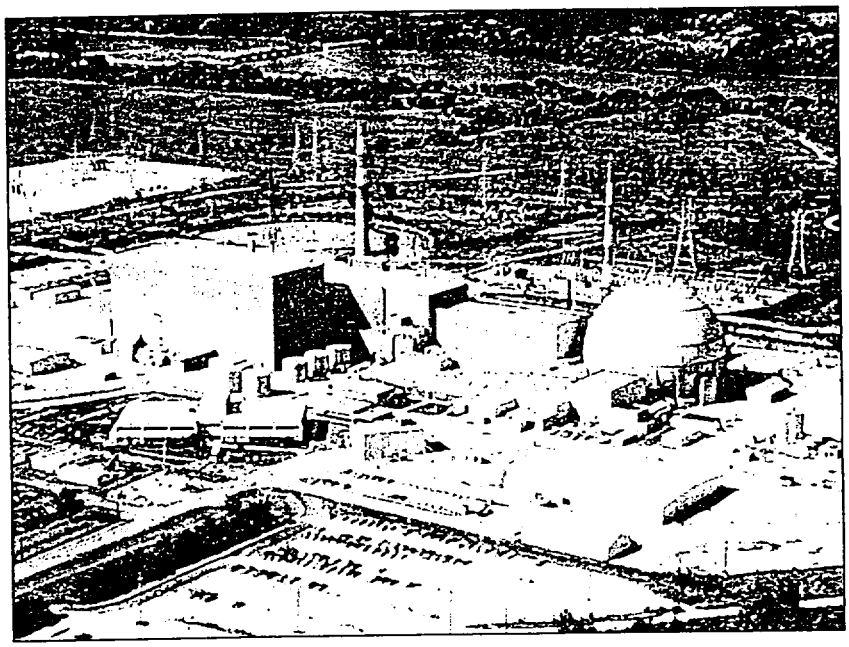
# COMMONWEALTH EDISON COMPANY
# DRESDEN NUCLEAR STATION
# UNITS 2 & 3



## 99-4025
## PENETRATION SEAL ASSESSMENT

(Dresden Report No. 12-N208-04)

Revision 0

December 17, 1999

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# PENETRATION SEAL ASSESSMENT

# DRESDEN NUCLEAR POWER STATION

## December 17, 1999

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# 1.0 GENERAL

This section of the assessment provides general information regarding this assessment.

## 1.1 Purpose

The purpose of this assessment is to:

1. Identify the Dresden Station fire penetration seal design details,
2. Confirm that these design details are fully qualified by approved fire test(s) or station evaluation(s), and
3. Organize bounding design parameters for each qualified fire penetration seal detail in a user-friendly format for use in modifications and surveillances.

## 1.2 Scope

The assessment qualifies Dresden Unit 2 and Unit 3 fire penetration seal design details used to protect openings through fire barriers for mechanical and electrical (pipe, conduit and cable trays etc.) components. The scope is limited to assessing the fire penetration seal design details installed in fire barriers used for Fire Safe Shutdown (10 CRF50 Appendix R, Section III.G) and to protect safety-related areas (UFHA, Appendix A to APCSB 9.5-1 Comparison). The qualification is limited to fire resistance only. Qualification for other features such as environmental isolation or pressure differentials are beyond the scope of this assessment.

## 1.3 Methodology

The following methodology was used to prepare this assessment.

1.3.1 A search was performed to identify the Station licensing commitments applicable to the fire penetration seals.

1.3.2 Pertinent inputs (drawings, test reports, evaluations, and procedures) were gathered from the Station.

1.3.3 Fire penetration seal details installed at the Station were identified by reviewing Station procedures DFPS 4175-02 and DFPS 4175-03.

1.3.4 Generic fire penetration seal design bounding parameters were developed using station commitments as input.

1.3.5 A fire test qualification procedure was developed. The procedure outlined the primary testing methodologies and criterion.

1.3.6 The quality of fire tests was verified by reviewing them against the test qualification procedure.

1.3.7 The qualified test documentation and previously performed station engineering evaluations were then used to determine bounding design parameters for the station's fire penetration seal details.

1.3.8 ComEd fire penetration seal detail drawings were revised to include the bounding design parameters.

## 1.4 Assumptions

None

## 1.5 Dresden Station Licensing Commitments

Commitments were identified by reviewing licensing basis documents contained in the Dresden Fire Protection Report (FPR) (Reference 5.12) and the Dresden Fire Protection Program Documentation Package (FPPDP) (Reference 5.13 and 5.14).

In the initial Dresden Safety Evaluation Report (SER) dated March 22, 1978, the NRC stated: *"The licensee will provide a description of the test program for cable penetration fire stops and subsequent test results."* In response, the Station issued letters dated April 14, 1978, June 29, 1978, and September 29, 1978 to the NRC.

The April 14, 1978 letter stated ComEd's proposed test procedure for cable penetration fire stops used at Dresden, Quad Cities, and Zion. This letter and procedure made the following commitments regarding testing of cable penetration fire stops. These commitments follow the general guidelines of IEEE Standard 634 - 1978 edition.

Standard Time-Temperature Curve

The fire tests of the fire stops shall be controlled by the standard time-temperature curve as defined in ANSI/ASTM E119, 1976.

Exposed Side Temperature

The temperature on the exposed side shall be the average temperature obtained from the readings of a minimum of two thermocouples symmetrically disposed and distributed to show the temperature for each cable penetration fire stop. Not less than 5 thermocouples per 100 square feet shall be used.

The thermocouples shall be enclosed in sealed porcelain tubes, 3/4" in outside diameter and 1/8" in wall thickness. The exposed end of the pyrometer tube and thermocouple in the flame area shall be not less than 12 inches. Other types of protecting tubes or pyrometers may be used that give equivalent test results.

For cable penetrations through floors, the junction of the thermocouples shall be placed 12 inches away from the exposed face of the test penetration. In the case of cable penetrations through walls the thermocouples shall be placed 6 inches away from the exposed face of the penetration.

The temperatures shall be read at intervals not exceeding 5 minutes during the first 2 hours and at intervals of 10 minutes or less thereafter.

Unexposed Side Temperature

Temperatures on the penetration cold side shall be measured with thermocouples located on the surface of each fire stop under test.

Temperature shall be measured at the cable jacket/cable penetration fire stop interface, the interface between the fire stop and through-metallic components other than the insulated cable conductor, and on the surface of the fire stop material.

Temperature readings shall be taken at intervals not exceeding 15 minutes until a reading exceeding 212° F has been obtained at any one point. Thereafter, the readings may be taken more frequently at the discretion of the tester, but the intervals need not be less than 5 minutes.

Cable Insulation

The cable within the penetration shall protrude 3 to 5 feet on the unexposed side. The cable on the exposed side shall protrude a minimum of 1 foot. Vertical cables in floor penetration tests shall be supported on the unexposed side to simulate continuous cables as in an actual installation.

Acceptance Criteria

A fire stop shall be considered acceptable if it remains in the opening during the fire endurance test without permitting passage of flame or the occurrence of flaming on any element of the unexposed surface (i.e. Cable) of the assembly for a period equal to the hourly rating for the fire stop.

Cellular Concrete Fire Stops

Based on the justification in Appendix A of the test procedure, ComEd did not intend to include cellular concrete fire stops in the test program. However, the NRC responded to this justification stating that they believe the justification to be reasonable, however, the justification must be supported by tests.

Cable Construction

Since cables used at ComEd are not IEEE 383 qualified, ComEd proposed to use PE-PVC cable construction for the fire stop tests. The PE-PVC cable construction is believed to have flammability characteristics comparable to or greater than BR-PVC cable, which is used at Dresden.

In a letter dated May 26, 1978, the NRC responded to ComEd's proposed test procedure. In this letter, the NRC found the proposed test procedure acceptable, with the following exceptions:

Acceptance Criteria

Ensure that the temperature levels for the unexposed side are analyzed and demonstrate that the maximum temperatures are sufficiently below the cable ignition temperature.

The test should be expanded to include a hose stream test. The hose stream test should demonstrate that the barrier remains intact and does not allow projection of water beyond the unexposed surface.

Cellular Concrete Fire Stops

The fire test procedure should include at least one test for cellular concrete penetration seals.

The June 29, 1978 letter transmitted the preliminary test results to the NRC. No licensing commitments were made in this letter.

The September 29, 1978 letter transmitted the final results of the cable penetration fire test. Most of the items addressed in the NRC letter of May 26, 1978 were addressed in this test. However, a hose stream test was not performed. In a supplement to the March 1978 SER, transmitted via letter dated 12/2/80, the NRC stated that the Dresden Units 2 and 3 cable penetration barriers satisfy the objectives of Section 2.2 of the SER and are, therefore, acceptable. However, no mention was made regarding the lack of a hose stream test.

The Updated Fire Hazards Analysis (UFHA), Section 2.3.1.2 states that all penetrations in a fire resistive barrier are protected so that they have an equivalent fire resistance rating, or were evaluated to ensure their

adequacy to withstand the hazards associated with the area. This includes doors, wall penetrations, and dampers.

The UFHA, Section 3.7.1 states that wherever cables pass through barriers for which credit is taken in the Appendix R analysis or a previous commitment was made, it was demonstrated that the penetrations are sealed in a manner that preserves the integrity of the fire barriers in accordance with the requirements of Appendix A to BTP APCSB 9.5-1.

The UFHA, Section 3.7.2 states that, in accordance with the Appendix R safe shutdown analysis, certain walls and floors in the reactor building, turbine building, and service building are required to have a 3-hour fire resistance rating. To justify the 3-hour rating of a wall, all mechanical penetrations must be sealed and those seals must be 3-hour fire rated.

Section 5.0 of the UFHA contains the Appendix A to BTP APCSB 9.5-1 comparison. Section 5.4.D.3 (d) contains the requirements for cable penetrations. ComEd's response to this item states the following: "Cable and cable tray penetrations are sealed to give protection equivalent to that of the rated fire barrier. The evaluation of existing penetration seals is provided in the report entitled, 'Review of Existing and Proposed Penetration Seal Fire Testing and Installation Program.'" This report identifies that the 1978 fire tests did not address all the seal configurations in the plant. As a result, additional testing was performed and documented in a report titled, "Evaluation of the Penetration Seal Systems at the Dresden and Quad Cities Nuclear Power Plants." This report documents the penetration seal test requirements and test results (bounding parameters).

