Section 4.2.4, 2nd Bullet; Why do the structural changes from one test to the other not change the performance results.	Both assemblies included the same large opening, which is the limiting case from a structural performance perspective, and

REV. 0

	Stand Alone.	the FPL assembly passed the hose stream test.
8)	Pgs. 12 & 13, Section 4.2.5; This description describes the construction of the test barrier. It does not mention that the support angles on the Fire Side are covered with trowel grade Thermo-Lag material. How is it attached? Wire mesh, etc.	Section 4.2.5 states "Thermo-Lag 330-1 trowel grade material was then applied over the panel joint areas, the exposed nuts and washers and on the steel angle framework."
9)	Pg. 16, Section 4.3.1, 2nd paragraph; This references a 3 x 3 x 1/4 angle attached to the floor. The test used a 3 x 3 x 3/8 angle for the perimeter members. Address this difference.	Differences in steel member sizes for tested & installed configurations have been adequately addressed in Section 4.3.1.
10)	Pg. 17, top paragraph; Reference the largest panel size to support the last sentence in the paragraph.	Incorporated
11)	Pg. 17, Section 4.3.3, 2nd paragraph; The second to last sentence references ¾ in Thermo-Lag applied to the outside and inside of the duct. This is not done in the plant. Only the outside of the duct is covered, per drawing, CAR-2168-528 S05.	The tested configuration used blockouts lined with steel sleeves as penetrations. Unlike penetrating HVAC ducts, the inside & outside surfaces of sleeve penetrations are covered with trowel grade material per DCNs 650-697, 650-724, 650-742, 650-789.
12)	Pg. 18, Section 4.3.4, 1st paragraph; Should "or Thermo-Lag" be added to the last sentence to additionally clarify?	Incorporated
13)	Pg. 19, Section 4.3.5, 2nd paragraph; Is the metal lath installed between the two T-Lag panels or on the structural steel or both? I always thought it was installed between the two panels. Clarify.	Clarification Incorporated
14)	Pg. 19, Section 4.3.5, 2nd Bullet; Clarify that the trowel grade is covering only the outside of the bolts. "Nut and Washer", not bolt head on the inside.	Clarification Incorporated
15)	Pg. 23, 2nd Bullet; ADD "as" BEFORE "installed configuration....", to clarify that this is describing the as built in the plant configuration.	Incorporated
16)	Pg. 24, conclusion paragraph; The term "replicate" is not the exact condition, since the chain fall does not truly replicate the plant support. Explain better, Stand Alone.	Clarification Incorporated