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NUMARC INDUSTRY APPLICATION GUIDE

TO

EVALUATE

EXISTING THERMO-LAG

FIRE BARRIER SYSTEMS

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1.0 BACKGROUND

In 1981, Appendix R to 10CFR50 was issued and Section III.G specifically addressed the requirements regarding the protection of safe shutdown systems. These requirements have been made applicable to all nuclear power plants. Two of the acceptable methods of complying with 10CFR50 Appendix R Section III.G credit enclosing safe shutdown equipment/raceways in a fire rated (either 1 or 3 hour) barrier. One material widely used to construct these barriers is the Thermo-Lag 330 fire barrier system manufactured by Thermal Science, Inc. (TSI).

Generic Letter 86-10 provided guidance for evaluation of fire barriers installed on conduits and cable trays where exact replication of tested configurations could not be achieved. Additionally, the guidance stated that for newly identified conduit and cable trays requiring protection, new materials which meet a 325°F maximum temperature criteria on the unexposed surface when subjected to a standard fire exposure should be used.

Generic Letter 92-08 identified three major areas of concern relative to Thermo-Lag 330 fire barriers: 1) the fire endurance capability of installed barriers, 2) the ampacity derating of cables enclosed in Thermo-Lag barriers, and 3) the evaluation and application of the results of tests conducted to determine the fire endurance ratings and ampacity derating factors of these barriers.

The NRC, through Bulletin 92-01 and Supplement 1, declared existing Thermo-Lag installations to be indeterminate, and called into question previous testing. In order to provide a basis to evaluate the effectiveness of Thermo-Lag fire barriers, an industry fire test program was conducted by NUMARC. To address the generic industry issues, the NUMARC Industry Test Program:

- Assessed current industry configurations through the use of survey data.
- Conducted tests to determine performance of various baseline and upgraded fire barrier system assemblies.
- Developed a guideline to assist utilities in evaluating their as-built configurations.

This document summarizes the results of the fire endurance tests and provides a process by which the utilities may evaluate their installed configurations.

2.0 PURPOSE AND SCOPE

It is recognized that it is not feasible to perform specific testing for all configurations of fire barriers. The purpose of the Application Guide is to provide utilities with the necessary information and a process to evaluate installed configurations against fire endurance test(s). Utilities may use this process to 1) establish the expected performance of installed Thermo-Lag barriers, and 2) provide reasonable assurance that these barriers

will provide sufficient fire resistance to ensure that one train of Safe Shutdown systems will remain free of fire damage. This process is consistent with the GL 86-10 guidance, but in recognizing the unique performance characteristics of Thermo-Lag, has been greatly expanded in detail. Additionally, to the extent that utilities may determine that upgraded Thermo-Lag barriers are required, the specific methods used to construct design upgrades tested by NUMARC will be issued via separate NUMARC guidance.

The scope of the Industry Application guide includes results of specific fire endurance tests performed by Tennessee Valley Authority, Texas Utilities Electric, and NUMARC on Thermo-Lag fire barrier systems. The area of concern relating to ampacity derating of cables enclosed in Thermo-Lag barriers as described in GL 92-08 is not addressed by the Application Guide.

3.0 DEFINITIONS

The following terms will be used throughout the Industry Application Guide.

Baseline Configuration: Items which describe the base construction, in terms of fire resistive barrier performance parameters, before the application of any upgrades.

Commodity: Materials, including raceway, cabling, etc. enclosed within the fire barrier system segment being evaluated.

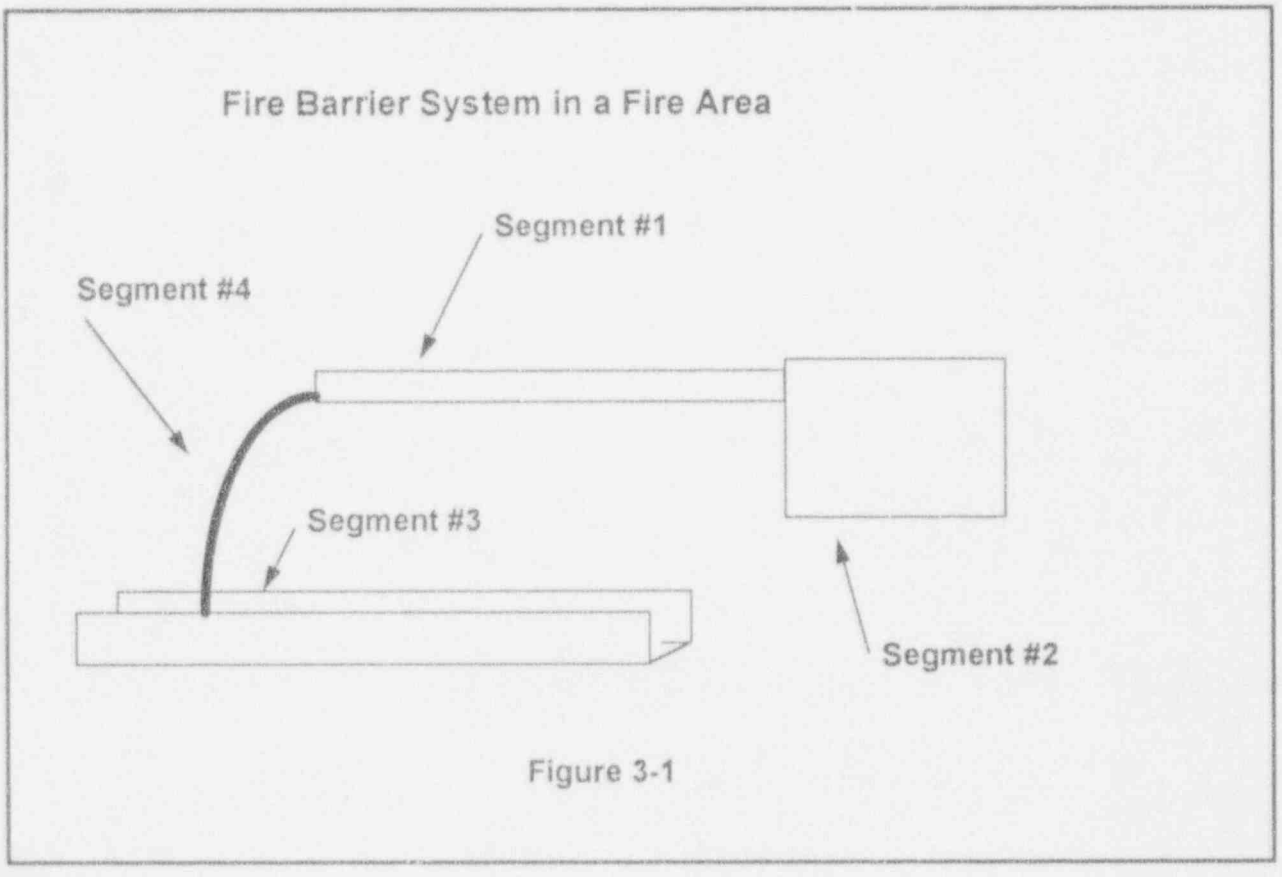


Figure 3-1

Commodity Performance Parameters: The parameters of the commodity being evaluated that could affect the performance of the fire barrier. These parameters include: size, type of material, amount and type of cable, etc.

Fire Barrier: All materials, fasteners, seals, etc. comprising the barrier assembly and enclosing the protected commodity.

Fire Barrier System (FBS): The continuous fire barrier segments enclosing the protected commodities within a fire area. In Figure 3-1, fire barrier segments 1, 2, 3, and 4 make up the Fire Barrier System within the fire area.

Fire Barrier System (FBS): The continuous fire barrier segments enclosing the protected commodities within a fire area. In Figure 3-1, fire barrier segments 1, 2, 3, and 4 make up the Fire Barrier System within the fire area.

Fire Barrier System Segment: For purposes of evaluation, each change of construction technique, deviation from applicable installation criteria, change in material and change in orientation in a Fire Barrier System should be considered a separate segment. See Figure 3-1.

Fire Barrier Performance Parameters: The parameters of the Thermo-Lag assembly (both baseline and upgrade configurations) which could affect the performance of the fire barrier. These parameters include: type of material, thickness, stiffener (v-rib) location/orientation, stress skin location, joint reinforcement mechanisms, joint type, gap width, fastener spacing and location, fastener size and material, unsupported span, etc.

Rating: The fire endurance rating expressed in units of time (i.e., hours) as determined by fire endurance test for a specific Fire Barrier System

Upgrade Configuration: Upgrades, expressed in terms of fire resistive barrier performance parameters, applied to a baseline configuration.

4.0 EVALUATION CRITERIA

To evaluate installed (i.e., as-built) fire barrier configurations, the following two types of criteria should be considered:

1) commodity and fire barrier performance parameter bounding criteria that pertain to the installed configuration, and

2) acceptance basis or criteria for each supporting test used to evaluate the installed configuration

Reasonable assurance for the acceptability of installed configurations can then be established provided the following are satisfied:

1) engineering evaluations demonstrate that the aggregate of commodity and barrier performance parameters for installed configurations are bounded by tested configurations, and

2) the acceptance bases of supportive tests are valid and applicable to installed configurations

The following sections provide a more detailed explanation of the evaluation criteria:

4.1 Performance Parameters

For fire barrier systems there are essentially two basic failure mechanisms:

- Structural failures
- Thermal failures

The NUMARC and utility test programs have provided insight into the effects that variations in both commodity and barrier performance parameters have on the basic failure mechanisms. Thermal failures can be generally attributed to thickness, continuity and overall performance of the Thermo-Lag material. Structural failures can be generally attributed to unsupported material spans (i.e., the size of the commodity being protected), change in orientation, and methods used to construct the fire barrier.

Table 4-1 addresses each performance parameter, the failure mechanism it contributes to and the associated bounding criteria. It should be noted that the basic failure mechanisms are not necessarily independent of one another. For example, the outcome of a structural failure could be a thermal failure. Additionally, testing has demonstrated that the significance of each parameter can vary with barrier configuration. For purposes of this guide Table 4-1 addresses each performance parameter separately.

4.2 Test Acceptance Criteria

Draft Supplement 1 to Generic Letter 86-10 provides the NRC staff's revised Fire Barrier Acceptance Criteria. This criteria is summarized in Figure 4-1 and will be utilized by the Application Guide to evaluate installed barrier performance. As noted in Figure 4-1, the basis for acceptability of a fire test is different for tests which do not pass based on temperature and fire barrier condition. A review of the basis for acceptability of fire tests used to evaluate installed configurations should be conducted to ensure that the test acceptance basis remains valid for the installed configuration.

Additionally, for purposes of this guide, the following positions relative to acceptance of previously conducted tests will be assumed:

1) Baseline barrier performance data for elapsed time to failure based on temperature criteria can be used to evaluate installed barrier configurations regardless of the barrier inspection results. For example, for 3-hour baseline cable tray or conduit barriers which exceeded temperature criteria at 90 minutes, an 89 minute duration of acceptable performance could be used to evaluate similarly constructed barriers regardless of observed barrier openings following the hose stream test.

2) Cable tray barrier performance data can be used to evaluate installed barrier configurations regardless of whether #8 bare copper conductors with thermocouples were installed within the barrier envelope during the test. For example, results of TU Electric tests for 1-hour cable tray barriers, which did not utilize thermocouples on bare conductors, could be used to evaluate similarly constructed cable tray barriers. Additionally, results of NUMARC Phase 1 tests for 1 or 3-hour cable tray barriers, which did not utilize bare conductors under tray rungs, could be used to evaluate similarly constructed tray barriers.

3) For evaluation of installed cable tray barrier performance, cable fill (percent by area) utilized during testing would bound tray barriers containing higher cable fill. If installed cable tray barriers are not bounded by cable fills utilized during testing, the total enclosed mass per unit length (i.e., lbm per ft.) comprised by similar cabling and cable tray can be used. For example, a 15% cable fill contained in a cable tray test assembly would be used to evaluate similarly constructed tray barriers containing greater cable fills. Alternatively, a 15% cable fill contained in a tray barrier test assembly can be used to evaluate cable trays and barriers of similar construction which contain cable fills less than 15%, provided the total enclosed mass per unit length (i.e., lbm per ft.) of the installed configuration is greater than that of the tested cable tray assembly (i.e., cable tray plus cabling).

4) Although not addressed within this guide, evaluation of cable functionality of temperatures which exceed test acceptance values provides an option. For such cable functionality evaluations, the following temperature profile data can be used:

Conduit Barriers - temperatures recorded by thermocouples on #8 AWG bare copper conductors contained within the conduit assembly.

Cable Tray Barriers - temperatures recorded by thermocouples installed on tray side rail surfaces or on #8 AWG bare copper conductors (if applicable) located on or above tray rungs.