To summarize, the following are the Station's licensing commitments as identified in the Station's FPR and FPPDP:

1. The fire tests of the fire stops are exposed to the standard time-temperature curve as defined in ANSI/ASTM E119, 1976.

2. Fire tests are performed in accordance with IEEE 634 – 1978, "IEEE Standard Cable Penetration Fire Stop Qualification Test."

3. All penetrations in a fire resistive barrier are protected so that they have an equivalent fire resistance rating, or were evaluated to ensure their adequacy to withstand the fire hazards associated with the area.

# 2.0 TYPICAL SEAL DETAILS

## 2.1 Introduction

Section 2.2 identifies the applicable bounding design parameters of the fire penetration seal details. Section 2.3 summarizes the station evaluations. Sections 2.4 and 2.5 provide the following information with regards to the electrical and mechanical fire penetration seal details, respectively:

1. Location of fire penetration seal details by drawing.
2. A brief description of the seal's physical characteristics.
3. The fire test or station evaluations that qualifies the fire penetration seal detail.
4. The bounding design parameters for the seal details where the qualification documents existed.

## 2.2 Bounding Design Parameters

ComEd standard NES-MS-05.2 provides acceptance criteria for qualifying regulatory required fire barrier penetration seals. In accordance with this standard, the bounding design parameters for evaluating penetration seals are:

1. Barrier Construction and Thickness
2. Maximum Size of Sealed Openings
3. Penetrating Items (Quantity, Type, Size)
4. Spacing of Penetrants
5. Orientation
6. Cable Fill
7. Seal Material
8. Damming Material
9. Symmetry

Each bounding design parameter is discussed in detail below.

### 2.2.1 Barrier Construction and Thickness

Common types of barrier construction include poured concrete, hollow concrete block, filled concrete block, and gypsum wallboard. The thickness required to provide a specific fire resistance rating varies for each type of construction. The type and thickness of the barrier in which a penetration seal is installed is important for a number of reasons. For

example, a thicker concrete wall would provide a better heat sink than a thinner wall of the same construction.

When evaluating the installed penetration seal assembly against tested configurations, the following must be considered:

a. The construction material of the fire barrier containing the installed and tested penetration seal configurations should be comparable.

b. The use of a particular fire barrier slab thickness for testing can be used to qualify similar configurations of greater slab thickness except thinner installed slabs can be used where the minimum thickness of penetration seal material is maintained.

2.2.2 Maximum Size of Sealed Openings

The opening size for a particular penetration seal configuration should not exceed the opening size of the tested configuration. The opening size for a tested configuration can be used to qualify the same configuration for a smaller opening. An opening which exceeds the maximum opening size of the fire test may result in an excessive unsupported span of seal material, which would violate the spacing of penetrants rules.

2.2.3 Penetrating Items (Quantity, Type, Size)

The quantity of through components affects the amount of heat transferred to the unexposed side of the seal assembly. Different types of penetrants transfer different amounts of heat. In general, penetrating items having a larger diameter represent a more severe condition than those having a smaller diameter. A fewer number of penetrating items is typically better than a larger quantity provided penetrant spacing is considered to ensure the overall structural integrity of the assembly is not compromised.

When evaluating the installed penetration seal assembly against tested configurations, the following must be considered:

a. The installed penetrants should be comparable.

b. The material type of the installed penetrating item and the tested penetrating item should be comparable.

c. The size of a particular penetrating item should not exceed the size of the largest penetrating item in the tested configuration.

2.2.4 Spacing of Penetrants

The spacing between penetrating items and between the penetrating items and the barrier must be evaluated to ensure the spacing is not less than the minimum tested spacing. The minimum spacing served two important purposes. First, adequate separation between penetrating items must be maintained to ensure continuity of the sealant material during the installation process. Second, through metallic components, which are in contact with each other typically, transfer more heat to the unexposed side than similar penetrating items, which are separated. The absence of an intervening seal material lessens the ability of the seal to absorb heat from the penetrating items before it is transferred to the unexposed side of the seal assembly.

2.2.5 Orientation

Seal assemblies may be installed in one of two orientations, either a wall orientation or a floor/ceiling orientation. Seals installed in floor/ceilings are more likely to fail due to the higher severity exposure. Additionally, large spans of unsupported materials such as ceramic fiber and silicone foam without permanent damming are more likely to be affected by the eroding effects of a hose stream than would the same materials covered by a rigid damming board.

Since a qualified floor/ceiling configuration is considered worse case, a penetration assembly installed in a wall is qualified by a similar penetration assembly tested in a floor/ceiling.

2.2.6 Cable Fill

Cables passing through penetration seals provide a means for heat transmission through the barrier. The higher the cable mass passing through the barrier, the higher the amount of heat transmission to the unexposed side. Therefore, a higher cable fill percentage in the tested configuration can be used to qualify the same or smaller cable fill percentages in the installed configuration.

2.2.7 Seal Material

In order for a penetration seal assembly to be qualified, the installed seal materials must be similar to the tested seal configuration. In addition, satisfactory testing of a particular seal configuration with a specific seal material thickness can be used to qualify the same configuration with a greater thickness of the same material.

2.2.8 Damming Material

Damming materials can be either permanent or temporary. Damming materials are primarily used to keep the primary seal materials is place during cure. Sometimes the damming materials are removed prior to the test. If damming materials are left in place during the test, then similar damming materials must be used and left in place in the installed barrier.

2.2.9 Symmetry

The symmetry of a penetration seal, when required by design, must also be considered. Configurations that are not symmetrical should be tested on both sides.

## 2.3 Engineering Evaluations

"*Evaluation of Penetration Seal Systems at the Dresden and Quad Cities Nuclear Power Plants*" Professional Loss Control, Inc. Rev. 0, September 21, 1987

In 1984 Commonwealth Edison Company contracted Professional Loss Control, Inc. (PLC) to evaluate the fire protection programs and features at their Dresden and Quad Cities Nuclear Stations. In the interest of providing more complete documentation on the adequacy of existing fire barrier penetration seals, additional fire tests were performed. Commonwealth Edison Company decided to pursue a fire testing program in hopes of:

1. Resolving discrepancies between the 1978 test results and accepted test standard procedures issued subsequent to that test.
2. Any variations between electrical penetrations sealing system found in the plant and those tested in the 1978 Test Program.
3. Demonstrating that the electrical penetration sealing systems installed at the Station are acceptable and do have a 3 hour fire resistive rating.
4. Documenting the conditions for installing electrical penetration seals based on actual fire test.

A test plan was developed on the basis of bounding conditions and IEEE 634 test criteria. Plant walkdowns were performed to determine the installed configurations. These walkdowns concluded the following:

1. Two types of configurations were found throughout the plant and encompassing the majority of the penetrations. The first configuration

was cables routed through a 5" diameter conduit sleeve penetrating a barrier. The other configuration was cables routed in a cable pan through a barrier. These configurations were found in horizontal and vertical positions.

2. Similar design details were found between Dresden and Quad Cities Nuclear plants. These details were identified on Station drawings 12E-6508 and 12E-6508A for Dresden and 4E-6508 and 4E-6508A for Quad Cities. Details 2, 8, 10, and 11 on 12E-6508 and Detail 17 on 12E-6508A were identified in the plant during the walkdowns. The remaining details were not identified in the walkdown of Appendix R Barriers and were excluded from the testing program.
3. Cable jacking found in the plant was predominately PE/PVC and PE/BR (non IEEE 383 qualified).
4. The walkdowns identified that repairs had been made to penetrations. When repairs were made, portions of the seal were cut, new cables pulled through the seal and fiber material packed around the new cables. The seal surface was recoated with mastic around the new cable to cover the fiber. In cases, different mastic and fiber products were used in the repairs. In cases, the original ceraboard had been removed to facilitate the installation of new cabling.
5. Cable Fills for conduit sleeve and cable pans were established comparing the installed configurations with the Slice Computer database. As a result, a minimum cable fill of 5% and maximum of 40% were established to bound the majority of installed configurations.
6. The selection of the maximum opening and cable pan size for the test was determined by the information gathered from the walkdown. The maximum opening size was established at 47" by 7". The opening size bound the majority of installed configurations. The maximum cable pan dimension was established as 32" by 6".

A test design was developed to encompass the worst case parameters identified above. The purpose of the test was to bound large amount of data with a single fire test. The test was designed to bound the following parameters:

1. Maximum Cable Fill Density – 40%
2. Minimum Cable Fill Density of – 5%
3. Minimum Distance Between Penetrants and Boundary – Tray bottom resting against barrier
4. Maximum Distance Between Penetrant and Boundary – 12 ½"
5. Cable Tray Construction – Solid Bottom

6. Cable Jacket Material – PE-PVC (non IEEE 383 qualified)
7. Maximum Cable Size – 250 MCM
8. Cable Tray Passing Through Barrier
9. Maximum Cable Tray Size – 32" x 6"
10. Maximum Opening Size – 45" x 7"
11. Configuration – Wall or Floor
12. Minimum Sealing Material Thickness – 12"
13. Minimum Density of Sealing Material – 9 lb./ft.$^3$
14. Damming Material – $^1/_8$" of mastic
15. Minimum Barrier Thickness – 12"
16. Symmetry – Symmetrical seals tested

The test was performed in accordance with IEEE 634-1978 test criteria at Construction Technology Laboratories (CTL). The seal assemblies passed the 3 hour fire exposure test and hose stream test in accordance with IEEE 634-1978 standard. The following test criteria were met.

- The unexposed side temperature never exceeded 700° F.
- No flame propagation or flame though was observed on the unexposed side.
- No water projected beyond the unexposed surface at any penetration during the hose stream test.