Figure 4-1

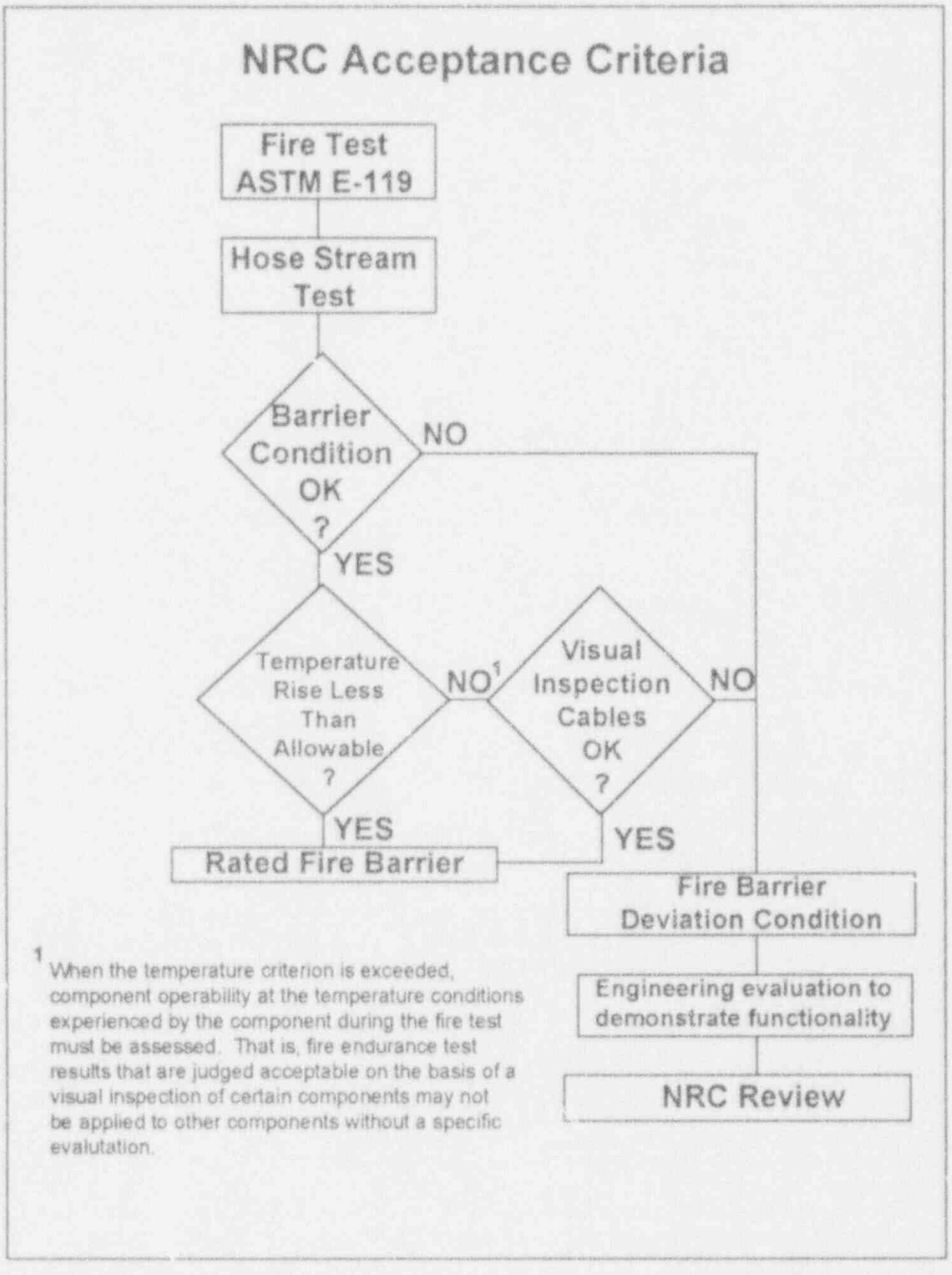

NRC Acceptance Criteria
Fire Test ASTM E-119
Hose Stream Test
Barrier Condition OK ?
NO
YES
Temperature Rise Less Than Allowable ?
NO1
Visual Inspection Cables OK ?
NO
YES
YES
Rated Fire Barrier
Fire Barrier Deviation Condition
Engineering evaluation to demonstrate functionality
NRC Review
1 When the temperature criterion is exceeded, component operability at the temperature conditions experienced by the component during the fire test must be assessed. That is, fire endurance test results that are judged acceptable on the basis of a visual inspection of certain components may not be applied to other components without a specific evalutation.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Commodity	Size • Conduit	Thermal	• 3/4" through 6" diameter conduits.	• Smallest conduit is the most thermally challenging and will bound larger conduits.	• The smallest conduit represents the smallest thermal capacity, least thermal resistance, and the largest external surface area to thermal capacity ratio. Therefore, anything larger (i.e., higher thermal capacity, larger thermal resistance, and less external surface area to thermal capacity ratio) would be bounded. BASIS: NUMARC Tests 1-6, 1-7, 2-1, and 2-3; TUE Tests 9-1, 10-1, and 10-2.
	• Tray		• 6" through 36" cable trays	• No significant correlation, use test for tray of closest size to as-built.	• Test data does not indicate a correlation between tray size and temperature. BASIS: All cable tray tests.
	• Box		• Junction Boxes - various sizes	• The smallest box is the most thermally challenging and would bound larger boxes.	• The smallest box represents the smallest thermal capacity and the largest external surface area to thermal capacity ratio. Therefore, anything larger (i.e., higher thermal capacity and less external surface area to thermal capacity ratio) would be bounded. Thinner enclosures provide less thermal resistance resulting in higher (bounding) internal temperatures. BASIS: ASTM E05.11.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Commodity	Size - Continued • Air Drops	Thermal - Continued	• Air Drops 1" through 5" diameter bundles	• The smallest utilizing the thinnest enclosure is the most thermally challenging and would bound larger air drops.	• The smallest represents the smallest thermal capacity and the largest external surface area to thermal capacity ratio. Therefore, anything larger (i.e., higher thermal capacity and less external surface area to internal area ratio) would be bounded. BASIS: NUMARC Tests 1-4; TUE Tests 11-1 and 11-2.
		Structural	Not applicable.	Not applicable.	Not applicable.
Commodity	Material	Thermal	Aluminum cable trays, conduits, and junction boxes.	Aluminum bounds steel.	Lower thermal capacity and higher thermal conductivity (less thermal resistance) of aluminum results in higher aluminum temperatures. BASIS: NUMARC Test 1-6.
		Structural	Not applicable.	Not applicable.	Not applicable.
Commodity	Thermal mass of contents	Thermal	NUMARC 15% or less cable fill for trays, no cable for conduits. Low thermal mass commodities. TUE 40% cable fill for conduits and air drops, single layer cable fill for trays. Representative thermal mass for commodities.	Contents with larger cable fill or greater thermal capacity (weight /linear foot) is bounded by contents with lower cable fill or thermal capacity (wt/linear ft).	ce material and size discussions. BASIS: ASTM E.05-11.
Commodity	Thermal mass of contents - Continued	Structural	Not applicable.	Not applicable.	Not applicable.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Commodity	Orientation	Thermal and Structural	Both horizontal and vertical orientations for conduits and cable tray assemblies.	All barrier orientations bounded for conduits and cable trays.	Previous test results for all conduit and cable tray tests.
Barrier	Material Type	Thermal	See specific tests for Thermo-Lag materials.	Different types of material provide different thermal protection. Therefore, a test for Thermo-Lag 330 materials will not bound a Thermo-Lag 330-660 flexi-blanket configuration.	Previous test results. BASIS: TUE Tests 9-1, 11-1, and 11-2.
		Structural	See specific tests for Thermo-Lag materials.	Different types of materials require different joining techniques. Therefore, a test for Thermo-Lag 330 materials will not bound a Thermo-Lag 330-660 Flexi-Blanket configuration.	Previous test results. BASIS. TUE Tests 9-1, 11-1, 11-2.
Barrier	Thickness	Thermal	Thermo-Lag 330-1 and 330-660 for air drops, etc. NUMARC Baseline panel and conduit section thickness: 1 Hour: 0.50" +.125"- 0") 3 Hour: 1.00"+.250" - 0") TUE Baseline panel and conduit section thickness: 1 Hour: 0.625" +/- .125"	Thin material provides less thermal resistance and less material to activate and therefore is more challenging. Therefore the thinnest material will bound thicker material applications.	Previous test results. BASIS. NUMARC Tests 1-1, 1-6, 2-1, 2-7. TUE Tests 9-1, 10-1, 10-2, 12-1, 12-2, 11-5, 13-1, 13-2
		Structural		Thin material bounds thicker material.	Previous test results. BASIS: NUMARC Tes. 1-1.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Barrier	Stiffener (V-Rib) Location/ Orientation	Thermal	TUE tests with flat panels on JBs and V-rib panels on JBs. NUMARC tests with V-ribs on JBs	Configurations with stiffeners (v-ribs) oriented facing outward or without stiffeners would bound configurations with the stiffeners (v-ribs) oriented facing inward.	Commodities in direct contact with the barrier material are more conservative than configurations with an air gap between the commodity and the backside of the barrier material. Additional air gap provides an added thermal resistance which will reduce internal temperatures. BASIS: NUMARC Test 1-6. TUE tests 10-1, 10-2.
		Structural	TUE cable tray tests with "V" ribs perpendicular to tray run (unsupported span) NUMARC Tests with "V" ribs parallel to tray run (unsupported span)	For configurations with large unsupported spans, panels installed with stiffeners (v-ribs) oriented parallel to an unsupported span would bound perpendicular orientation.	In previous cable tray tests, panels installed with stiffeners (v-ribs) oriented perpendicular (i.e., across tray top and bottom surfaces) have exhibited better structural support against sagging effects. BASIS: NUMARC Tests 1-1, 2-7. TUE Tests 11-5, 12-1, 12-2, 14-1, 15-1.
Barrier	Stress Skin Location	Thermal and structural	1 Hour: Material installed with stress skin facing commodity. 3 Hour: Not applicable (stress skin on both sides).	All configurations with stress skin installed consistent with tested configurations.	Variations in stress skin locations not tested.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Barrier	Joint Type	Thermal and structural	TUE testing of pre-buttered joints; NUMARC Testing of post buttered upgrades and score and fold joints.	Dry fit joints bound post-buttered joints. Post-buttered joints bound pre-buttered joints. Score and fold joints bound pre or post-buttered butt joints. See Appendix D for generic assembly techniques.	Previous test results. BASIS: NUMARC Phase 1 and 2 tests.
Barrier	Fasteners: Band/Wire Spacing	Thermal	Band / wire spacing, maximum 12" O.C. and 2" - 3" from joints. Closer spacing for mitered joints at radial bends, etc. were tested.	Band/Wire spacing that is greater than that tested is bounded.	Close band/wire spacing on radial bends displayed minimal thermal effect - However external fastening devices can inhibit material activation as demonstrated in cone calorimeter testing, thus impacting barrier performance. (Reference 6.6.)
		Structural	Band / wire spacing, maximum 12" O.C. and 2" - 3" from joints. Closer spacing for mitered joints at radial bends, etc. were tested.	Band/wire spacing that is less than that tested is bounded.	Previous test results. All NUMARC and TUE Testing.
Barrier	Fasteners: Band/Wire Size and Material	Thermal	NUMARC and TUE Tests with tie wires and bands. Cone calorimeter tests with fasteners over sample. (Reference 6.6.)	Bands bound tie wires.	In cone calorimeter testing and fire tests, the tie wires appeared to inhibit the intumescence of the material less than bands. Therefore tie wires allow for better temperature performance at the fastener location. (Omega point cone calorimeter testing of Thermo-Lag). BASIS: NUMARC and TUE Testing and reference 6.6.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Barrier	Fasteners: Band/Wire Size and Material - Continued	Structural	6" through 36" Cable Tray and box enclosures.	Bands bound wires.	In previous tests, the char layer on the outside of the tested Thermo-lag tended to surround and protect wires. Thus, bands are more exposed to the heat and tend to expand more. BASIS: NUMARC Tests 1-1, 1-4, 1-5, 2-7, 2-8, 2-9, 2-10. TUE Tests 11-5, 12-1, 12-2, 13-1, 13-2, 14-1.
Barrier	Fasteners: Band/Wire Distance from Joints	Thermal	Not applicable.	Not applicable.	Not applicable.
		Structural	2" - 3" distance from joints for 6" through 36" cable trays and box design.	Band/Wire spacing such that fasteners are 3" or closer to joints are bounded.	Reduced band/wire spacing would provide increased structural support. BASIS: NUMARC, TUE, TVA Testing.
Barrier	Fasteners Edge Guards	Thermal	Not applicable.	Not critical.	Not applicable.
		Structural	Not applicable.	Not critical.	Not applicable.
Barrier	Unsupported Span	Thermal	Not applicable.	Not applicable.	Not applicable.
		Structural	Unsupported butt seams tested with various span widths.	The largest unsupported span bounds smaller unsupported spans.	The greater the unsupported span the more structural challenge to the FRB. This increases sagging of material and joint failure. BASIS: NUMARC Tests 1-1, 2-7.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Barrier	Joint Reinforcement: Stress Skin/Trowel Grade Overlays	Thermal	6" through 36" cable trays and box enclosures.	Thermo-Lag material installed without stress skin overlay and additional trowel grade material bounds installations using overlays and additional trowel grade material.	Previous testing has demonstrated that external stress skin overlay with trowel grade material provides greater thermal resistance. BASIS: NUMARC Tests 1-1, 2-7, 2-8. TUE Tests 11-5, 12-1, 12-2, 13-1, 13-2, 14-1, 15-1.
		Structural	6" through 36" cable trays and box enclosures.	• Thermo-Lag material installed without stress skin overlay and additional trowel grade material bounds installations using overlays and additional trowel grade material.	• Previous testing has shown that stress skin overlays and additional trowel grade material provide better structural support at joints as material softens. BASIS: NUMARC Tests 1-1, 2-7, 2-8. TUE Tests 11-5, 12-1, 12-2, 13-1, 13-2, 14-1, 15-1.
Barrier	Joint Reinforcement: Stress Skin Ties	Thermal	12" through 36" cable trays.	Not applicable.	Not applicable.
		Structural	12" through 36" cable trays.	Barrier Configurations installed without stress skin ties bound installations using ties.	Previous testing has shown that stress skin ties provide better structural support at joints as material softens. BASIS: NUMARC Tests 1-1, 2-7, 2-8. TUE Tests 11-5, 12-1, 12-2, 13-1, 13-2, 14-1, 15-1.

Table 4-1
Performance Parameters

CATEGORY	PERFORMANCE PARAMETER	FAILURE MECHANISM	TESTED CONFIGURATION	BOUNDED CONFIGURATION	BASIS
Barrier	Joint Reinforcement: Internal Banding	Thermal	6" through 24" cable trays.	Cable tray configurations without internal banding bound installations with internal banding..	Previous testing has shown that with the improved structural performance and limited sagging, reduced heat transfer occurs. BASIS: NUMARC Tests 1-1, 2-9. TUE Test 15-1.
		Structural	6" through 24" cable trays.	Barrier Configurations without internal banding bound installations with internal banding..	Previous testing has shown that internal banding provides better structural support as material softens.
Barrier	Joint Reinforcement: Joint Gap	Thermal and structural	Joints with maximum gap of 1/4" during fit up.	Not critical.	Provided adequate trowel grade material and fasteners are utilized to seal joints, original gaps have not shown to be a critical parameter. BASIS: All NUMARC and TUE testing.
Barrier	Box Enclosure Performance	Thermal	Junction Boxes, Conduit Boxes, Boxed Enclosures around conduits, and air drops.	Tested box configurations not attached to walls or ceilings would bound boxes of similar size and construction which are attached on one or more sizes to concrete walls or ceilings provided acceptable mechanical attachment to the concrete is utilized.	Previous testing has shown that box configurations attached to concrete perform equal or better than boxes totally exposed on all sides. BASIS: NUMARC Tests 1-6, 2-2. TUE Tests 10-1, 10-2, 11-4.

5.0 METHODOLOGY

The following methodology can be used to evaluate installed configurations against those tested. This method is consistent with the guidance and acceptance criteria provided in Generic Letter 86-10 and its proposed supplement. Figure 4.2 depicts the methodology. Appendix H contains examples of this method.

Step 1 - Identify configurations to be evaluated:

Step 1a: Separate each fire barrier system into unique segments (refer to Figure 3-1).

Step 1b: Document the performance parameters of each segment's installed configuration. Appendix G contains a suggested evaluation form.

Step 2 - Determine Tests to be Utilized in the Evaluation:

For each segment, review Appendix A, "Tested Assemblies" to determine the test(s) which have similar performance parameters as the configuration being evaluated. Where such parameters do not directly correlate, review pertinent bounding performance parameters in Table 4-1 to determine other tests that may apply to the installed configuration. When selecting tests for use in the evaluation, methods of barrier construction, commodity configuration and test acceptance basis should be considered. Review Appendices B-E, as applicable, to further refine tested configurations to be used. Once tests have been selected continue to the next step.

Step 3 - Evaluate Fire Barrier and Commodity performance parameters:

Step 3a: Using the selected tests, compare and evaluate each performance parameter of the installed and tested configurations against the acceptance criteria (Table 4-1) for that parameter. If all performance parameters are bounded and the referenced test(s) passed based on temperature and barrier condition, then the configuration is acceptable. Document results.

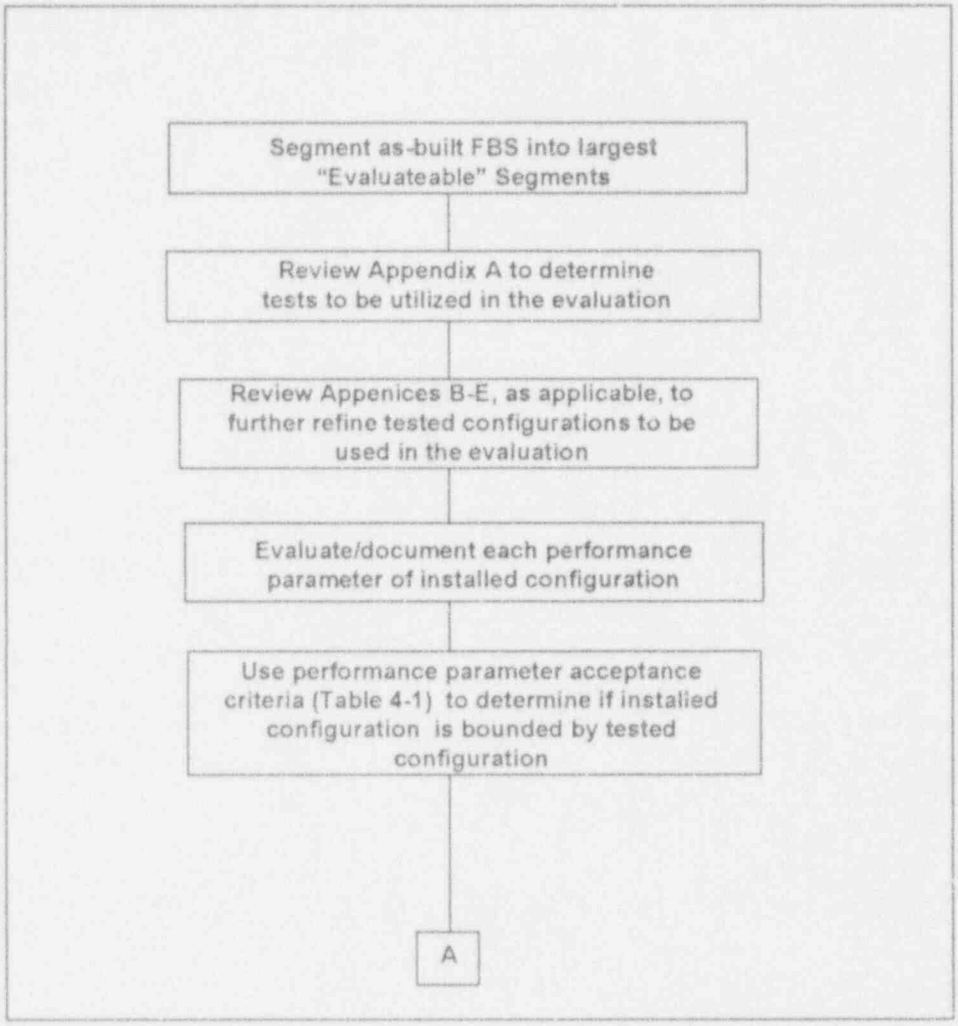
Step 3b: If all performance parameters are bounded but temperature acceptance criteria was exceeded for the referenced test(s), (i.e., test passed based on cable visual inspection or barrier deviation condition), then an assessment of component operability at the temperature conditions which were experienced inside the barrier during the fire test is required. The assessment should address, as a minimum, 1) the cable or component function, 2) the cable insulation type or component material, and 3) the component operability at the temperature conditions experienced during the test.

Step 3c: If all performance parameters are not bounded then perform an engineering evaluation to determine if equivalency to a rated barrier can be established for the installed configuration. The following Generic Letter 86-10 guidance should be considered when performing the evaluation:

- Is the continuity of the fire barrier material consistent with the tested configurations?
- Is the effective thickness of the barrier material consistent with the tested configurations?
- Is the nature and effectiveness of the support assembly (if applicable) consistent with the tested configurations?
- Is the application or end use of the fire barrier consistent with the tested configurations?
- Was the configuration reviewed by a qualified fire protection engineer and determined to provide an equivalent level of protection?

Step 3d: If equivalency to a rated barrier configuration cannot be established by evaluation, then justification for exemption or deviation can be considered. To develop such justification, applicable baseline barrier performance during testing could be compared to similar installed barrier configurations and evaluated for acceptability under specific plant conditions.

FIGURE 4-2


Segment as-built FBS into largest "Evaluateable" Segments
Review Appendix A to determine tests to be utilized in the evaluation
Review Appenices B-E, as applicable, to further refine tested configurations to be used in the evaluation
Evaluate/document each performance parameter of installed configuration
Use performance parameter acceptance criteria (Table 4-1) to determine if installed configuration is bounded by tested configuration
A

6.0 REFERENCES

The following references were used to develop this application guide:

6.1 TUE Fire Endurance Tests (see Appendix B)

6.2 TVA Fire Endurance Tests (see Appendix E)

6.3 ASTM Standard Test Methods for Fire Tests of Fire Resistive Barrier Systems for Electrical System Components, Draft 16, February 4, 1994

6.4 NUMARC Fire Endurance Tests (see Appendix C and D)

6.5 "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems used to Separate Redundant Safe Shutdown Trains within the same Fire Area" Supplement 1 to Generic Letter 86-10, "Implementation of Fire Protection Requirements" (Draft)

6.6 Omega Point Laboratories Project No. 12340-94105, "Evaluation of Heat Release Parameters on Thermo-Lag 330," prepared for TU Electric, March 5, 1993 (Draft)

5.0 METHODOLOGY

The following methodology can be used to evaluate installed configurations against those tested. This method is consistent with the guidance and acceptance criteria provided in Generic Letter 86-10 and its proposed supplement. Figure 4.2 depicts the methodology. Appendix H contains examples of this method.

Step 1 - Identify configurations to be evaluated:

Step 1a: Separate each fire barrier system into unique segments (refer to Figure 3-1).

Step 1b: Document the performance parameters of each segment's installed configuration. Appendix G contains a suggested evaluation form.

Step 2 - Determine Tests to be Utilized in the Evaluation:

For each segment, review Appendix A, "Tested Assemblies" to determine the test(s) which have similar performance parameters as the configuration being evaluated. Where such parameters do not directly correlate, review pertinent bounding performance parameters in Table 4-1 to determine other tests that may apply to the installed configuration. When selecting tests for use in the evaluation, methods of barrier construction, commodity configuration and test acceptance basis should be considered. Review Appendices B-E, as applicable, to further refine tested configurations to be used. Once tests have been selected continue to the next step.

Step 3 - Evaluate Fire Barrier and Commodity performance parameters:

Step 3a: Using the selected tests, compare and evaluate each performance parameter of the installed and tested configurations against the acceptance criteria (Table 4-1) for that parameter. If all performance parameters are bounded and the referenced test(s) passed based on temperature and barrier condition, then the configuration is acceptable. Document results.

Step 3b: If all performance parameters are bounded but temperature acceptance criteria was exceeded for the referenced test(s), (i.e., test passed based on cable visual inspection or barrier deviation condition), then an assessment of component operability at the temperature conditions which were experienced inside the barrier during the fire test is required. The assessment should address, as a minimum, 1) the cable or component function, 2) the cable insulation type or component material, and 3) the component operability at the temperature conditions experienced during the test.

Step 3c: If all performance parameters are not bounded then perform an engineering evaluation to determine if equivalency to a rated barrier can be established for the installed configuration. The following Generic Letter 86-10 guidance should be considered when performing the evaluation:

- Is the continuity of the fire barrier material consistent with the tested configurations?
- Is the effective thickness of the barrier material consistent with the tested configurations?
- Is the nature and effectiveness of the support assembly (if applicable) consistent with the tested configurations?
- Is the application or end use of the fire barrier consistent with the tested configurations?
- Was the configuration reviewed by a qualified fire protection engineer and determined to provide an equivalent level of protection?

Step 3d: If equivalency to a rated barrier configuration cannot be established by evaluation, then justification for exemption or deviation can be considered. To develop such justification, applicable baseline barrier performance during testing could be compared to similar installed barrier configurations and evaluated for acceptability under specific plant conditions.