The following conclusions regarding penetration limitations and seal design parameters were made based on the successful results of the 1986 fire test. Penetration assemblies within these limitations were considered to have a 3 hour fire rating. The limitations are as follows:

Penetration Limitations:

| | |
|---|---|
| 1) Maximum tray size and fill density | 32" x 6" tray with between 40% and 5% cable fill. |
| 2) Maximum opening | 45" x 7"<br>Minimum distance of tray side to barrier – ½"<br>Minimum distance of bottom of tray to barrier – 0" |

| | |
|---|---|
| | (A minimum ½" clearance recommended between bottom of tray and barrier with cerafiber for future installations but the test passed with no clearance between the barrier and tray bottom.)<br>Maximum distance side of tray to barrier – 12 ½" |
| 3) Cable sizes and jacketing | Maximum cable conductor is 250 MCM. Any larger cables must be reviewed separately and documented. Cable fill densities should not exceed 40% in cable trays or 40% in 5" diameter conduit s without specific documented evaluations.<br>All future cable jacketing is required to be IEEE-383 qualified but the test used non-qualified PC-PVC jackets. |
| 4) Penetrant configuration | Either floor/ceiling or wall configuration<br>. |
| 5) Maximum blank opening | Maximum opening without penetrating items sealed with a cerafiber mastic seal design is 12 ½" x 7". |

Cable Tray Limitations:

| | |
|---|---|
| 1) Fiber density and depth | Minimum density 9 lb./ft.$^3$ For a minimum depth of 12". (Fiber packed "hand-tight" in a penetration 12" deep was calculated to be more than 9 lb./ft.$^3$) |
| 2) Mastic thickness | Minimum thickness of $^1/_8$" over entire seal overlapping the opening by 1". |
| 3) Minimum barrier thickness | 12" thick barrier construction to achieve a 3 hour barrier. |
| 4) Mastic Materials | Flamastic 77, Vimasco 3I, Flamesafe S-100, GE RTV-133 can be used entirely or in combination as repairs to cover the Cerafiber. |
| 5) Fiber fills | Minimum 12" depth of Cerafiber and /or Kaowool. |
| 6) Ceraboard | 1" thick Ceraboard is not required but may be used on either side of the seal to aid the application of mastic covering. Both cases passed the fire test. |

5" Diameter Conduit Sleeve Seals Between Reactor/Turbine Buildings Limitations:

| | |
|---|---|
| 1) Sleeve arrangement | Sleeves must be cast in barrier, grouted or sealed between barrier and sleeve with a 3 hour rated and approved seal. |
| 2) Sleeve diameter | Maximum 5" diameter, no minimum diameter. |
| 3) GE-RTV-133/fiber seal design | Minimum 9 lb./ft.$^3$ of fiber packed 48" deep in a 48" thick barrier. Minimum $^1/_8$" thick mastic coating applied to both sides of the seal. |

| | |
|---|---|
| 4) RTV-627/fiber seal design | Seal arrangement can be in either a floor/ceiling or wall configuration.<br>Minimum 3" fiber covered with minimum ¼" mastic on low end.<br>Sleeve in minimum 48" thick barrier.<br>Sleeve may only be installed at 5° incline to allow the RTV to flow into the sleeve.<br>Pour RTV-627 mix into the sleeve in proportion of 1 gallon/280 $in^3$ of void space around cables.<br>Minimum of 9 $lb./ft.^3$ fiber in remaining void space for minimum overall seal thickness of 48".<br>Upper end covered with minimum ½" thick mastic over fiber. |

In addition, an evaluation of the mechanical penetrations was performed. The mechanical penetration evaluation involved four stages:

1. Review existing mechanical seal details to determine which seal arrangements would provide an adequate barrier to fire.

   Typical mechanical penetration seal details used at Dresden and Quad Cities Nuclear Stations were reviewed. These details were identified on drawings B-440/B-442 for Dresden and M-608/M-609 for Quad Cities. These details were reviewed for combustible content (e.g. Urethane foam) and low melting point materials (e.g. Lead wool). If a detail contained such materials, they were rejected for use in fire barriers. Details using grout or steel plate were compared to similar material designs with established fire rating.

2. Identify all mechanical penetrations in fire barriers and determine which details, if any, were used for each.

   Plant walkdowns were conducted to identify all plant fire barriers in the Append R Safe Shutdown and fire Hazard Analyses.

3. Install, repair, or replace unacceptable penetrations seals with approve arrangements.

   Commonwealth Edison began a modification program for their mechanical penetration seals located in fire barriers, based on the conclusions from the walkdown.

4. Evaluate unique seal arrangements that are not 3 hour fire rated.

During the walkdown, a number of penetration seals were found which deviated from standard details. These penetrations were evaluated on a case-by-case basis.

ABB Impell Fire Seal Report No. 597-341-001, Rev. 0, September 1992

In 1992, a review of penetration seal details was conducted for Zion Station. Zion Station penetration details found on 22E-0-3130 sheet 1 are similar to the details found on Dresden drawing 12E-6508 and Quad Cities drawing 4E-6508. As part of the Zion review, ABB Impell performed and evaluation to provide bound parameters for these details based on the qualified fire test configurations. The ABB Impell report was utilized to provide bounding parameters that were not specified as part of the PLC Evaluation stated above.

## 2.4 Electrical Details

The following list identifies the electrical details at the Station. The 'Installed' column indicates if the detail is identified in the station surveillance procedures DFPS 4175-02 and DFPS 4175-03. The 'Qualified' column indicates if the detail is qualified by an evaluation or fire test. The bounding design parameters for qualified design details are documented in Appendix C. The specific evaluation and fire test information is documented in Appendix C.

| *No.* | *Detail* | *Description* | *Installed* | *Qualified* | | |
|---|---|---|---|---|---|---|
| | | | | *Y/N* | *Fire Test* | *Eval.* |
| 1. | Detail 1, Drawing 12E-6508 | This penetration detail is for a sleeve through a fire stop at the base of a Control Board through the Control Room floor. | N | N | | |
| 2. | Detail 2, Drawing 12E-6508 | This penetration detail is for a cable opening with or with out a conduit sleeve. This detail represents a cable opening through an existing flame retardant mastic and inorganic fiber penetration fire stop system, with or without a conduit sleeve. | Y | Y | | Y |
| 3. | Detail 3, Drawing 12E-6508 | This penetration detail is for an unused penetration sleeve filled with fiber and capped. | N | N | | |
| 4. | Detail 4, Drawing 12E-6508 | This penetration detail is for an unused penetration sleeve filled with fiber and capped. | N | N | | |
| 5. | Detail 5, Drawing 12E-6508 | This detail represents a conduit terminating at a cable pan, junction box, panel, or other similar conduit termination point on one side of a floor or wall and free air cables through an open conduit or conduit bushing on the other side. | Y | Y | | Y |
| 6. | Detail 6, Drawing 12E-6508 | This penetration detail is a repair detail for cracks in existing cellular concrete fire stops. | N | N | | |
| 7. | Detail 7, Drawing 12E-6508 | This penetration detail is for an unused penetration sleeve filled with fiber, and sealed with a mastic covering. | N | N | | |
| 8. | Detail 8, Drawing 12E-6508 | This penetration detail represents a cable tray riser through the floor. | Y | Y | | Y |
| 9. | Detail 9, Drawing 12E-6508 | This detail is a cable pan fire stop that would be installed in a cable pan between ESS divisions. | N | N | | |

| No. | Detail | Description | Installed | Qualified | | |
|---|---|---|---|---|---|---|
| | | | | Y/N | Fire Test | Eval. |
| 10. | Detail 10, Drawing 12E-6508 | This penetration detail represents a cable tray riser through a wall. | Y | Y | | Y |
| 11. | Detail 11, Drawing 12E-6508 | This penetration detail is for a cable opening with or with out a conduit sleeve. This detail represents an existing cable opening previously sealed with GE RTV-108 sealant. | N | Y | | Y |
| 12. | Detail 12, Drawing 12E-6508 | This penetration detail is for a cable pan through a floor. | N | N | | |
| 13. | Detail "Repair Detail for Opening Under 2/3 Control Room Center Desk, Drawing 12E-6508 | This penetration detail is for a repair of an opening in the Unit 2/3 Control Room. | N | N | | |
| 14. | Detail 13A, Drawing 12E-6508A | This detail is a fire stop detail in a vertical cable riser. | N | N | | |
| 15. | Detail 13B, Drawing 12E-6508A | This penetration detail is a vertical cable opening through a floor. | N | N | | |
| 16. | Detail 14, Drawing 12E-6508A | This detail is a fire stop detail in a horizontal cable tray. | N | N | | |
| 17. | Detail 15, Drawing 12E-6508A | This penetration detail is a horizontal firestop in a conduit sleeve. | N | N | | |
| 18. | Detail 16, Drawing 12E-6508A | This penetration detail is a horizontal firestop in a conduit sleeve. | N | Y | | Y |
| 19. | Detail 17, Drawing 12E-6508A | This penetration detail represents a penetration through the secondary containment wall. Two details are shown, the first detail is for an existing air seal and firestop and the second detail is for a new air seal and firestop. | Y | Y | | Y |
| 20. | Detail 18, Drawing 12E-6508A | This penetration detail is a horizontal firestop in a conduit sleeve. | N | Y | | Y |
| 21. | Detail 19, Drawing 12E-6508A | This detail is an internal conduit fire stop. | N | N | | |

| No. | Detail | Description | Installed | Qualified | | |
|---|---|---|---|---|---|---|
| | | | | Y/N | Fire Test | Eval. |
| 22. | Detail 20, Drawing 12E-6508A | This detail is an internal conduit fire stop. | N | N | | |
| 23. | Detail 21, Drawing 12E-6508B | This penetration detail is a firestop in a conduit sleeve. This detail shows a 3-hour rated firestop assembly for electrical cables passing through a minimum 6" barrier. | N | N | | |
| 24. | Detail 22, Drawing 12E-6508B | This penetration detail is a firestop in a conduit sleeve. This detail shows a 3-hour rated firestop assembly for electrical cables passing through a minimum 6" barrier. | N | Y | Y | |
| 25. | Detail 23, Drawing 12E-6508B | This penetration detail is an existing firestop in a conduit sleeve. This detail shows a 3-hour rated firestop assembly for electrical cables passing through a minimum 6" barrier. | N | N | | |
| 26. | Detail 24, Drawing 12E-6508B | This penetration detail is a firestop in a conduit sleeve with no penetrating items. This detail shows a 3-hour rated firestop assembly through a minimum 6" barrier. | N | N | | |
| 27. | Detail 25, Drawing 12E-6508B | This penetration detail is a Unit 2/3 Control Room firestop and air seal. | N | N | | |