FIGURE 4-2

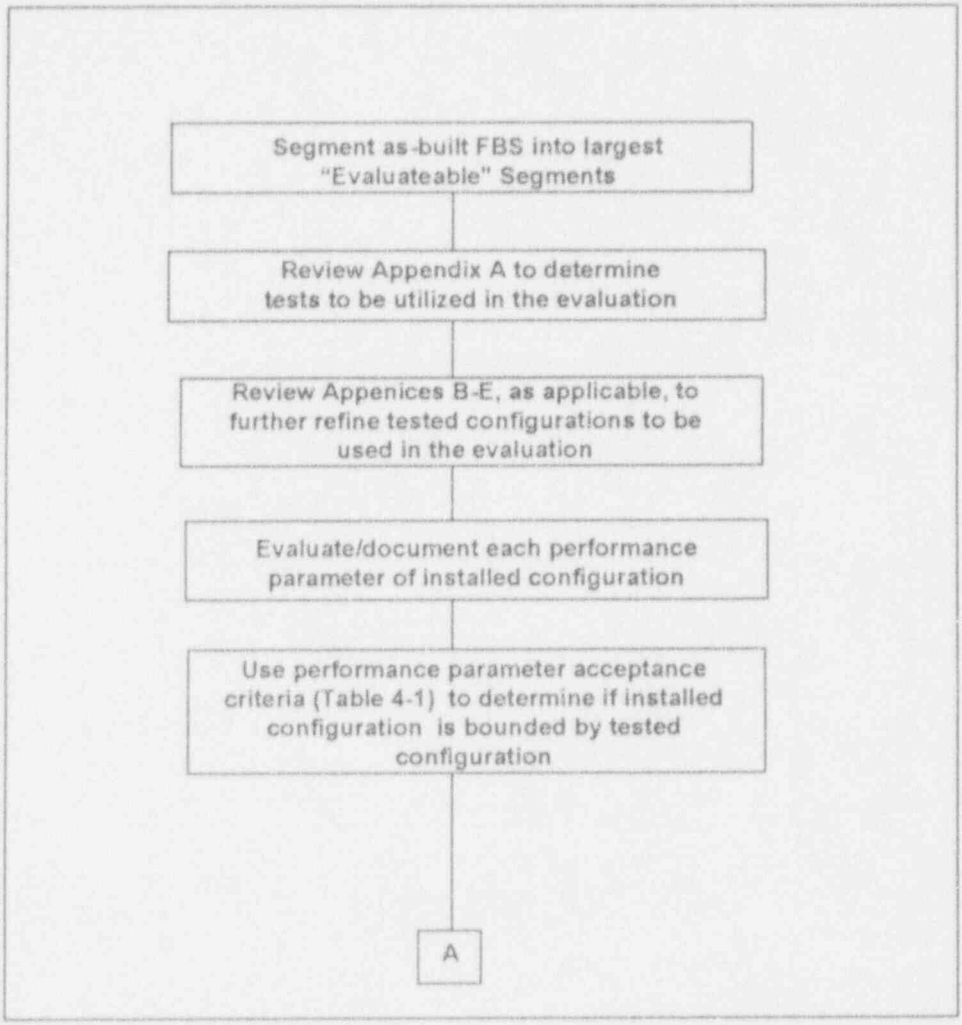
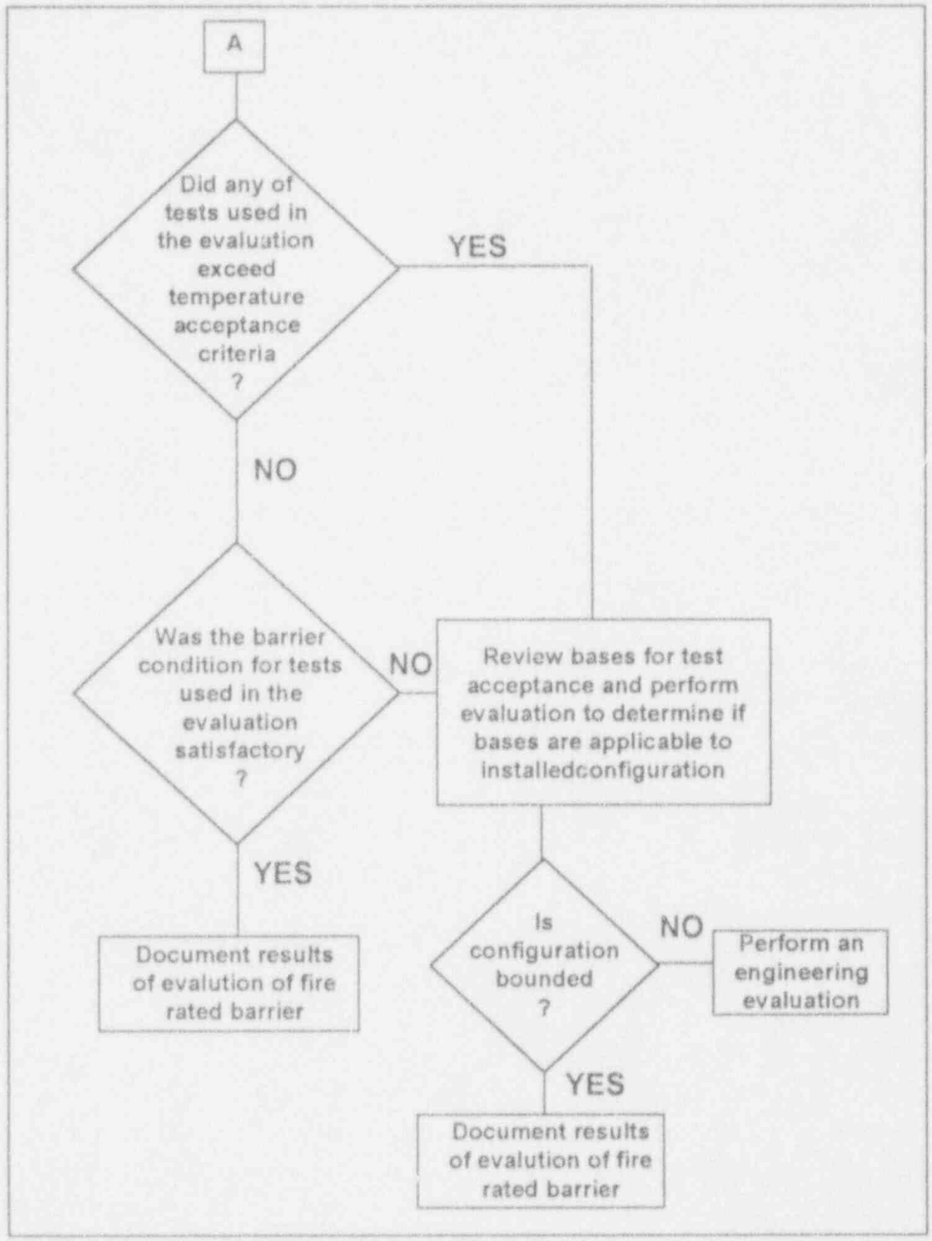

Segment as-built FBS into largest "Evaluateable" Segments
Review Appendix A to determine tests to be utilized in the evaluation
Review Appenices B-E, as applicable, to further refine tested configurations to be used in the evaluation
Evaluate/document each performance parameter of installed configuration
Use performance parameter acceptance criteria (Table 4-1) to determine if installed configuration is bounded by tested configuration
A

FIGURE 4-2 Continued



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6.3 ASTM Standard Test Methods for Fire Tests of Fire Resistive Barrier Systems for Electrical System Components, Draft 16, February 4, 1994

6.4 NUMARC Fire Endurance Tests (see Appendix C and D)

6.5 "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems used to Separate Redundant Safe Shutdown Trains within the same Fire Area" Supplement 1 to Generic Letter 86-10, "Implementation of Fire Protection Requirements" (Draft)

6.6 Omega Point Laboratories Project No. 12340-94105, "Evaluation of Heat Release Parameters on Thermo-Lag 330," prepared for TU Electric, March 5, 1993 (Draft)

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Appendix A
Tested Assemblies

1 HOUR
CONDUITS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3/4 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with post-buttered joints. Baseline layer reinforced with towel grade and stress skin at couplings and supports. Additional overlay of 1/4 in. preshaped sections with pre-buttered joints. Overlay layer reinforced with Trowel grade and stress skin at all joints and at entire radial bend area.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-6
3/4 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay or trowel grade for conduit or radial bends.	Single point and average temperature requirements exceeded at 27 minutes Through opening in barrier developed	NUMARC 2-1
3/4 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Additional overlay of 1/4 in. preshaped sections with pre-buttered joints. Overlay layer reinforced with trowel grade buildup and stress skin at entire radial bend area.	Indeterminate conduit temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1
2 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay or trowel grade for conduit or radial bends.	Average temperature requirements exceeded at 39 minutes Satisfactory barrier condition	NUMARC 2-1
2 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Trowel grade buildup and stainless steel mesh reinforcement over entire radial bend areas.	Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 13-2
3 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with post-buttered joints. Baseline joints reinforced with trowel grade buildup and stress skin. Additional trowel grade buildup and stress skin at couplings, supports and over entire radial bend area.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-6

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Appendix A
Tested Assemblies

1 HOUR
CONDUITS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with post-buttered joints. Baseline joints reinforced with trowel grade buildup and stress skin. Additional trowel grade buildup and stress skin at couplings, supports and over entire radial bend area.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-6
3 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Trowel grade buildup and stress skin over entire radial bend area.	Indeterminate conduit temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1
3 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints.	Indeterminate conduit temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 10-1 and Scheme 10-2
4 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay or trowel grade for conduit or radial bends.	Average temperature requirements exceeded at 48 minutes Satisfactory barrier condition	NUMARC 2-1
5 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with post-buttered joints. Baseline joints reinforced with trowel grade buildup and stress skin. Additional trowel grade buildup and stress skin at couplings, supports and over entire radial bend area.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-6

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Appendix A
Tested Assemblies

1 HOUR
CONDUITS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
5 in. Steel with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Trowel grade buildup and stress skin over entire radial bend area.	Indeterminate conduit temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1
6 in. Aluminum with Radial Bend	1/2 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay or trowel grade for conduit or radial bends.	Average temperature requirements exceeded at 50 minutes Satisfactory barrier condition	NUMARC 2-1
3/4 in. Aluminum with Radial Bend	1 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay on trowel grade for conduit or radial bend.	Average temperature requirement exceeded at 63 minutes Through openings in barrier developed	NUMARC 2-3
3/4 in. Steel with Radial Bend	1 in. preshaped conduit sections with post-buttered joints. Additional overlay of 7/8 in. preshaped sections with pre-buttered joints. Overlay layer reinforced with trowel grade buildup and stress skin at all joints and at entire radial bend area.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-7
3 in. Aluminum with Radial Bend	1 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay on trowel grade for conduit or radial bend.	Single point temperature requirement exceeded at 91 minutes Through openings in barrier developed	NUMARC 2-3
3 in. Steel with Radial Bend	1 in. preshaped conduit sections with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and over entire radial bend area.	Single point conduit temperature requirement exceeded at 112 minutes Satisfactory barrier condition	NUMARC 1-7

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Appendix A
Tested Assemblies

3 HOUR
CONDUITS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
5 in. Steel with Radial Bend	1 in. preshaped conduit sections with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and over entire radial bend area.	Average conduit temperature requirement exceeded at 113 minutes Satisfactory barrier condition	NUMARC 1-7
6 in. Aluminum with Radial Bend	1 in. preshaped conduit sections with pre-buttered joints. Separate "mitered" pieces at radial bend areas. No reinforcement of baseline joints or additional overlay on trowel grade for conduit or radial bend.	Average conduit temperature requirement exceeded at 102 minutes Through openings in barrier developed	NUMARC 2-3
3/4 in. Aluminum LBD Condulet (Long Leg Vertical)	1/2 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-6
3/4 in. Aluminum LBD Condulet (Long Leg Vertical)	1/2 in. V-Rib panels with pre-buttered joints. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-1
3/4 in. Steel LBD Condulet (Long Leg Vertical)	1/2 in. flat panels with pre-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and interfaces.	Indeterminate surface temperatures (Refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1
2 in. Aluminum LBD Condulet (Long Leg Vertical)	1/2 in. V-Rib panels with pre-buttered joints. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-1
3 in. Aluminum LBD Condulet (Long Leg Horizontal)	1/2 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-6

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Appendix A
Tested Assemblies

1 HOUR
BOXED COMMODITIES (OTHER THAN CABLE TRAYS)

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3 in. Steel LBD Conduiet (Long Leg Vertical)	1/2 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-6
3 in steel LBD Conduiet (Long Leg Vertical)	1/2 in. flat panels with pre-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Indeterminate surface temperatures (Refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1
3 in. Steel LBD Conduiet (Long Leg Horizontal)	1/2 in. flat panels with pre-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Indeterminate surface temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 10-1 and Scheme 10-2
4 in. Aluminum LBD Conduiet (Long Leg Vertical)	1/2 in. V-Rib panels with pre-buttered joints. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-1
5 in. Aluminum LBD Conduiet (Long Leg Vertical)	1/2 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-6
5 in. Steel LBD Conduiet (Long Leg Vertical)	1/2 in. flat panels with pre-buttered joints. Panel scored to conform to LBD curvature; scores filled with trowel grade. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Indeterminate surface temperatures (Refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 9-1

Appendix A
Tested Assemblies

1 HOUR
BOXED COMMODITIES (OTHER THAN CABLE TRAYS)

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
6 in. Aluminum LBD Condulet (Long Leg Vertical)	1/2 in. V-Rib panels with pre-buttered joints. One panel scored to accommodate curvature of fitting. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-1
18 in. x 12 in. x 6 in. Steel Junction Box (12 in. Side Vertical) and 18 in. x 12 in. x 6 in. Steel Junction Box (6 in. Side Vertical)	1/2 in. flat panels with pre-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Indeterminate surface temperatures (Refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 10-2
18 in. x 12 in. x 6 in. Steel Junction Box (12 in. Side Vertical) and 18 in. x 12 in. x 6 in. Steel Junction Box (6 in. side vertical)	1/2 in. panels with pre-buttered joints. Additional overlay of 1/2 in. V-rib panels with pre-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces (outer layer only).	Indeterminate surface temperatures (Refer to Appendix B, Note 1) Satisfactory barrier condition Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 10-1
24 in. x 12 in. x 8 in. Aluminum Junction Box (12 in. Side Vertical)	1/2 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-6

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Appendix A
Tested Assemblies

1 HOUR
BOXED COMMODITIES (OTHER THAN CABLE TRAYS)

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3/4 in., 2 in. and 3 in. Aluminum Conduits with LBD Condulets inside 46 in. (long) x 26 in. (wide) x 22 in. (deep) five-sided enclosure	1/2 in. V-Rib panels (2) with "score and fold" method used to construct sides and bottom of box. Panels flared out onto underside of concrete test slab, pre-buttered with trowel grade material and secured with 1/4 in. x 2-1/4 in. anchor bolts at 12 in. intervals. Butt joint between panels pre-buttered. Scored panel areas filled with trowel grade material. Ends of box used separate panel pieces with pre-buttered joints. End panels also flared out onto underside of test slab, pre-buttered with trowel grade material and secured with anchor bolts at 12 in. intervals. Stainless steel banding used around entire enclosure.	Satisfactory conduit temperatures Through opening in barrier developed Informational thermocouples on unexposed panel surfaces reached 407°F average temperature and 430°F single point maximum temperature.	NUMARC 2-2
3/4 in., 2 in. and 3 in. Aluminum Conduits with LBD Condulets inside 46 in. (long) x 26 in. (wide) x 22 in. (deep) five-sided enclosure	1/2 in. V-Rib panels (2) with "score and fold" method used to construct sides and bottom of box. Panels flared out onto underside of concrete test slab, pre-buttered with trowel grade material and secured with 1/4 in. x 2-1/4 in. anchor bolts at 12 in. intervals. Butt joint between panels post-buttered. Scored panel areas filled with trowel grade material. Ends of box used separate panel pieces with post-buttered joints. End panels also flared out onto underside of test slab, pre-buttered with trowel grade material and secured with anchor bolts at 12 in. intervals. Stainless steel banding used around entire enclosure. All joints between panels and seams in scored areas reinforced with additional trowel grade buildup and stress skin secured with staples and tie wires.	Satisfactory conduit temperatures Satisfactory barrier condition Informational thermocouples on unexposed panel surfaces reached 362°F average temperature and 377°F single point maximum temperature.	NUMARC 2-2
3/4 in. Aluminum LBD Condulet (Long Leg Vertical)	1 in. V-Rib panels with pre-buttered joints. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-3

Appendix A
Tested Assemblies

3 HOUR
BOXED COMMODITIES (OTHER THAN CABLE TRAYS)

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3/4 in. Steel LBD Condulet (Long Leg Vertical)	1 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints. Outer panel layer joints stitched with tie wire and reinforced with trowel grade and stress skin. Trowel grade buildup and stress skin reinforcement at conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-7
3 in. Aluminum LBD Condulet (Long Leg Vertical)	1 in. V-Rib panels with pre-buttered joints. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-3
3 in. Steel LBD (Long Leg Horizontal)	1 in. V-rib panels, post-buttered. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints. Outer panel layer joints stitched with tie wire and reinforced with trowel grade and stress skin. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-7
5 in. Steel LBD (Long Leg Vertical)	1 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints. Outer panel layer joints stitched with tie wire and reinforced with trowel grade and stress skin. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Single point surface temperature requirement exceeded at 151 minutes Satisfactory barrier condition	NUMARC 1-7
6 in. Aluminum LBD Condulet (Long Leg Vertical)	1 in. V-Rib panels with pre-buttered joints. One panel scored to accommodate curvature of fitting. No reinforcement of joints or conduit interfaces.	Later	NUMARC 2-3

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Appendix A
Tested Assemblies

1 HOUR
CABLE TRAYS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
12 in. x 4 in. Steel Ladder Back with Radial Bends	1/2 in. V-rib panels with pre-buttered joints. V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bends; scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade buildup and stress skin. Butt joints between panels stitched at various locations.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 13-1
12 in. x 4 in. Steel Ladder Back with Radial Bends	1/2 in. V-rib panels with pre-buttered joints. V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bends; scores filled with trowel grade	Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 13-2
24" x 4" Aluminum Ladder Back with Radial Bend	1/2 in. V-rib panels with pre-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Baseline application with no upgrades applied.	Single point temperature criterion exceeded at 21 minutes on the conductor below the tray rungs. Through openings in barrier developed prior to ending the test at 48 minutes	NUMARC 2-7
24" x 4" Aluminum Ladder Back with Radial Bend	1/2 in. V-rib panels with pre-buttered joints. Score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend. Baseline application with no upgrades.	Single point temperature criterion exceeded at 23 minutes on the conductor below the tray rungs. Openings in barrier developed prior to ending the test at 48 minutes	NUMARC 2-7
24 in. x 4 in. Aluminum Ladder Back with Radial Bend and Fire Stop	1/2 in. V-rib panels with post-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Thermo-Lag fire stop in horizontal tray commodity to close envelope. Longitudinal joints at side panels and butt joints between panels reinforced with trowel grade and stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition Single high temperature on one tray rail adjacent to fire stop at 60 minutes attributed to fire stop performance	NUMARC 2-8

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Appendix A
Tested Assemblies

1 HOUR
CABLE TRAYS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
24 in. x 4 in. Aluminum Ladder Pack with Radial Bend	1/2 in. V-rib panels with post-buttered joints. Score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend. Longitudinal butt joints and score and fold joints at side panels and butt joints between panels reinforced with trowel grade and stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 2-8
24 in. x 4 in. Steel Ladder Back w/Radial Bend	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints, V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bend, scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade and stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 11-5
24 in. x 4 in. Steel Ladder Back w/Radial Bend, 90° Square Fitting and Tee Section	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints, V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bend; scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade and stress skin. Butt joints between panels stitched at various locations and reinforced with stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 12-2
30 in. x 4 in. Steel Ladder Back w/Radial Bends	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints, V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bends; scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade and stress skin. Butt joints between panels stitched at various locations and reinforced with stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 12-1

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Appendix A
Tested Assemblies

1 HOUR
CABLE TRAYS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
30 in. x 4 in. Steel Ladder Back w/Radial Bend, 90° Square Fitting and Tee Section	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints, V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bends; scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade and stress skin. Butt joints between panels reinforced with trowel grade and stress skin.	Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 14-1
36 in. x 4 in. Steel Ladder Back w/Radial Bends	1/2 in. V-rib panels with post-buttered joints; V-ribs parallel to tray rails on top and bottom of tray. Scored panels on inside and outside face of one radial bend; scores filled with trowel grade. Separate mitered panel pieces on inside and outside face of other radial bend. Longitudinal joints at side panels and butt joints between panels reinforced with trowel grade and stress skin.	Single point temperature criterion exceeded at 54 minutes for conductor on top of cable layer Through opening in barrier developed	NUMARC 1-1
36 in. x 4 in. Aluminum Ladder Back Cable Tray with Radial Bends	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints; V-ribs parallel to tray rails on top and bottom of tray. Scored panels on inside and outside face of one radial bend; scores filled with trowel grade. Separate mitered panel pieces on inside and outside face of other radial bend. Longitudinal joints at side panels and butt joints between panels reinforced with trowel grade and stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 2-9
36 in. x 4 in. Steel Ladder Back w/Radial Bends	Internal banding installed on cable tray. 1/2 in. V-rib panels with pre-buttered joints, V-ribs perpendicular to tray rails on top and bottom of tray. Scored panels on inside and outside face of radial bends; scores filled with trowel grade. Longitudinal joints at side panels reinforced with trowel grade and stress skin. Butt joints between panels reinforced with trowel grade and stress skin.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 15-1

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Appendix A
Tested Assemblies

3 HOUR
CABLE TRAYS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
6 in. x 4 in. Aluminum Ladder Back with Radial Bend	1 in. V-rib panels with pre-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Baseline application with no upgrades applied.	Satisfactory raceway temperatures at 86 minutes when test was terminated Satisfactory barrier condition Opening developed in the barrier	NUMARC 2-10
6 in. x 4 in. Aluminum Ladder Back with Radial Bend	1 in. V-rib panels with pre-buttered joints. Score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend. Baseline application with no upgrades.	Satisfactory raceway temperatures at 85 minutes when test was terminated Satisfactory barrier condition Opening developed in the barrier (panel fell off in furnace at 85 minutes)	NUMARC 2-10
24 in. x 4 in. Aluminum Ladder Back w/Radial Bends and Tee Section	1/2 in. v-rib panels with post-buttered joints. V-ribs parallel to tray rails on top and bottom of tray and on inside and outside panels above radial bends. V-ribs perpendicular on inside and outside of radial bends. Panels on inside and outside of left radial bend and tee section radius were scored. Inside and outside panels on right radial bend were mitered. Additional overlay of 5/8 in. V-rib panels with V-ribs perpendicular to tray rails. Joints were pre-buttered. Butt joints were stitched and reinforced with trowel grade and stress skin. Longitudinal joints reinforced with stitches, trowel grade and stress skin.	Single point raceway temperature requirement exceeded at 172 minutes Hose stream dislodged panel creating through opening	NUMARC 1-5
24 in. x 4 in. Steel Ladder Back w/Radial Bends	1/2 in. v-rib panels with post-buttered joints. V-ribs parallel to tray rails on top and bottom of tray and on inside and outside panels above radial bends. V-ribs perpendicular on inside and outside of radial bends. Panels on inside and outside of right radial bend were scored. Inside and outside panels on left radial bend were mitered. Additional overlay of 5/8 in. V-rib panels with V-ribs perpendicular to tray rails. Joints were pre-buttered. Butt joints were stitched and reinforced with trowel grade and stress skin. Longitudinal joints reinforced with stitches, trowel grade and stress skin.	Satisfactory raceway and conductor temperatures Satisfactory barrier condition	NUMARC 1-4

Appendix A
Tested Assemblies

3 HOUR
CABLE TRAYS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
24 in. x 4 in. Aluminum Ladder Back with Radial Bend	1 in. V-rib panels with pre-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Baseline application with no upgrades applied.	Single point temperature criterion exceeded at 86 minutes on the tray siderail	NUMARC 2-10
24 in. x 4 in. Aluminum Ladder Back with Radial Bend	1 in. V-rib panels with pre-buttered joints. Score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend. Baseline application with no upgrades.	Single point temperature criterion exceeded at 85 minutes on the conductor below the tray rungs	NUMARC 2-10
36 in. x 4 in. Steel Ladder Back w/Radial Bends	1/2 in. v-rib panels with post-buttered joints. V-ribs parallel to tray rails on top and bottom of tray and on inside and outside panels above radial bends. V-ribs perpendicular on inside and outside of radial bends. Panels on inside and outside of left radial bend were scored. Inside and outside panels on right radial bend were mitered. Additional overlay of 5/8 in. V-rib panels with V-ribs perpendicular to tray rails. Joints were pre-buttered. Butt joints were stitched and reinforced with trowel grade and stress skin. Longitudinal joints reinforced with stitches, trowel grade and stress skin.	Single point raceway temperature requirement exceeded at 167 minutes Through opening in barrier developed	NUMARC 1-3

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Appendix A
Tested Assemblies

1 HOUR
AIR DROPS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
Two 750KCM Power Cables in Exposed 36 in. x 4 in. Steel Ladder Back Tray	Two layers 330-660 Flexi-Blanket on each cable, seams on second layer pre-buttered with 330-660 trowel grade. Note: Protected cables laid in horizontal cable tray. Tray was exposed (no Thermo-Lag applied).	Satisfactory cable visual inspection Satisfactory barrier condition Satisfactory cable functionality	TU Electric Scheme 15-2
Cable Bundle (3 cables) exiting 1-1/2 in. vertical conduit stub; entering fire stop in end of horizontal cable tray	Two layers 330-660 Flexi-Blanket, seams on second layer pre-buttered with 330-660 trowel grade. Flexi-Blanket reinforced at conduit stub interface with staples	Satisfactory cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-2
Cable bundle (4 cables) exiting 2 in. vertical conduit stub; entering horizontal cable tray	Two layers 330-660 Flexi-Blanket, seams on second layer pre-buttered with 330-660 trowel grade. Flexi-Blanket reinforced at conduit stub interface with staples	Single point temperature exceeded on cable at 59 minutes Satisfactory barrier condition Satisfactory visual inspection Satisfactory cable functionality	TU Electric Scheme 11-2
Single nonessential cable protruding from vertical cable tray replicating thermal short	Two layers 330-660 Flexi-Blanket, overlap on second layer pre-buttered with 330-660 trowel grade.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Scheme 11-2
Cable bundle (1 cable) exiting 1 in. vertical conduit stub; entering fire stop in end of horizontal cable tray	Three layers 330-660 Flexi-Blanket, seams on all layers pre-buttered with 330-660 trowel grade	Satisfactory cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1

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Appendix A
Tested Assemblies

1 HOUR
AIR DROPS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
Cable bundle (5 cables) exiting 2 in. vertical conduit stub; entering fire stop in end of horizontal cable tray	Three layers 330-660 Flexi-Blanket, seams on all layers pre-buttered with 330-660 trowel grade	Satisfactory cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1
Cable bundle (10 cables) exiting 3 in. vertical conduit stub; entering horizontal cable tray	Two layers 330-660 Flexi-Blanket, seams on both layers pre-buttered with 330-660 trowel grade	Satisfactory cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1
Cable bundle (14 cables) exiting 5 in. vertical conduit stub; entering horizontal cable tray	Two layers 330-660 Flexi-Blanket, seams on both layers pre-buttered with 330-660 trowel grade	Satisfactory cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1
Single nonessential cable protruding from vertical cable tray replicating thermal short	Two layers 330-660 Flexi-Blanket, seams on all layers pre-buttered with 330-660 trowel grade. Reinforcement at tray interface.	Satisfactory raceway cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1
Single nonessential cable protruding from 5 in. (essential) cable drop replicating thermal short	Two layers 330-660 Flexi-Blanket, seams on all layers pre-buttered with 330-660 trowel grade.	Satisfactory essential cable temperatures Satisfactory barrier condition	TU Electric Scheme 11-1

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Appendix A
Tested Assemblies

1 HOUR
AIR DROPS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
24 air drop cables from two 24 in. x 4 in. steel ladder back horizontal cable trays (stacked) through embedded sleeves	2'-11-1/2" (W) x 1'-7-1/2" (H) x 11-1/2" (D) box design enclosure around air drop cables and embedded sleeves. 1/2 in. V-rib panels on top, front and sides of box with pre-buttered joints. V-ribs perpendicular to trays on top panel. V-ribs vertical on front and sides. 1/2 in. flat panel on bottom with pre-buttered joints. All joints reinforced with trowel grade buildup and stress skin. Panel butt joints at concrete wall interface reinforced using stress skin and 2 in wide flat panel pieces mechanically fastened to wall.	Satisfactory cable temperature Hose stream opened joint between panels causing through opening Satisfactory cable visual inspection Satisfactory cable functionality	TU Electric Scheme 11-4