## 2.5 Mechanical Details

The following list identifies the electrical details at the Station. The 'Installed' column indicates if the detail is identified in the station surveillance procedures DFPS 4175-02 and DFPS 4175-03. The 'Qualified' column indicates if the detail is qualified by an evaluation or fire test. The bounding design parameters for qualified design details are documented in Appendix C. The specific evaluation and fire test information is documented in Appendix C.

| *No.* | *Detail* | *Description* | *Installed* | *Qualified* | | |
|---|---|---|---|---|---|---|
| | | | | *Y/N* | *Fire Test* | *Eval.* |
| 1. | Details 1 and 1A, Drawing B-440 | These details represent a cored opening with a steel sleeve and a steel plate. | Y | Y | | Y |
| 2. | Detail 2, Drawing B-440 | This detail represents a cored opening with a steel sleeve and a steel plate with a pipe passing through. | Y | Y | | Y |
| 3. | Details 3, 3A, and 3B, Drawing B-440 | These details represent a sleeve opening with an insulated pipe. | N | N | | |
| 4. | Detail 4, Drawing B-440 | Detail 4 is a cored opening with insulated pipe or empty hole. | N | N | | |
| 5. | Detail 5, Drawing B-440 | Detail 5 is a cored opening with insulated or uninsulated pipe through a pipe sleeve. Detail shows a 2" gap between the penetrant and the grout. | Y | Y | | Y |
| 6. | Details 6 and 6A, Drawing B-440 | These details are for an uninsulated pipe through a cored opening. | N | N | | |
| 7. | Detail 7, Drawing B-440 | This detail is a pipe or conduit in opening sealed with grout. | Y | Y | | Y |
| 8. | Detail 8, Drawing B-440 | This detail is an uninsulated pipe with a steel sleeve and a steel plate. | N | N | | |
| 9. | Detail 9, Drawing B-440 | This detail represents an opening with a steel plate. | Y | Y | | Y |
| 10. | Details 10, 11, and 11A, Drawing B-440 | Detail shows a 2" gap between the penetrant and the grout. | Y | Y | | Y |
| 11. | Details 12 and 13, Drawing B-440 | These details represent an opening with a steel plate. | Y | Y | | Y |
| 12. | Detail 14, Drawing B-440 | Detail shows a 2" gap between the penetrant and the grout. | Y | Y | | Y |
| 13. | Detail 15, Drawing B-440 | This detail is a pipe in floor slab with 4" of concrete in opening. | N | Y | | Y |
| 14. | Detail 16, Drawing B-440 | This detail is a steel plate around pipes. | N | N | | |
| 15. | Detail 17, Drawing B-440 | This detail is a pipe through a sleeve. | N | N | | |

| No. | Detail | Description | Installed | Qualified | | |
|---|---|---|---|---|---|---|
| | | | | Y/N | Fire Test | Eval. |
| 16. | Detail 18, Drawing B-440 | This detail is a pipe through an opening filled with lead wool. | N | N | | |
| 17. | Detail 19, Drawing B-440 | This detail is a collar shielding for pipe through a cored opening. | N | N | | |
| 18. | Detail 20, Drawing B-440 | This detail is a collar shielding for pipe through a cored opening. | N | N | | |
| 19. | Detail 21, Drawing B-440 | This detail is for a typical insulated pipe ventilation seal in the 4" CMU wall inside of the Auxiliary Electric Equipment Room. | N | N | | |
| 20. | Detail 22, Drawing B-440 | This detail consists of three separate details. The first detail is for a conduit in a fire barrier wall sealed with grout and ceramic fiber. The second detail is for an uninsulated pipe sealed with grout and ceramic fiber. The third detail is for an insulated pipe sealed with gout. | N | N | | |
| 21. | Detail 23, Drawing B-440 | This detail is for a typical uninsulated pipe or conduit ventilation seal in the 4" CMU wall inside of the Auxiliary Electric Equipment Room. | N | N | | |
| 22. | Detail 21, Drawing B-442 | This detail is for dressing an existing opening. | N | N | | |
| 23. | Detail 22, Drawing B-442 | This detail is for an opening filled with GE RTV. | N | N | | |
| 24. | Detail 23, Drawing B-442 | This detail is an opening filled with lead wool. | N | N | | |
| 25. | Detail 24, Drawing B-442 | This detail is for filling the gap between a floor slap and a non-load-bearing wall. | N | N | | |
| 26. | Details 25 and 26, Drawing B-442 | These details are a pipe through a pipe sleeve. | N | N | | |
| 27. | Details 25A and 26A, Drawing B-442 | These details are a pipe through a pipe sleeve filled with urethane foam. | N | N | | |
| 28. | Details 25B and 26B, Drawing B-442 | These details are a pipe through a pipe sleeve. | N | N | | |
| 29. | Detail 27, Drawing B-442 | This detail represents an opening with a steel plate with extended valve stem through a pipe sleeve. | N | N | | |
| 30. | Detail 28, Drawing B-442 | This detail is an insulated pipe in a pipe sleeve. This detail shows a 2" gap between the penetrant and the grout. | N | N | | |
| 31. | Detail 28A, Drawing B-442 | This detail is an insulated pipe in a pipe sleeve. | N | N | | |

| No. | Detail | Description | Installed | Qualified | | |
|---|---|---|---|---|---|---|
| | | | | Y/N | Fire Test | Eval. |
| 32. | Detail 29, Drawing B-442 | This detail is a copper tubing line passing through a steel plate. | N | N | | |
| 33. | Details 30 and 31, Drawing B-442 | These details are for a link seal for uninsulated pipes through a flood protection wall. | N | N | | |
| 34. | Details 32, Drawing B-442 | This detail is for a pipe and kick plate detail. | N | Y | | Y |
| 35. | Details T-M1A, T-M1B, and T-M1C, Drawing Transco M-1 | These details are for a flood/air boot for a single stationary or moving element. | Y | N* | | |
| 36. | Details T-M2A, T-M2B, and T-M2C, Drawing Transco M-2. | These details are for a flood/air boot and ceramic blanket fire barrier for a single stationary or moving element. Detail 'A' represents a bare penetrating member. Detail 'B' represents a penetrating member covered with cold or anti-sweat insulation. Detail 'C' represents a penetrating member covered with thermal insulation. Fire tests TR-125, TR-127, TR-128, TR-131, TR-144, and TR-148 were used to evaluate these details. The bounding parameters for these details are found on drawing B-440 Sheet 4 | Y | Y | Y | |
| 37. | Details T-M3A, T-M3B, and T-M3C, Drawing Transco M-3. | These details are for radiation seals for stationary or moving element utilizing Transbond 150M as the sealing material. Detail 'A' represents a bare penetrating member. Detail 'B' represents a penetrating member covered with cold or anti-sweat insulation. Detail 'C' represents a penetrating member covered with thermal insulation. | Y | Y | Y | |
| 38. | Details T-M4A, T-M4B, and T-M4C, Drawing Transco M-4. | These details are for radiation seals for stationary elements utilizing high density silicone as the sealing material. Detail 'A' represents a bare penetrating member. Detail 'B' represents a penetrating member covered with cold or anti-sweat insulation. Detail 'C' represents a penetrating member covered with thermal insulation. | Y | Y | Y | |

| No. | Detail | Description | Installed | Qualified | | |
|---|---|---|---|---|---|---|
| | | | | Y/N | Fire Test | Eval. |
| 39. | Details M-5-DR, Drawing Transco M-5-DR | This detail is for a CT Gypsum fire seal for a single stationary bare penetrating member. | Y | Y | Y | |
| 40. | Details M-6-DR, Drawing Transco M-6-DR. | This detail is for a Gypsum and fiber blanket fire seal for a single stationary bare penetrating member. | N | Y | Y | |
| 41. | Details M-7-DR, Drawing Transco M-7-DR | This detail is for a caulk and fiber fire seal for a single stationary bare penetrating member. | Y | Y | Y | |
| 42. | Details M-8-DR, Drawing Transco M-8-DR | This detail is for a Gypsum and fiber blanket penetration through a checkered plate. | Y | Y | Y | |
| 43. | Details M-9-DR, Drawing Transco M-9-DR | This detail is for a Gypsum and fiber with no penetrating members. | Y | Y | Y | |
| 44. | Details T-M10, Drawing Not Available | Detail drawing not available. | Y | N** | | |
| 45. | Details M-11-DR, Drawing Transco M-11-DR | This detail is for a seismic gap seal between a wall and a wall, with no penetrating members. | Y | Y | Y | |
| 46. | Details M-12-DR, Drawing Transco M-12-DR | This detail is for a seismic gap seal between a wall and a ceiling, with no penetrating members. | Y | Y | Y | |
| 47. | Details T-M13A and T-M13B, Drawing Transco M-13. | These details are for a ceramic blanket fire barrier for a single or multiple stationary or moving elements. Detail 'A' represents a bare penetrating member. Detail 'B' represents a penetrating member covered with insulation. | Y | Y | Y | |
| 48. | Details T-M14A, T-M14B, and T-M14C, Drawing Transco M-14 | These details are for silicone foam for stationary element. Detail 'A' represents a bare penetrating member. Detail 'B' represents a penetrating member covered with cold or anti-sweat insulation. Detail 'C' represents a penetrating member covered with thermal insulation. | Y | Y | Y | |
| 49. | Details M-15-DR, Drawing Transco M-15-DR | This detail is for a gap seal between a wall and a wall, with a penetrating member. | Y | Y | Y | |
| 50. | Details M-16-DR, Drawing Transco M-16-DR | This detail is for a gap seal for small annular gaps, with a penetrating member. | Y | Y | Y | |
| 51. | Details M-17-DR, Drawing Transco M-17-DR | This detail is for a concrete and steel gap seal. | Y | Y | Y | |

* Detail T-M1 was identified in station surveillance DFPS 4175-02. This detail is a boot configuration that can be installed to the exterior of an approved qualified fire penetration to qualify the penetration for air/flood. The surveillance does not indicate the fire penetration detail installed behind the boot.

** Detail T-M10 was identified in station surveillance DFPS 4175-03. A detail drawing was not available for this Transco Detail. The Vendor was contacted to obtain a copy of the detail drawing, however, the information had not been received.