Appendix A
Tested Assemblies

3 HOUR
AIR DROPS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
2 bare copper conductors exiting 5 in. vertical conduit stub into horizontal cable tray	1 in. preshaped conduit sections with post-buttered joints. Trowel grade buildup and stress reinforcement at longitudinal and butt seams.	Average conductor temperature requirement exceeded at 104 minutes Satisfactory barrier condition	NUMARC 1-4

Appendix A
Tested Assemblies

1 HOUR
SUPPORTS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
P1001 Unistrut - Vertical	1/2 in. V-rib panels with post-buttered joints. Protected distance was 9 in. from nearest conduit envelope. Joints between panels reinforced with trowel grade buildup and stress at interface with conduits.	Satisfactory conduit temperatures Satisfactory barrier condition	NUMARC 1-6
P1001 Unistrut - Vertical	1/2 in. flat panels with pre-buttered joints. Protected distance was 9 in. from nearest conduit envelope.	Indeterminate conduit temperatures (refer to Appendix B, Note 1) Satisfactory barrier condition	TU Electric Scheme 9-1
3 in. Steel Channel (C3x4.1) - Vertical	1/2 in. flat panels with pre-buttered joints. Protected distance was 9 in. from cable tray envelope.	Satisfactory raceway temperatures Satisfactory barrier condition	TU Electric Schemes 11-1, 11-2, 12-1, 12-2, 13-1, 13-2, 14-1, 15-1

Appendix A
Tested Assemblies

3 HOUR
SUPPORTS

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
3 in. Steel Channel (C3x4.1) - Vertical	1 in. V-rib panels with post-buttered joints. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints and stitched along longitudinal joints.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 1-3
P1001 Unistrut - Horizontal	1 in. V-rib panels with post-buttered joints. Protected distance was 18 in. from cable tray envelope. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints and stitched along longitudinal joints.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 1-3
Thermo-Lag Cable Tray Fire Stop (Tested to IEEE 634 for 1 hour)	36" x 4" cable tray with 40% cable fill (1/3 mix of power, control and instrument) mounted vertically with 5" deep Thermo-Lag 330-1 fire stop poured in place and extending over the entire inside width of the cable tray 12" from the bottom of the tray. The fire stop and the tray above the fire stop were covered with V-rib panels with pre-buttered joints and no internal banding or joint reinforcement leaving the bottom 12" of tray and cable fill unprotected by Thermo-Lag. V-ribs were perpendicular to tray rails on top and bottom of tray (front and back panels) with V-ribs on side panels installed vertically (parallel to tray rails). Side panels were installed in compression.	Satisfactory temperatures on the inside of the envelope which met the requirements of IEEE 634. Joints on the Thermo-Lag envelope around the fire stop opened during the hose stream test (straight stream hose). However, the hose stream did not penetrate or dislodge the Thermo-Lag fire stop.	TU Electric Scheme 4

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APPENDIX B

EXCERPTS FROM

TU ELECTRIC THERMO-LAG 330 TEST REPORTS

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APPENDIX B

TABLE OF CONTENTS

Scheme 11, Assembly 2 TU Electric Report No. 12340-95766 One Hour Fire Test, 24 in. Cable Tray Assembly	Cover, ii, 7 through 16, 18 through 23, Appendix A (7 pages). Appendix I (13 pages)
Scheme 11, Assembly 4 TU Electric Report No. 12340-95767 One Hour Fire Test, Box Design Air Drop from Two Nested 24 in. Cable Assemblies	Cover, ii, 7 through 14, 16 through 21, Appendix A (9 pages) Appendix I (6 pages)
Scheme 11, Assembly 5 TU Electric Report No. 12340-95768 One Hour Fire Test, Three 24 in. Cable Tray Assemblies	Cover, ii, 7 through 13, 16 through 23, Appendix A (10 pages) Appendix I (13 pages)
Scheme 12, Assembly 1 TU Electric Report No. 12340-94367i One Hour Fire Test, 30 in. Cable Tray	Cover, ii, 8 through 14, 17 through 20, Appendix A (7 pages), Appendix J (3 pages)
Scheme 12, Assembly 2 TU Electric Report No. 12340-94367h One Hour Fire Test, 24 in. Cable Tray with Tee	Cover, ii, 8 through 14, 16 through 19, Appendix A (9 pages), Appendix J (3 pages)
Scheme 13, Assembly 1 TU Electric Report No. 12340-94367l One Hour Fire Test, 12 in. Cable Tray	Cover, ii, 8 through 14, 16 through 18, Appendix A (7 pages), Appendix J (4 pages)
Scheme 13, Assembly 2 TU Electric Report No. 12340-95769 One Hour Fire Test, 12 in. Cable Tray & 2 in. Conduit	Cover, ii, 7 through 14, 17 through 21, Appendix A (9 pages), Appendix I (5 pages)
Scheme 14, Assembly 1 TU Electric Report No. 12340-94367m One Hour Fire Test, 30 in. Cable Tray with Tee	Cover, ii, 8 through 14, 16 through 18, Appendix A (9 pages), Appendix J (2 pages)
Scheme 15, Assembly 1 TU Electric Report No. 12340-95100a One Hour Fire Test, 36 in. Cable Tray	Cover, ii, 7 through 13, 15 through 17, Appendix A (7 pages), Appendix I (2 pages)

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TU Electric Report No. 12340-95770 One Hour Fire Test, Flexi-Blanket Wrapped Cables Laid in a 36 in. Cable Tray	Cover, ii, 7 through 11, 13 through 16, Appendix A (7 pages), Appendix I (6 pages)

GENERAL NOTES FOR TU ELECTRIC THERMO-LAG TESTS

Notes on Material and Installation

1. The Thermo-Lag thickness given in the test descriptions are nominal. The actual thickness is the stated thickness ± 1/8 inch.

2. Steel bands used in the tests were 1/2 in. wide x 0.020 in. thick type 304 stainless steel rolled-edge banding straps.

3. Tie wires used in the tests were 16 to 18 GA stainless steel.

4. Band spacing for all tests was 12 inch, maximum.

5. All Thermo-Lag panels had stress skin monolithically adhered to the panel on one face. The face with the stress skin was installed adjacent to the protected commodity.

Notes on Test Acceptance

1. Conduit surface Temperatures (Schemes 9-1, 10-1 and 10-2)

During the fire endurance tests of Scheme 9-1 and Scheme 10-1, the temperatures reported by some of the thermocouples installed on the conduit surfaces between the conduit and the Thermo-Lag material rose faster and higher than expected. For example, after 31 minutes, a thermocouple on the 3-inch diameter conduit for Scheme 9-1 reported a temperature of 1480°F (804°C). The corresponding cable thermocouple temperatures were less than 200°F (93°C). By the end of the test, the temperature reported by this conduit surface thermocouple had dropped to 468°F (242°C). It was also noted that the thermocouple with the longest run of thermocouple wire had the highest temperature reading. During the post-fire inspection of the barrier, the fire barrier was intact and virgin Thermo-Lag material remained between the char layer and the conduit surface thermocouples. When the laboratory disassembled the fire barrier, it was noted that many of the thermocouple wires located between the outer conduit surface and the Thermo-Lag material were coated with a dark brown gummy substance and that the braided fiberglass thermocouple wire insulation was saturated with the substance in places. The foreign substance appeared to be mixture of water and decomposed Thermo-Lag material that had migrated into the enclosure under fire exposure and condensed on the cool conduit surfaces.

The morning after the fire test, the laboratory tested the operability of the Scheme 9-1 thermocouple that reported the highest temperature. It performed correctly. When the laboratory immersed a residue-saturated segment of the insulation in warm water, with the thermal junction exposed to ambient air, the thermocouple reported a

temperature rise of about 10°F (12°C). The temperature reported by the thermocouple should not have changed. This demonstrated that the saturation of the thermocouple wire insulation affected the temperature reading.

The test laboratory concluded that the high temperatures reported by the conduit surface thermocouples were caused by saturation of thermocouple wire insulation with a residue composed of water and Thermo-Lag off-gases which migrated through the thermo-Lag material and condensed on the conduit surfaces. The saturation set up an ionic potential across the thermocouple wires which affected the thermocouple readings. The longer the thermocouple wire, the greater the potential, and the higher the temperature reported by the thermocouple. When the conduit surface reached 212°F (100°C), the water began to evaporate. This dried out the thermocouple wire insulation and reduced the potential, thereby lowering the thermocouple reading.

The conduit surface temperatures for Schemes 10-1 and 10-2 were also irregular and inconsistent with visual observations. It was concluded that the conduit surface temperatures for the three fire tests were indeterminate.

The fire test acceptance criteria specified that a fire test was successful if the barrier did not burn through and the cables did not have any visual fire damage even if the temperature criteria were exceeded. Scheme 9-1, and the Schemes 10-1 and 10-2 fire tests met the conditions of acceptance for post-fire barrier condition and post-fire cable condition; therefore, the conduit surface temperatures were not needed to declare these three fire tests satisfactory. This was, therefore, an acceptable deviation from the temperature acceptance criteria.

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APPENDIX C

EXCERPTS FROM

NUMARC PHASE 1

THERMO-LAG 330 TEST REPORTS

APPENDIX C

TABLE OF CONTENTS

GENERAL NOTES FOR NUMARC THERMO-LAG TESTS

Notes on Material and Installation

1. The Thermo-Lag thickness given in the test descriptions are nominal. The actual thickness is the stated thickness + 1/8 inch, - 0 inch.

2. Steel bands used in the tests were 1/2 in. wide x 0.020 in. thick type 304 stainless steel rolled-edge banding straps.

3. Tie wires used in the tests were 16 to 18 GA stainless steel.

4. Band spacing for all tests was 12 inch, maximum, and within 2 inches from butt joints.

5. All Thermo-Lag panels had stress skin monolithically adhered to the panel on one face. The face with the stress skin was installed adjacent to the protected commodity.

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APPENDIX E

EXCERPTS FROM

TVA

THERMO-LAG 330 TEST REPORTS

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APPENDIX F

GENERIC THERMO-LAG

ASSEMBLY TECHNIQUES

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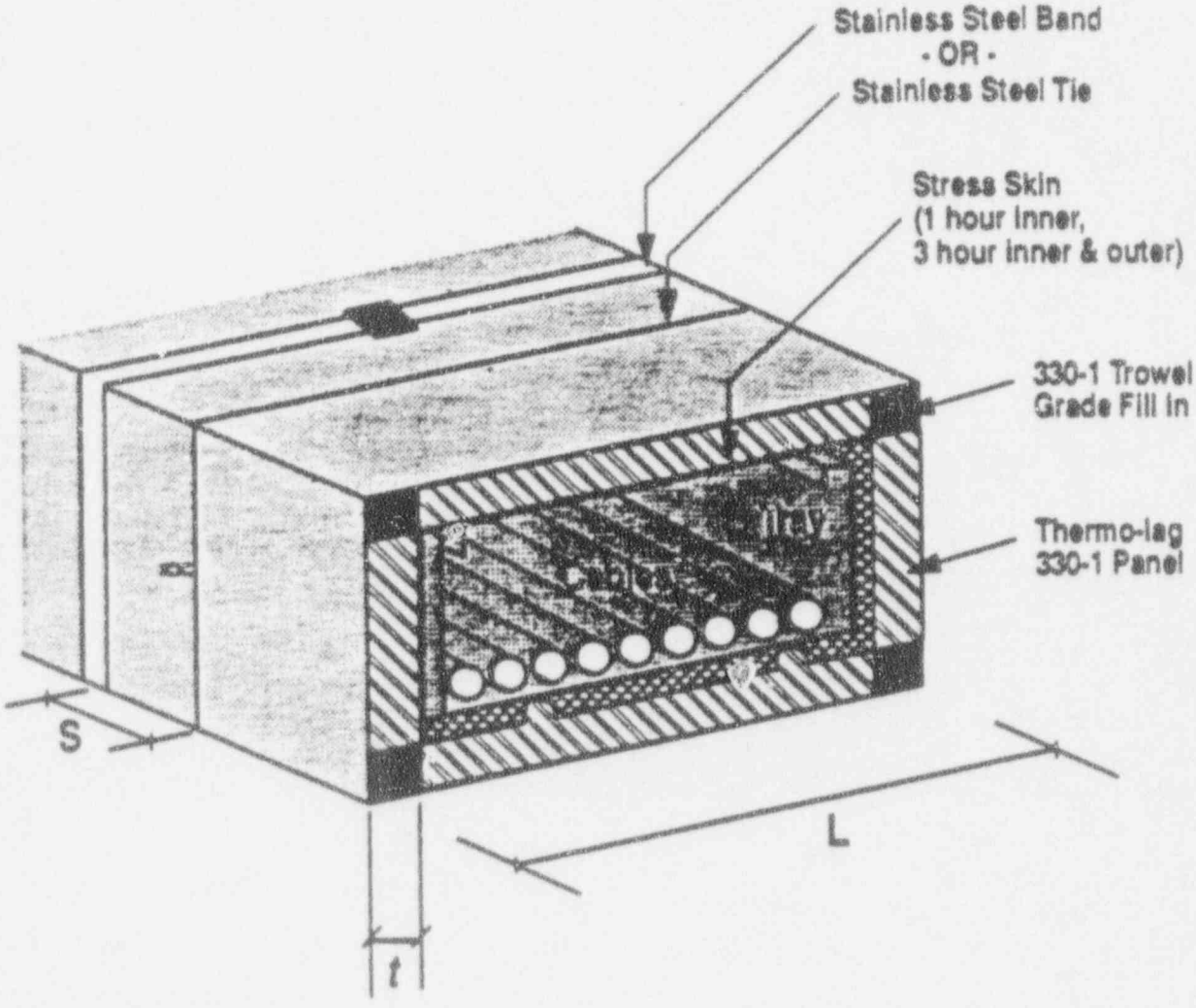
ILLUSTRATION #1

ELEMENTS OF A TYPICAL THERMO-LAG CABLE TRAY ENCLOSURE



L = Unsupported barrier span

S = Spacing

t = Barrier panel thickness

NOTE:

Panels composing this assembly were scored (cut with a knife and folded open). Stress Skin remains continuous at scored seams. Enclosure could be made with only one longitudinal seam tied.