# 3.0 FIRE TESTS

## 3.1 Introduction

Section 3.2 defines the criteria used to qualify the fire tests that contain the bounding design parameters. Section 3.3 lists the fire tests reviewed and summarizes the results of the review.

## 3.2 Fire Test Acceptance Criteria

Acceptance criteria are dependent on whether the penetrating item is combustible (i.e. cables) or non-combustible (i.e. pipes).

For combustible penetrating items, IEEE 634-1978 states that the test can be considered acceptable and the penetration fire stop suitable for use in accordance with the fire test if all of the following conditions are met:

3.2.1. *Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method?*

IEEE 634 provides qualification test procedures for testing cable penetration fire stops when mounted in rated fire barriers. The tested configuration of the penetration seal is tested such that it represents the type of configuration to be used in final installations.

3.2.2. *Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)?*

Information Notice 88-04, "Inadequate Qualification and Documentation of Fire Barrier Penetration Seals," states that the fire tests should be conducted by an independent, recognized testing authority.

3.2.3. *Did the exposure correspond to at least the time-temperature curve of ASTM E-119?*

IEEE 634 identifies that the test penetration module shall be subjected to the standard time-temperature curve in ASTM E119. The standard fire is defined by a time-temperature relationship, which must be produced by the test furnace. The seven defined points on this curve are given as follows:

1000° F (538° C) at 5 min.
1300° F (704° C) at 10 min.
1550° F (834° C) at 30 min.
1700° F (927° C) at 1 hr.
1850° F (1,010° C) at 2 hr
2000° F (1,093° C) at 4 hr.
2300° F (1,260° C) at 8 hr. or more

3.2.4. *Was the fire resistance rating of the assembly determined by the test to be at least 3 hours?*

IEEE 634 stipulates that this rating is expressed in hours and represents the ability of that barrier to withstand, without failure, exposure to a standard fire for that length of time. The cable penetration fire stop shall have withstood the fire endurance test as specified without passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side for a period equal to the required fire resistance rating

3.2.5. *Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)?*

IEEE 634 specifies a minimum of 3 thermocouples symmetrically distributed on the exposed side of the test specimen. A minimum of 3 thermocouples shall be located on the unexposed side of the test specimen. These thermocouples shall be arranged to measure the cable jacket, cable penetration fire stop interface, the interface between the fire stop, and through metallic components on the surface of the fire stop material.

3.2.6. *Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method?*

IEEE 634 identifies that a hose stream test shall be conducted immediately following the end of the fire endurance test and removal, if necessary, of the test slab. For power-generating stations a 1 ½ in. hose discharging through a nozzle approved, for use on

fires in electrical equipment producing long-range-narrow-angle (30-90° set at 30° included angle) high velocity spray only shall be used. The hose stream shall be applied to the exposed side. The water pressure shall be 75 psi., calculated, at the base of the nozzle and minimum flow of 75 gpm with duration of application of 2-½ min. per 100 $ft.^2$ of test slab. The nozzle distance shall be 10 ft. from the center of the exposed surface of the test specimen. The fire stop shall have withstood the hose stream test without the hose stream causing an opening in the test specimen.

3.2.7. *Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)?*

IEEE 634 states that the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self-ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable penetration fire stop. For power generation station, the maximum temperature is 700° F.

3.2.8. *Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side?*

IEEE 634 states the cable penetration fire stop shall have withstood the fire endurance test without passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side for a period equal to the required fire rating.

### 3.3 Evaluation of Fire Tests

The fire tests reviewed are listed below. All information used from these tests passed the criteria specified in Section 3.2 above. The detailed evaluations of the fire tests are included in Appendix B.

TR-106: Fire and Hose Stream Tests of #TCO-008 Blanket Seismic Gap Seal

TR-109: Fire and Hose Stream Tests of #TCO-001 Cement

TR-118: Fire and Hose Stream Tests of Transbond 150M

TR-125: Fire and Hose Stream Tests of Transbond 150M and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-126: Fire and Hose Stream Tests of #TCO-001 Cement and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-128: Fire and Hose Stream Tests of #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-131: Fire and Hose Stream Tests of #TCO-010 Ceramic Blanket Fire Barriers for Mechanical Penetrations

TR-144: Fire and Hose Stream Tests of #TCO-026 Ceramic Blanket Fire Barriers for a Mechanical Penetration

TR-148: Fire and Hose Stream Test of #TCO-003 High Density Silicone Elastomer, #TCO-049 High Density Silicone Gel, #TCO-050 Silicone Foam, and #TCO-029 Pre-Fab Aluminized Boot Seals for Mechanical Penetrations

TR-149: Fire and Hose Stream Tests of #TCO-001 Cement used in an Electrical penetration

TR-160: Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal)

SwRI Project No. 01-8821-028b: Three-Hour Fire Test of Through-Penetration Fire Stops for detail SWR-2-7 Nelson Electric Company, Williams Contracting Group, Incorporated and its Subsidiaries

## 4.0 CONCLUSIONS

This assessment identified 78 station fire penetration design details. The assessment provides bounding design parameters for 34 fire penetrations design details. The bounding design parameters are identified in Appendix C of this assessment.

The remaining 44 design details were not qualified. Six of these details were outside of the scope of this assessment (i.e. internal conduit seals, fire breaks, etc...). One of the details did not have a design detail available. The remaining 37 non-qualified details were not installed in fire barriers used for Fire Safe Shutdown (10 CRF50 Appendix R, Section III.G) and to protect safety-related areas (UFHA, Appendix A to APCSB 9.5-1 Comparison).

## 5.0 REFERENCES

References that were not readily available at the Station have been attached.

5.1 NUREG 1552, "*Fire Barrier Penetration Seals in Nuclear Power Plants*", July 1996

5.2 IEEE 634-1978 "IEEE Standard Cable Penetration Fire Stop Qualification Test."

5.3 12E-6508, Rev. AP, 05/17/96, "*Electrical Installation Air-Seals and Fire-Stops*"

5.4 12E-6508A, Rev. AM, 04/10/97, "*Electrical Installation Air Seals and Fire-Stops*"

5.5 12E-6508B, Rev. B, 05/27/93, "*Electrical Installation Air-Seals and Fire Stops*"

5.6 B-440, Rev. N, 09/29/98, "*Typical Details for Sealing Floor & Wall Openings Sheet 1*"

5.7 B-442, Rev. H, 08/11/95, "*Typical Details for Sealing Floor & Wall Openings-Sheet 2*"

5.8 DFPS 4175-02, Rev. 05, "*Operating Fire Stop/Break Surveillance*"

5.9 DFPS 4175-03, Rev. 04, "*Shutdown Fire Stop/Break Surveillance*"

5.10 NSWP-S-04, Rev. 1, 07/17/90, "*Fire Stop Installation and Inspection*"

5.11 NES-MS-05.2, Rev. 0, "*Fire Barrier Penetration Seals Evaluation*"

5.12 Dresden Station Units 2 and 3, Commonwealth Edison Company, Fire Protection Reports, Volume 1 - Updated Fire Hazards Analysis, Revision: Amendment 12

5.13 Dresden Station Units 2 and 3, Commonwealth Edison Company, Fire Protection Program Documentation Package, Volume 6 - Fire Protection Analyses/Supplementary Guidance, Revision: Amendment 12

5.14 Dresden Station Units 2 and 3, Commonwealth Edison Company, Fire Protection Program Documentation Package, Volume 1 - Licensing Basis Support Document - Historical, Revision: Amendment 12

5.15 Information Notice 88-04, "*Inadequate Qualification and Documentation of Fire Barrier Penetration Seals*", February 5, 1988

5.16 Letter from W. R. Sohlman to R. Bishop, dated 07/29/1992, "*RE: Use of Grout as a Fire Seal*" (Attachment A)

5.17 "*Evaluation of Penetration Seal Systems at the Dresden and Quad Cities Nuclear Power Plants*" Professional Loss Control, Inc. Rev. 0, September 21, 1987

5.18 ABB Impell Fire Seal Report No. 597-341-001, Rev. 0, September 1992 (Attachment B)

5.19 Fire Test TR-106, "*Fire and Hose Stream Tests of #TCO-008 Blanket Seismic Gap Seal*", 03/31/83

5.20 Fire Test TR-109, "*Fire and Hose Stream Tests of #TCO-001 Cement*", 02/22/83

5.21 Fire Test TR-118, "*Fire and Hose Stream Tests of Transbond 150M*", 05/25/83

5.22 Fire Test TR-125, "*Fire and Hose Stream Tests of Transbond 150M and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration*", 12/13/83

5.23 Fire Test TR-126, "*Fire and Hose Stream Tests of #TCO-001 Cement and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration*", 12/19/83

5.24 Fire Test TR-128, "*Fire and Hose Stream Tests of #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration*", 12/19/83

5.25 Fire Test TR-131, "*Fire and Hose Stream Tests of #TCO-010 Ceramic Blanket Fire Barriers for Mechanical Penetrations*", 11/21/83

5.26 Fire Test TR-144, "*Fire and Hose Stream Tests of #TCO-026 Ceramic Blanket Fire Barriers for a Mechanical Penetration*", 01/27/84

5.27 Fire Test TR-148, "*Fire and Hose Stream Test of #TCO-003 High Density Silicone Elastomer, #TCO-049 High Density Silicone Gel, #TCO-050 Silicone Foam, and #TCO-029 Pre-Fab Aluminized Boot Seals for Mechanical Penetrations*", 03/14/85

5.28 Fire Test TR-149, "*Fire and Hose Stream Tests of #TCO-001 Cement used in an Electrical penetration*", 05/24/84

5.29 Fire Test TR-160, "*Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal)*", 08/29/85

5.30 Fire Test SwRI Project No. 01-8821-028b, "*Three-Hour Fire Test of Through-Penetration Fire Stops for detail SWR-2-7 Nelson Electric Company, Williams Contracting Group, Incorporated and its Subsidiaries*", September 1986

5.31 Generic Letter 89-10, "Implementation of Fire Protection Requirements" April, 24, 1986

5.32 Generic Letter 89-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems used to Separate Redundant Safe Shutdown Trains Within the Same Fire Area" March, 25, 1994

APPENDIX A

Penetration Seal Fire Test Qualification Checklist

Procedure # 99-4025.001
Revision 0
Date: December 6, 1999

**DRESDEN UNITS 2 & 3**

**PENETRATION SEAL**

**FIRE TEST QUALIFICATION**

**CHECKLIST**

**Procedure # 99-4025.001**
**Revision 0**
**Date: December 6, 1999**

**Prepared by:** Joseph H. Talbert
Joseph H. Talbert, PE
Principal Engineer

**Reviewed by:** Craig J. Lucke
Craig Lucke, PE
Engineer

**Approved by:** Thomas J. McGrath

# PENETRATION SEAL

# FIRE TEST QUALIFICATION

# CHECKLIST

## 1. PURPOSE/OBJECTIVE

The purpose of this checklist is to qualify Fire Tests for use to justify the design of penetration seals as 3-hour rated fire barriers in fire walls.

## 2. METHODOLOGY

Commitments made to the NRC regarding penetration seals at Dresden Station have been identified. These commitments were identified by reviewing licensing basis documents contained in the Dresden Fire Protection Report (FPR) (Design Input 1)and the Dresden Fire Protection Program Documentation Package (FPPDP) (Design Input 2).

The specific licensing commitments are:

1. The fire tests of the fire stops should be controlled by the standard time-temperature curve as defined in ANSI/ASTM E-119, 1976.

2. Fire tests of the fire stops should be performed in accordance with IEEE 634-1978.

In addition, the adequacy of the fire tests was evaluated in accordance with "NRC Information Notice No. 88-04: Inadequate Qualification and Documentation of Fire Barrier Penetration Seals" (Design Input 3) issued February 5, 1988, which gives guidance regarding fire tests of Penetration Seals and the validity of test methods. Section B, Seal Acceptance Criteria in Appendix A, Attachment 1 to IN 88-04 gives specific criteria that should be considered in evaluating the validity of Penetration Seal Fire Tests. The criteria are contained in items B. 2 and B. 3. These criteria were used to develop the checklist.

The following items are evaluated in the checklist.

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

## 3. ACCEPTANCE CRITERIA

All items must be answered "Yes" or an equivalent means of verifying the performance of the Penetration Seal during the test must be developed to justify the use of the test to qualify fire penetration performance.

## 4. ASSUMPTIONS

None

## 5. DESIGN INPUTS

1. Dresden Fire Protection Reports
2. Dresden Fire Protection Program Documentation Package
3. NRC Information Notice No. 88-04: Inadequate Qualification and Documentation of Fire Barrier Penetration Seals, February 5, 1988.
4. IEEE Standard Cable Penetration Fire Stop Qualification Test, IEEE Std 634-1978

## 6. REFERENCES

None

**ATTACHMENT 1**

Test Number:_____ Procedure 99-4025.001

Evaluated by:_____ Evaluation Date:_____

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

**Test Number:**

**Date of Test:**

**Evaluated by:**

**Date of Evaluation:**

**Configuration:**

**Conclusions:**

Test Number:_____ Procedure 99-4025.001

Evaluated by:_____ Evaluation Date:_____

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   ____ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   ____ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   ____ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   ____ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   ____ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   ____ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   ____ Yes ____ No ____ Meets Intent (See Justification)

Test Number:_____ Procedure 99-4025.001

Evaluated by:_____ Evaluation Date:_____

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

____ Yes _____ No ____ Meets Intent (See Justification)

Justifications:

_____

_____

_____

_____

# APPENDIX B

## Penetration Seal Fire Test Qualification Checklist

Procedure # 99-4025.001
Revision 0
Date: December 6, 1999

TR-106: Fire and Hose Stream Tests of #TCO-008 Blanket Seismic Gap Seal

TR-109: Fire and Hose Stream Tests of #TCO-001 Cement

TR-118: Fire and Hose Stream Tests of Transbond 150M

TR-125: Fire and Hose Stream Tests of Transbond 150M and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-126: Fire and Hose Stream Tests of #TCO-001 Cement and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-128: Fire and Hose Stream Tests of #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration

TR-131: Fire and Hose Stream Tests of #TCO-010 Ceramic Blanket Fire Barriers for Mechanical Penetrations

TR-144: Fire and Hose Stream Tests of #TCO-026 Ceramic Blanket Fire Barriers for a Mechanical Penetration

TR-148: Fire and Hose Stream Test of #TCO-003 High Density Silicone Elastomer, #TCO-049 High Density Silicone Gel, #TCO-050 Silicone Foam, and #TCO-029 Pre-Fab Aluminized Boot Seals for Mechanical Penetrations

TR-149: Fire and Hose Stream Tests of #TCO-001 Cement used in an Electrical penetration

TR-160: Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal)

SwRI Project No. 01-8821-028b: Three-Hour Fire Test of Through-Penetration Fire Stops for detail SWR-2-7 Nelson Electric Company, Williams Contracting Group, Incorporated and its Subsidiaries

Test Number: TR-106

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

# CHECKLIST

# PENETRATION SEAL

# FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-106 |
| **Title:** | Fire and Hose Stream Tests of #TCO-008 Blanket Seismic Gap Seal |
| **Date of Test:** | February 17, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Unsymmetrical simulated expansion joint seismic gap opening (30" x 6" x 12" gaps) sealed with a combination ceramic blanket/silicone fabric assembly from one side of a floor or wall. Assembly was tested for a three hour rating. |
| **Conclusions:** | Transco Test 106 can be used to qualify Blanket Seismic Gap Sea #TCO-008 as 3-hour rated Penetration Fire Seals In accordance with IEEE 634-1978. |

Test Number: TR-106

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-106

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Test Number: TR-109, Cable Tray with Hypalon Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, Cable Tray filled with Hypalon jacketed cable |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TCO-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of the cable tray filled with Hypalon jacketed cable.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of Cable trays filled with Hypalon jacketed cable passing through 3-hour rated barriers where protected by the penetration seal described in the configuration section. |

Test Number: TR-109, Cable Tray with Hypalon Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-109, Cable Tray with Hypalon Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 464 degrees F.

Test Number: TR-109, Conduit filled with PVC Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, Conduit filled with PVC jacketed cable |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of conduit filled with PVC jacketed cable.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of conduit through 3-hour rated barriers where protected by the penetration seal described in the configuration section. The maximum temperature recorded was 704 degrees F (See Justification). |

Test Number: TR-109, Conduit filled with PVC Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   ____ Yes ____ No _X_ Meets Intent (See Justification)

Test Number: TR-109, Conduit filled with PVC Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: Justification for Item 7:

The temperature at the seal/conduit interface was recorded by thermocouple 35 to be 704 degrees F at the end of the test. This is slightly above the maximum allowable temperature of 700 degrees F. The temperature exceeded 700 degrees at about 2 hours, 55 minutes into the test. Since the self-ignition temperature of PVC jacketed is 850 degrees F according to IEEE 634, this maximum temperature still allows more than 100 degrees F of safety factor even at the end of the test. In addition, the maximum temperature allowed was exceeded for only 5 minutes during the test.

Comments:

Test Number: TR-109, Conduit with Hypalon Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, Conduit filled with Hypalon jacketed cable |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of conduit filled with Hypalon jacketed cable.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of Conduit filled with Hypalon jacketed cable passing through 3-hour rated barriers where protected by the penetration seal described in the configuration section. |

Test Number: TR-109, Conduit with Hypalon Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-109, Conduit with Hypalon Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 471 degrees F.

Test Number: TR-109, Hypalon cable passing through repair  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, Hypalon jacketed cable passing through repair in seal |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of Hypalon jacketed cable passing through a repair in the seal.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of conduit through 3-hour rated barriers where protected by the penetration seal described in the configuration section |

Test Number: TR-109, Hypalon cable passing through repair  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-109, Hypalon cable passing through repair Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded was 370 degrees F at thermocouple 210.

Test Number: TR-109, Ladder Back Tray with PVC Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, Ladder Back Cable Tray filled with PVC jacketed cable |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of the Ladder Back cable tray filled with PVC jacketed cable.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test CANNOT be used to qualify penetrations of Ladder Back cable tray 3-hour rated barriers where protected by the penetration seal described in the configuration section. The maximum temperature recorded was 809 degrees F. |

Test Number: TR-109, Ladder Back Tray with PVC Cable Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   ___ Yes _X_ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   ____ Yes _X_ No ____ Meets Intent (See Justification)

Test Number: TR-109, Ladder Back Tray with PVC Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 809 degrees F. The unexposed side of the test assembly exceeded 700 degrees F at approximately 2 hours, 25 minutes into the test.

Test Number: TR-109, PVC cable passing through repair Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, PVC jacketed cable passing through repair in seal |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of PVC jacketed cable passing through a repair in the seal.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of conduit through 3-hour rated barriers where protected by the penetration seal described in the configuration section |

Test Number: TR-109, PVC cable passing through repair  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-109, PVC cable passing through repair  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded was 179 degrees F at thermocouple 212.

Test Number: TR-109, Solid Back Tray with PVC Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-109, solid Back Cable Tray filled with PVC jacketed cable |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Three cable trays and two conduits penetrating a 109-1/2" x 32" x 12' deep opening protected by two substrates consisted of ¼" thick steel plate with two cast concrete substrate surfaces. Two trays were filled with PVC jacketed cable and the third tray was filled with Hypalon jacketed cable. The opening was filled with 5 inches of Transco #TCO-001/U.S. gypsum Firecode CT Gypsum Cement. Four inches of #TC)-009/U.S. Gypsum thermafiber damming material was used to dam inside of the cable trays and conduits only.<br><br>This checklist qualifies the test of the Solid Back cable tray filled with PVC jacketed cable.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | This test can be used to qualify penetrations of Solid Back cable tray 3-hour rated barriers where protected by the penetration seal described in the configuration section. The maximum temperature recorded was 627 degrees F. |

Test Number: TR-109, Solid Back Tray with PVC Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-109, Solid Back Tray with PVC Cable  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 627 degrees F at Thermocouple 29. This thermocouple was adjacent to the Power Cable.