This is for illustration purposes only.

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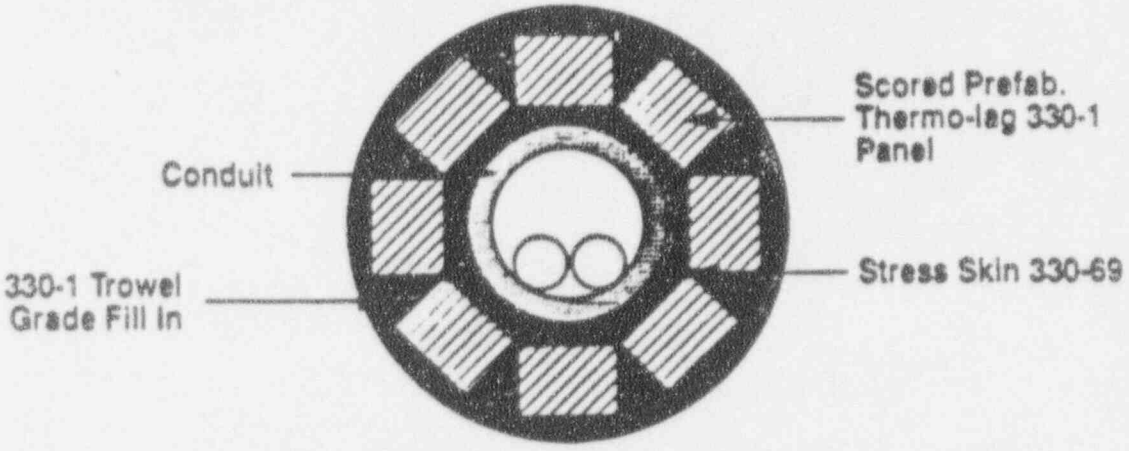
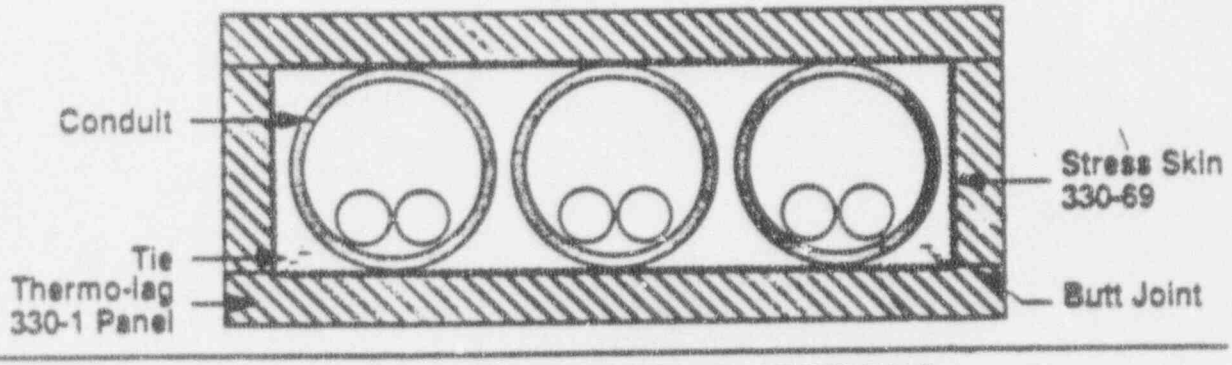
ILLUSTRATION #2

TYPICAL CONDUIT ENCLOSURES

SCORED PANEL WITH TROWEL GRADE FILL



BUTT JOINT BOX CONSTRUCTION



PRE-SHAPED CONDUIT SECTIONS WITH TROWEL GRADE JOINT FILL

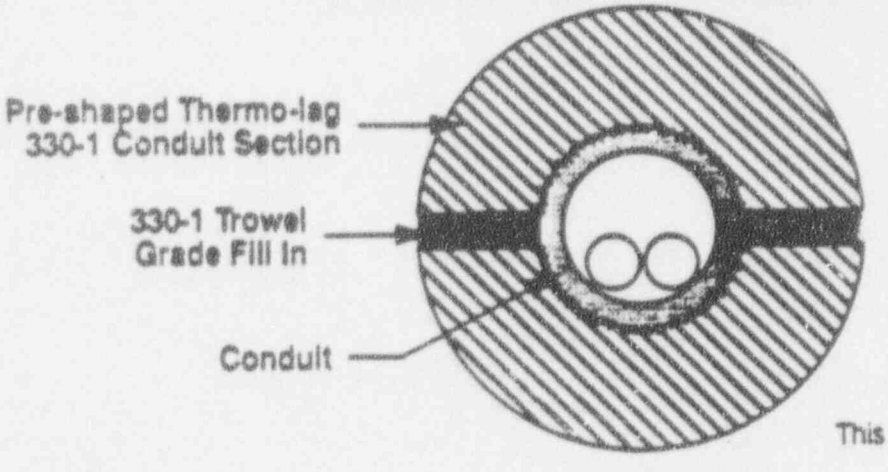


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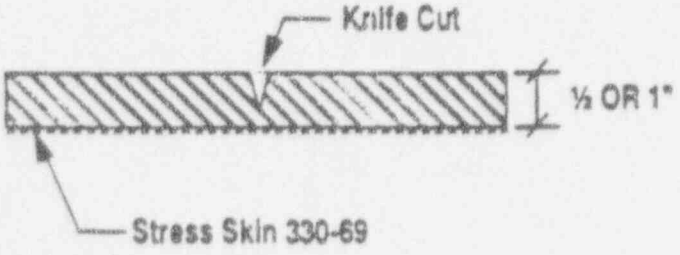
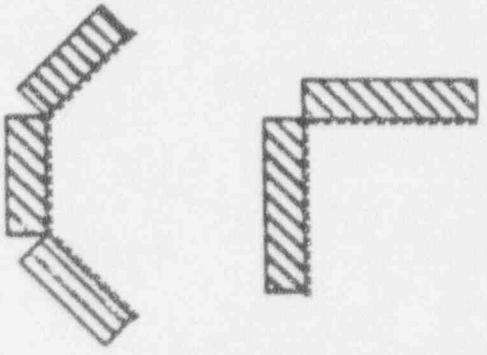
ILLUSTRATION #3

TYPICAL CONSTRUCTION TECHNIQUES

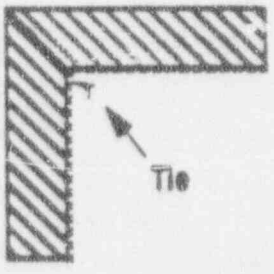
SCORING





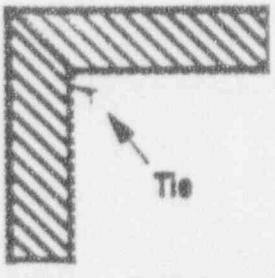
Fold and assemble
as needed to envelop raceway

GROOVING



Fold and assemble
as needed to envelop raceway

GROOVING



Fold and assemble
as needed to envelop raceway

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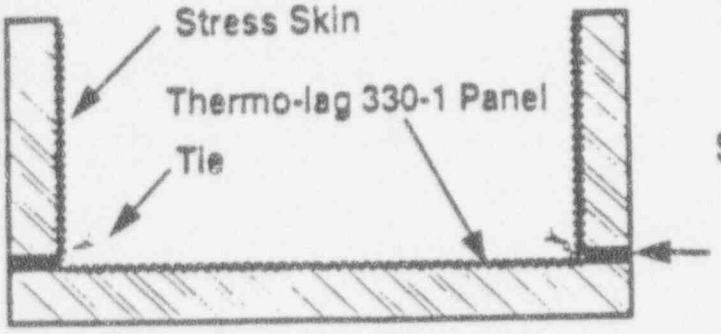
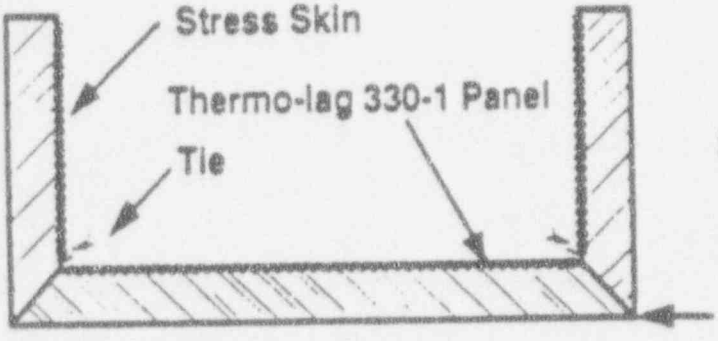
ILLUSTRATION #4

TYPICAL JOINT CONFIGURATIONS



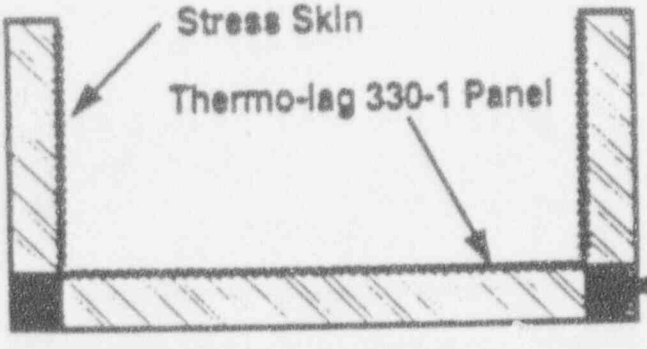
BUTT JOINT
INDIVIDUAL PIECES
SEVERED STRESS SKIN

"Pre-buttered" (Thermo-lag Trowel Grade 330-1 applied prior to joining)



MITERED JOINT
INDIVIDUAL PIECES
SEVERED STRESS SKIN

"Dry Fitting" (pieces joined together without filling in or "pre-buttering")



SCORED PANEL
FILLED JOINT
CONTINUOUS STRESS SKIN

330-1 Trowel Grade Fill In

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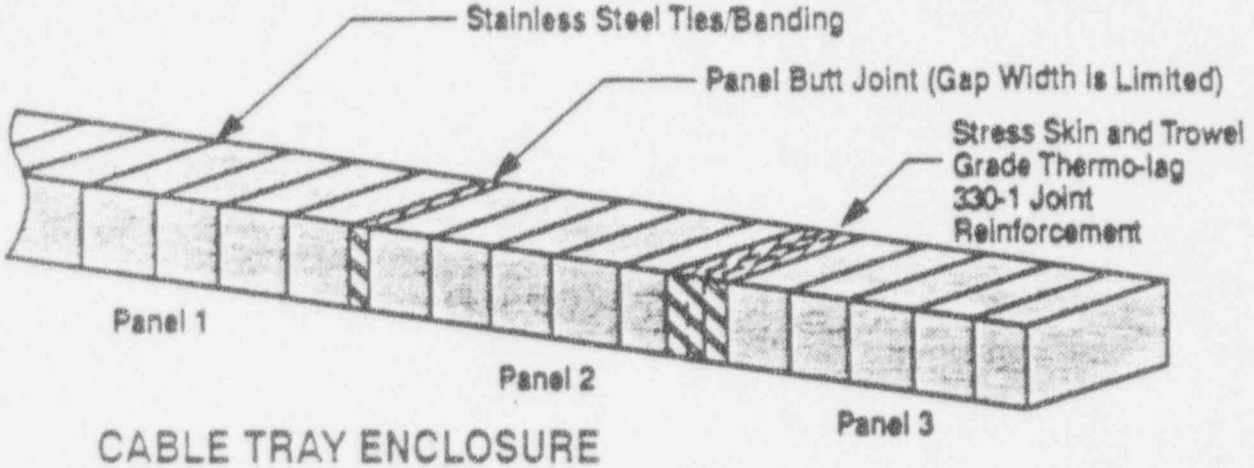
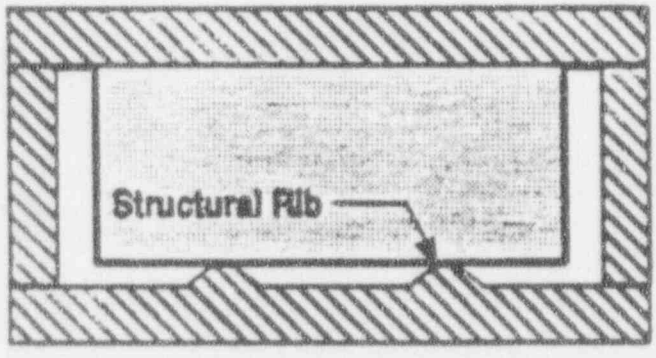
ILLUSTRATION #5