Test Number: TR-118

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-118 |
| **Title:** | Fire and Hose Stream Tests of Transbond 150M |
| **Date of Test:** | March 9, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | Two simulated mechanical openings which measured 12 " in diameter (one cast concrete opening and one sleeve opening). Each opening was penetrated by one bare 2" diameter steel pipe and one 2" pipe covered with one inch of thermal insulation and aluminum jacketing. The penetration seals consisted of 6 " of Transbond 150M (no permanent damming material was used). |
| **Conclusions:** | Test TR-118 can be used to qualify Transbond 150M as a 3-hour rated Penetration Fire Seal in accordance with IEEE 634-1978 when used to seal either a 12" diameter steel sleeve or a 12" diameter cast concrete opening containing 2 " diameter bare steel pipe or 2 " diameter pipe covered with one inch of thermal insulation and aluminum jacketing. |

Test Number: TR-118

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-118

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature noted was 374 degrees at Thermocouple 145C. This temperature was measured at the bare steel pipe passing through the penetration.

Test Number: TR-125, Transbond 150M and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-125 |
| **Title:** | Fire and Hose Stream Tests of Transbond 150M and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration |
| **Date of Test:** | December 13, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | 12 " diameter steel sleeve penetrated by a nominal 2.5 " diameter steel pipe (located slightly off center) and four ¼ " diameter copper tubes which were bunched and located approximately 0 to 1/8 " from the substrate. The test penetration was sealed by first wrapping an 8" wide by 1" thick section of #TCO-013 Ceramic blanket around the pipe. A piece of 20 gauge sheet metal was then wrapped around the ceramic blanket and fastened with three 1/8 " steel pop rivets. The remainder of the opening was sealed (around the sheet metal insert and ceramic blanket) with 6 " of #TCO-005 Transbond 150M (2 " of the sheet metal insert and ceramic blanket extended above the Transbond seal). The entire assembly was installed so that it was flush with the exposed surface of the test slab.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | TR-125 can be used to qualify the penetration protected as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-125, Transbond 150M and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-125, Transbond 150M and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 570 degrees F.

Test Number: TR-126, #TCO-001 Cement and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-126 |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement and #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration |
| **Date of Test:** | December 19, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | 12 " diameter steel sleeve penetrated by a nominal 2.5 " diameter steel pipe (located slightly off center) and five ¼ " diameter copper tubes evenly spaced around the perimeter of the opening (approximately ½" from the steel sleeve). The test penetration was sealed by first wrapping an 6" wide by 1" thick section of #TCO-013 Ceramic blanket around the pipe and holding it in place two #TCO-024 Clamps. The remainder of the opening was sealed with 4" of #TCO-001 Cement. Two inches of the ceramic blanket extended above the surrounding #TCO-001 Cement. The seal was installed so that it was flush with the slab's exposed surface.<br><br>Assembly was tested for a three hour rating. |
| **Conclusions:** | TR-126 can be used to qualify the penetration protected as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-126, #TCO-001 Cement and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-126, #TCO-001 Cement and #TCO-013 Ceramic Blanket

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 537 degrees F.

Test Number: TR-128, #TCO-013 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-128 |
| **Title:** | Fire and Hose Stream Tests of #TCO-013 Ceramic Blanket Seal for a Mechanical Penetration |
| **Date of Test:** | December 13, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | The test specimen consisted of a 12" diameter steel sleeve penetrated by a nominal 2.5" diameter steel pipe (located slightly off center). The test penetration was sealed by wrapping 8 " wide strips of #TCO-013 Ceramic Blanket around the pipe until the penetration was filled. The first layer of the blanket material (used around the pipe) was 10" wide and was installed so that 2" of it extended above the wrap surrounding it. A #TCO-024 Clamp was installed on this 2" extension so that the first layer of wrap would be secured to the pipe. Although the blanket was installed as a spiral wrap, additional small separate pieces of the blanket were used to fill any open spaces in the seal.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-128 can be used to qualify the penetration protected as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-128, #TCO-013 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-128, #TCO-013 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 447 degrees F.

Test Number: TR-131, #TCO-010 Ceramic Blanket Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-131 |
| **Title:** | Fire and Hose Stream Tests of #TCO-010 Ceramic Blanket Fire Barriers for Mechanical Penetrations |
| **Date of Test:** | November 13, 1983 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | The test specimen consisted of a simulated mechanical opening which measured 12" diameter by 12" (steel sleeve) and was cast into a 12" thick concrete test slab. This opening was penetrated by a nominal 2" diameter steel pipe which was located slightly off center to the penetration. The test penetration seal consisted of 1" thick #TCO-010 Ceramic Blanket wound around the pipe and pushed into the sleeve. The overall thickness of the seal was 8". The first layer (that was wound around the pipe) was slightly wider (than 8"). This first layer was cut so that it was approximately 9.5 " wide. This extra width was used so that the blanket seal (once it was wound around the pipe) could be clamped directly to the pipe. Extra pieces of the spiral wound seal were cut and pushed into the penetration to compensate for undercutting the initial pieces of the blanket seal and also to compensate for the pipe being slightly off center. |

Test Number: TR-131, #TCO-010 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

Before the ceramic blanket was installed into the sleeve (which was flush cut with both the exposed and unexposed surfaces of the test slab), a sheet metal sleeve was installed into the penetration. The 4" long sleeve would be used in the field for attaching a boot to the penetration. The sleeve is made of 18 gauge galvanized sheet metal and is held in place with a silicone adhesive. This sleeve was used here since in field applications, this sleeve may provide part of the substrate under the ceramic blanket seal. Although this sleeve was inserted into the penetration for the test, no boot was used on either side of the penetration. It was the purpose of this test to show that the ceramic blanket seal provides an adequate three hour fire barrier without the use of the boot.

The assembly was tested for a three hour rating.

**Conclusions:**

TR-131 can be used to qualify the penetration protected as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating.

Test Number: TR-131, #TCO-010 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-131, #TCO-010 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 556 degrees F.

Test Number: TR-144, #TCO-026 Ceramic Blanket Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-144 |
| **Title:** | Fire and Hose Stream Tests of #TCO-026 Ceramic Blanket Fire Barriers for a Mechanical Penetration |
| **Date of Test:** | January 26, 1984 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | The test specimen consisted of a 12" diameter steel sleeve penetrated by a nominal 2.5 " diameter steel pipe (located slightly off center) and two ¼ " diameter copper tubes. The test penetration was sealed by wrapping 8" wide strips of #TCO-026 Ceramic Blanket around the pipe until the penetration was filled. The first layer of the blanket materials (used around the pipe) was 10" wide and was installed so that 2" of it extended above the wrap surrounding it. A #TCO-026 Clamp was installed on this 2" extension so that the first layer of wrap would be permanently secured to the pipe. Although the blanket was installed as a spiral srap, additional small separate pieces of the blanket were used to fill any open spaces in the seal.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-144 can be used to qualify the penetration protected as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-144, #TCO-026 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-144, #TCO-026 Ceramic Blanket  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 552 degrees F.

Test Number: TR-148, Penetration A, with #TCO-029 Aluminized Boot

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-148, Penetration A |
| **Title:** | Fire and Hose Stream Test of #TCO-03 High Density Silicone Elastomer and #TCO-029 Pre-Fab Aluminized Boot Seals for Mechanical Penetrations |
| **Date of Test:** | March 14, 1985 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | The test specimen, a 48" x 48" x 12" thick concrete slab with a 30" x 30" opening, was divided into four approximately equal openings using ceramic board so each opening could act as a separate penetration. Three of the openings were identical in the fact that each contained a bare pipe, an insulated pipe, and an instrument tube. The instrument tube was added after the seal had been poured to simulate a repair. The pipes were positioned against the concrete substrate in each opening to demonstrate the sealing properties of the materials in narrow annular spaces. The three openings were then sealed flush with the concrete on both sides (12" depth), each using one of the three aforementioned silicone sealants. The repairs were made by drilling a hole through the seal the same diameter as the instrument tube and sliding the tube through the hole. Silicone caulk was placed around each repair on the unexposed surface only. |

Test Number: TR-148, Penetration A, with #TCO-029 Aluminized Boot

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

The fourth opening, the boot seal, contained a sheet metal sleeve used to create an annular space, with an insulated pipe passing through it and positioned off center. The sheet metal sleeve was embedded in 12" of #TCO-003 High Density Silicone Elastomer (for convenience) and extended approximately 2" beyond the concrete face on both sides of the slab. A #TCO-029 Pre-Fab Aluminized Boot was then attached to each side and the annular space stuffed with #TCO-010 Ceramic Blanket within the boot area only.

No permanent damming materials were used along with the tested seals. During seal installation, temporary forms were used and later removed prior to the fire test.

**Conclusions:**

TR-148, Penetration A can be used to qualify the penetration protected as described in the Configuration section above using #TCO-003 High Density Silicone Elastomer Seal and a #TCO-029 Pre-Fab Aluminized Boot with IEEE 634-1978 for a 3-hour fire resistance rating.

Test Number: TR-148, Penetration A, with #TCO-029 Aluminized Boot

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-148, Penetration A, with #TCO-029 Aluminized Boot

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No _____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 334 degrees F.

Unable to read Section H (Temperature Data Sheets) in the test report. Utilized section E (Thermocouples) to determine final temperature values.

Test Number: TR-149, #TCO-001 Cement  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-149 |
| **Title:** | Fire and Hose Stream Tests of #TCO-001 Cement used in an Electrical penetration |
| **Date of Test:** | May 18, 1984 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | The specimen consisted of a penetration seal cast into a 32" x 32" x 12" deep opening in a concrete slab. The overall dimensions of the test slab were 48" x 48" x 12". The slab opening was penetrated by two 4" x 30" solid back galvanized steel cable trays. One tray was filled with PVC jacketed cables while the other tray was left empty. The filled tray was sealed with 12" of #TCO-001 Cement. The remainder of the penetration (except for the sides and back of the empty tray) was filled with 5" of the #TCO-001 Cement material (symmetrically installed to the 12" tray seal). The sides and back of the empty tray were sealed with 0" to 2" of #TCO-013 Ceramic Blanket which was covered with a nominal ¼" thick bead of #TCO-007 Silicone Adhesive. The sides of the empty cable tray provided a nominal 1" wide space while the back of the tray extended 0" to ½" away from the edge of the slab (this tray was badly warped from a previous fire test but was used since the warpage could be utilized to demonstrate a varying gap width).<br><br>The assembly was tested for a three hour rating. |

Test Number: TR-149, #TCO-001 Cement

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**Conclusions:**

TR-149 can be used to qualify electrical penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating.

Test Number: TR-149, #TCO-001 Cement  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-149, #TCO-001 Cement  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 385 degrees F.

Test Number: TR-160, Opening B, #TCO-001 Cement 6" diameter, 48" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-160, Opening B |
| **Title:** | Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier / penetration seal) |
| **Date of Test:** | August 23, 1985 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.<br><br>Opening "B" measured 8" x 8" x 12" deep and contained one 6: diameter by 48" long rigid aluminum conduit. The conduit was mounted so that it extended one foot below and two feet above the test slab. The conduit was filled with the same cable types and quantities as was used in opening "A" (opening "A" was filled to 49.83% of its cross-sectional area with cables). The conduit was sealed at each end with 5" (max.) #TCO-001 Cement over 1" (max.) # TCO-010 Ceramic Blanket (used as a damming material) while the area around the conduit was filled with 5" (max.) #TCO-001 Cement without the use of permanent damming materials.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-160, Opening "B" can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-160, Opening B, #TCO-001 Cement 6" diameter, 48" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening B, #TCO-001 Cement 6" diameter, 48" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 600 degrees F.

Test Number: TR-160, Opening A, #TCO-001 Cement 6" diameter, 5" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-160, Opening A |
| **Title:** | Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal) |
| **Date of Test:** | August 23, 1985 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.<br><br>Opening "A" measured 8" x 8" x 12" deep and contained one 6: diameter by 5" long rigid aluminum conduit. The conduit was filled to 49.83% of its cross-sectional area with cables which extended a minimum of 12" below and 36" above the test slab. The conduit was sealed 5" (max.) deep with #TCO-001 Cement within the plane of the seal surrounding the conduit which also consisted of 5" (max.) #TCO-001 Cement. Permanent damming was not used with the seal materials for this test.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-160, Opening "A" can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-160, Opening A, #TCO-001 Cement 6" diameter, 5" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening A, #TCO-001 Cement 6" diameter, 5" long rigid aluminum conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 491 degrees F.

Test Number: TR-160, Opening C, #TCO-001 Cement
6" diameter, 5" long rigid steel conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-160, Opening C |
| **Title:** | Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal) |
| **Date of Test:** | August 23, 1985 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.<br><br>Opening "C" measured 8" x 8" x 12" deep and contained one 6: diameter by 5" long rigid steel conduit. The conduit was filled to 49.83% of its cross-sectional area with cables which extended a minimum of 12" below and 36" above the test slab. The conduit was sealed 5" (max.) deep with #TCO-001 Cement within the plane of the seal surrounding the conduit which also consisted of 5" (max.) #TCO-001 Cement. Permanent damming was not used with the seal materials for this test.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-160, Opening "C" can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-160, Opening C, #TCO-001 Cement 6" diameter, 5" long rigid steel conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening C, #TCO-001 Cement 6" diameter, 5" long rigid steel conduit

Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE

Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 406 degrees F.

Test Number: TR-160, Opening D, #TCO-001 Cement Procedure 99-4025.001
6" diameter, 48" long rigid galvanized steel conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | TR-160, Opening D |
| **Title:** | Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier / penetration seal) |
| **Date of Test:** | August 23, 1985 |
| **Evaluated by:** | Joseph H. Talbert, PE |
| **Date of Evaluation:** | December 6, 1999 |
| **Configuration:** | A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.<br><br>Opening "D" measured 8" x 8" x 12" deep and contained one 6: diameter by 48" long rigid galvanized steel conduit. The conduit was mounted so that it extended one foot below and two feet above the test slab. The conduit was filled with the same cable types and quantities as was used in opening "A" (opening "A" was filled to 49.83% of its cross-sectional area with cables). The conduit was sealed at each end with 5" (max.) #TCO-001 Cement over 1" (max.) # TCO-010 Ceramic Blanket (used as a damming material) while the area around the conduit was filled with 5" (max.) #TCO-001 Cement without the use of permanent damming materials.<br><br>The assembly was tested for a three hour rating. |
| **Conclusions:** | TR-160, Opening "D" can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating. |

Test Number: TR-160, Opening D, #TCO-001 Cement Procedure 99-4025.001
6" diameter, 48" long rigid galvanized steel conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening D, #TCO-001 Cement 6" diameter, 48" long rigid galvanized steel conduit  Procedure 99-4025.001

Evaluated by: Joseph H. Talbert, PE  Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 390 degrees F.

Test Number: TR-160, Opening F, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 48" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

**Test Number:** TR-160, Opening F

**Title:** Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal)

**Date of Test:** August 23, 1985

**Evaluated by:** Joseph H. Talbert, PE

**Date of Evaluation:** December 6, 1999

**Configuration:** A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.

Opening "F" consisted of an 8" x 8" x 12" deep opening penetrated by a 2" diameter by 48" long galvanized steel flexible steel conduit. The conduit extended a minimum of 12 " below and 24" above the slab. The conduit was filled to 64.93% of its cross-sectional area with cables which extended a minimum of 12" below and 36" above the test slab. The conduit was sealed 5" (max.) deep with #TCO-001 Cement over 1" (max.) #TCO-010 Ceramic Blanket (used as permanent damming material) at each end while the seal around the conduit also consisted of 5" (max.) #TCO-001 Cement. Permanent damming was not used for the seal surrounding the conduit.

The assembly was tested for a three hour rating.

**Conclusions:** TR-160, Opening "F can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating.

Test Number: TR-160, Opening F, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 48" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening F, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 48" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 267 degrees F.

Test Number: TR-160, Opening G, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 5" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

## CHECKLIST

## PENETRATION SEAL

## FIRE TEST QUALIFICATION

**Test Number:** TR-160, Opening "G"

**Title:** Three Hour Fire and Hose Stream Test of #TCO-001 Cement Installed in rigid aluminum conduit (installed both within the plane and on both sides of the surrounding fire barrier/penetration seal)

**Date of Test:** August 23, 1985

**Evaluated by:** Joseph H. Talbert, PE

**Date of Evaluation:** December 6, 1999

**Configuration:** A 48" x 48" x 12" thick concrete slab which had eight 8" x 8" x 12" deep openings and one 6" diameter embedded conduit was used for the test. The nine openings were identified with the letters "A" through "I" respectively.

Opening "G" contained a 2" diameter by 5" long galvanized steel flexible steel conduit filled with the identical cable types and quantities as used in opening "F" (the opening "F" conduit was filled to 64.93% of its cross-sectional area with cables which extended a minimum of 12" below and 36" above the test slab). The conduit was sealed 5" (max.) deep with #TCO-001 Cement within the plane of the surrounding seal which also consisted of 5 " (max.) #TCO-001 Cement. Permanent damming material was not used in the conduit or area surrounding it. Opening "G": also contained one 0.75" diameter by 60" long threaded rod as a miscellaneous penetrating element.

The assembly was tested for a three hour rating.

**Conclusions:** TR-160, Opening "G" can be used to qualify penetrations sealed as described in the Configuration section above with IEEE 634-1978 for a 3-hour fire resistance rating.

Test Number: TR-160, Opening G, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 5" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: TR-160, Opening G, #TCO-001 Cement Procedure 99-4025.001
2" diameter, 5" long galvanized steel flexible conduit

Evaluated by: Joseph H. Talbert, PE Evaluation Date: December 6, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 510 degrees F.

Test Number: SwRI Project No. 01-8821-028b Procedure 99-4025.001

Evaluated by: Craig Lucke, PE Evaluation Date: December 13, 1999

# CHECKLIST

# PENETRATION SEAL

# FIRE TEST QUALIFICATION

| | |
|---|---|
| **Test Number:** | SwRI Project No. 01-8821-028b |
| **Title:** | Three-Hour Fire Test of Through-Penetration Fire Stops for detail SWR-2-7 Nelson Electric Company, Williams Contracting Group, Incorporated and its Subsidiaries |
| **Date of Test:** | August 08, 1986 |
| **Evaluated by:** | Craig Lucke, PE |
| **Date of Evaluation:** | December 13, 1999 |
| **Configuration:** | Concrete floor slab measured 7' x 7' x 1' thick. The slab contained nine 8" diameter steel sleeves, two 4" diameter steel sleeves and one 7 ¼" diameter block out. Assembly was tested for a 3 hour rating. |
| **Conclusions:** | SwRI Project No. 01-8821-028b can be used to qualify Three-Hour Fire Test of Through-Penetration Fire Stops detail SWR-2-7 as a 3-hour rated Penetration Fire Seals In accordance with IEEE 634-1978. |

Test Number: SwRI Project No. 01-8821-028b Procedure 99-4025.001

Evaluated by: Craig Lucke, PE Evaluation Date: December 13, 1999

**CHECKLIST**

1. Was the Penetration Seal tested for fire resistance in accordance with the IEEE 634 test method? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

2. Was the test conducted by an independent, recognized testing authority (such as UL Inc., NIST, Southwest Research Laboratories, IITRI, FMRC, Construction Technology Laboratories, etc.)? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

3. Did the exposure correspond to at least the time-temperature curve of ASTM E-119? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

4. Was the fire resistance rating of the assembly determined by the test to be at least 3 hours? (Design Input 2)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

5. Were thermocouples positioned in accordance with IEEE 634-1978 (including the interface of the seal material and through penetrations)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

6. Did the fire stop remain in place during the fire test and the hose stream test afterwards when subjected to the hose stream test specified in the IEEE 634 test method? (Design Input 3)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

7. Were the unexposed surface temperatures acceptable throughout the test (not greater than 700 degrees F)? (Design Input 4)

   _X_ Yes ____ No ____ Meets Intent (See Justification)

Test Number: SwRI Project No. 01-8821-028b Procedure 99-4025.001

Evaluated by: Craig Lucke, PE Evaluation Date: December 13, 1999

8. Did the assembly prevent the passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side? (Design Input 4)

__X__ Yes _____ No ____ Meets Intent (See Justification)

Justifications: None

Comments: The maximum temperature recorded on the unexposed side was 669 degrees F.

# APPENDIX C

## Penetration Seal Matrix Drawings

12E-6508, Sheet 4
B-440, Sheet 2
B-440, Sheet 3
B-440, Sheet 4
B-440, Sheet 5
B-440, Sheet 6
B-440, Sheet 7
B-440, Sheet 8
B-440, Sheet 9
B-440, Sheet 10
B-440, Sheet 11