TYPICAL ORIENTATION OF STRUCTURAL RIBS

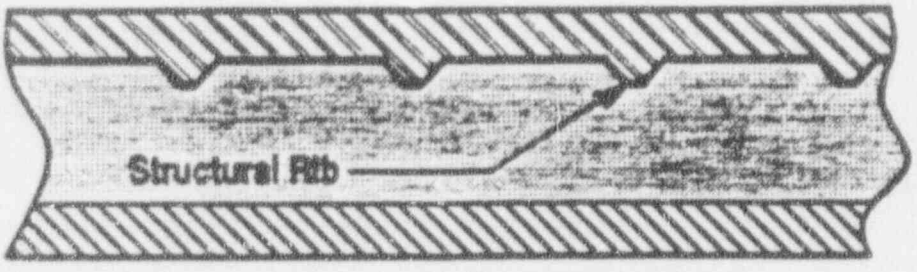


CABLE TRAY ENCLOSURE



CROSS SECTION

Structural Ribs help to prevent sagging between stainless steel ties/banding (Ribs running longitudinally with tray)



LONGITUDINAL SECTION

Structural Ribs help to prevent sagging between cable tray sides (Ribs running perpendicular to tray axis)

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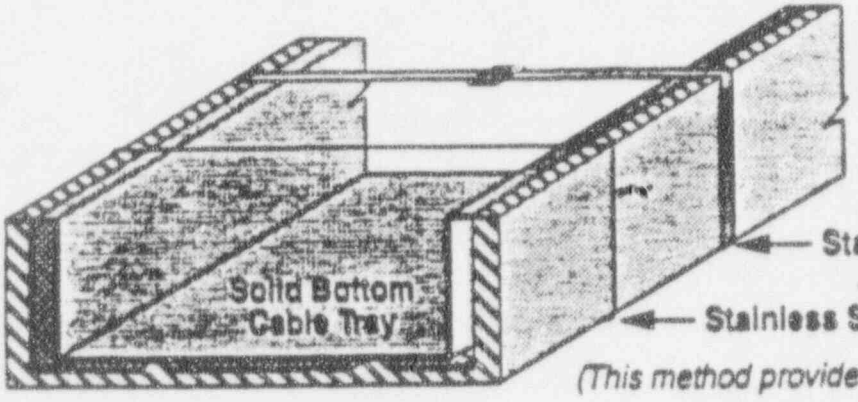
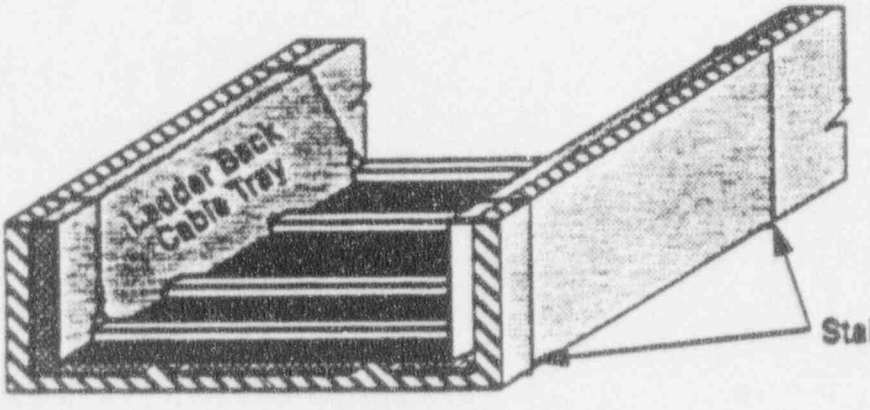
ILLUSTRATION #6

TYPICAL TIES



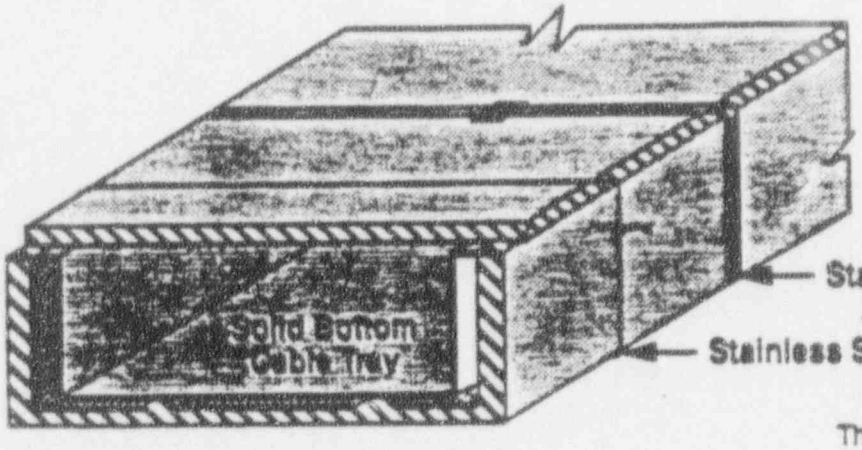
TIES BENEATH TOP PANEL

(This method provides support for TOP PANEL)



TIES TO RUNG OF LADDER BACK CABLE TRAY

NOTE: Edge guards may be used to prevent crushing of Thermo-lag



TIES AROUND ENTIRE ENCLOSURE

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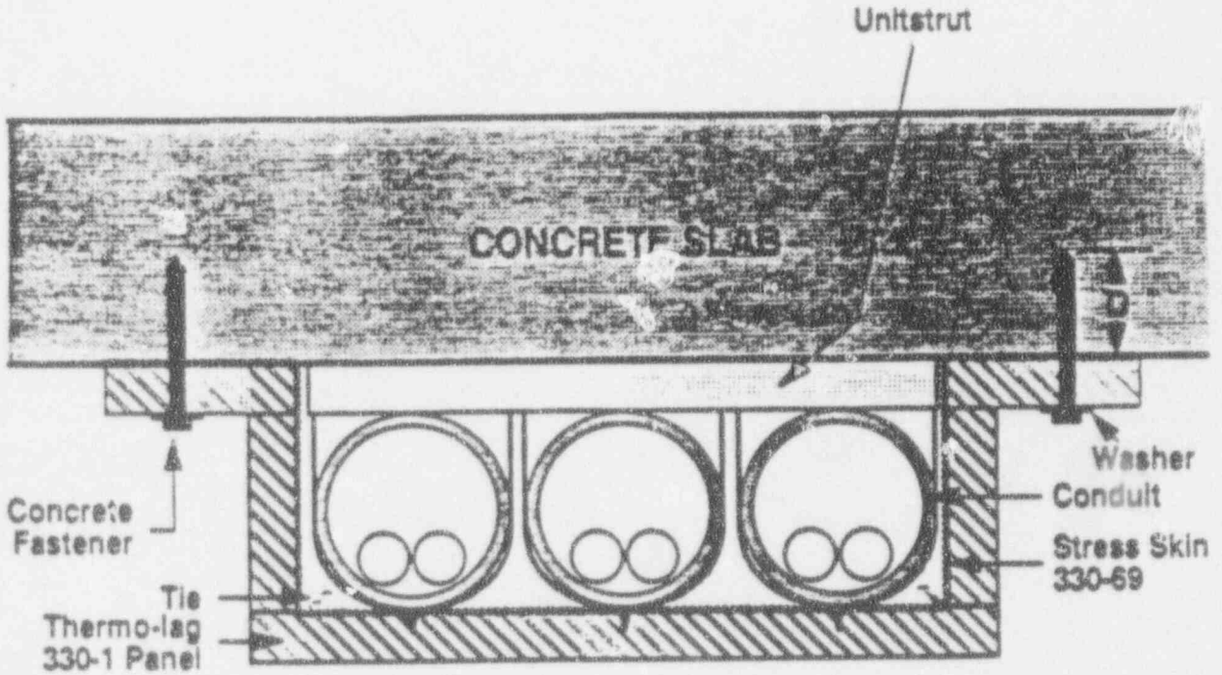
ILLUSTRATION #7

TYPICAL CONCRETE FASTENER DETAIL



D = Depth of penetration

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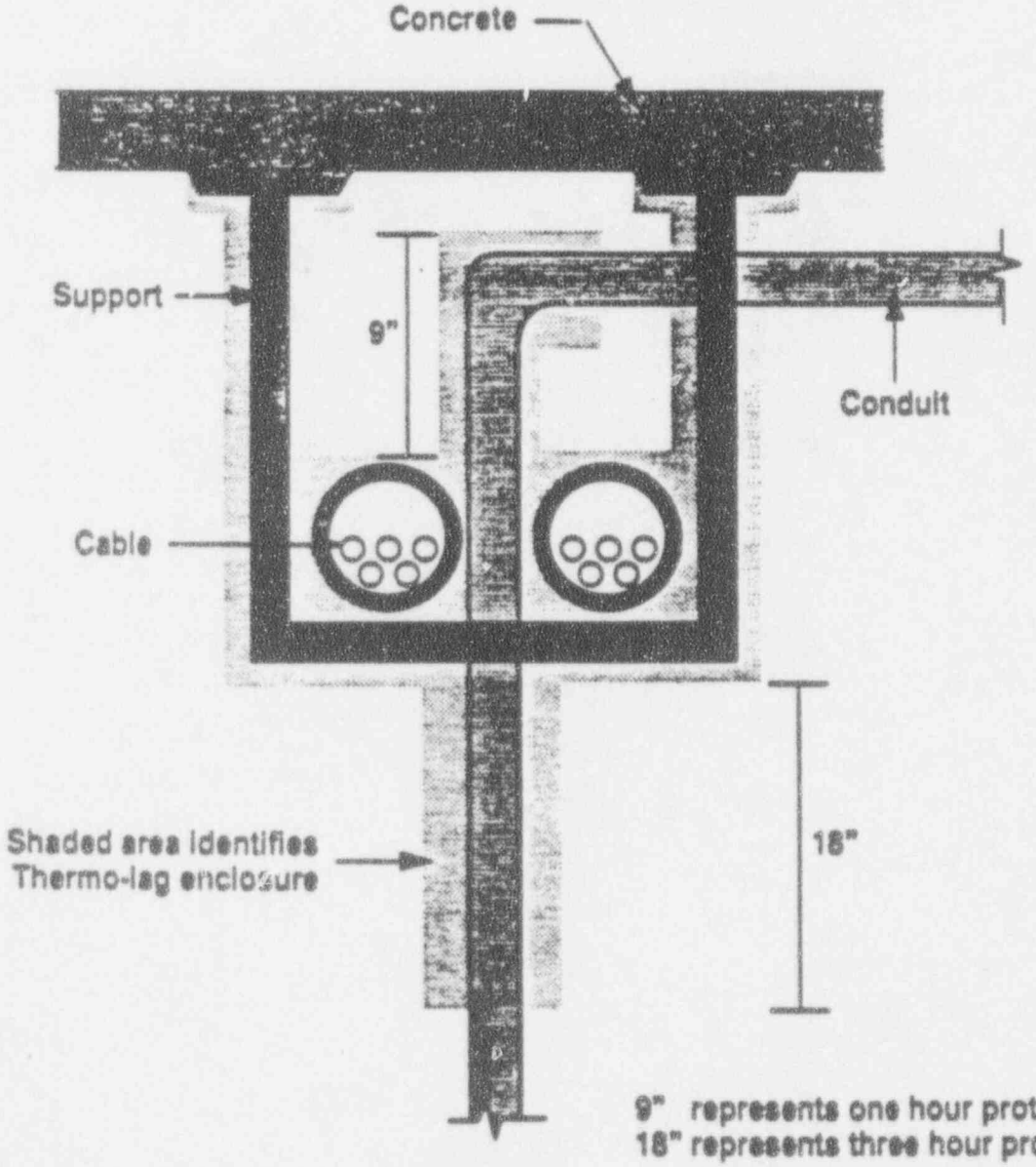
ILLUSTRATION #8

TYPICAL PROTECTION FOR SUPPORTS AND INTERVENING STEEL

(Cross-sectional View)



NOTE: Conduit is intervening steel

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APPENDIX G

EVALUATION GUIDE

Thermo-Lag Fire Barrier System:_____

Fire Area Location: _____

_____

Required Rating: _____

Unique Segments: _____

_____

_____

_____

_____

_____

_____

_____

_____

SKETCH

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AS-BUILT TO TESTED EVALUATION

PERFORMANCE PARAMETERS	FIRE RESISTIVE BARRIER: _____ SEGMENT: _____ RATING : _____		
COMMODITY	**AS BUILT CONFIGURATION**	**TESTED CONFIGURATION(S) UTILIZED FOR EVALUATION**	**EVALUATION**
TYPE			
SIZE			
MATERIAL			
CONTENTS			
ORIENTATION			

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AS-BUILT TO TESTED EVALUATION

PERFORMANCE PARAMETERS	FIRE RESISTIVE BARRIER: _____ COMMODITY : _____ RATING : _____		
BARRIER	**AS BUILT CONFIGURATION**	**TESTED CONFIGURATION(S) UTILIZED FOR EVALUATION**	**EVALUATION**
MATERIAL TYPE			
THICKNESS			
STIFFENER (V-RIB) LOCATION/ ORIENTATION			
STRESS SKIN LOCATION			

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AS-BUILT TO TESTED EVALUATION

PERFORMANCE PARAMETERS	FIRE RESISTIVE BARRIER: _____ COMMODITY : _____ RATING : _____		
BARRIER	**AS BUILT CONFIGURATION**	**TESTED CONFIGURATION(S) UTILIZED FOR EVALUATION**	**EVALUATION**
JOINT TYPE			
FASTENERS			

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AS-BUILT TO TESTED EVALUATION

PERFORMANCE PARAMETERS	FIRE RESISTIVE BARRIER: _____ COMMODITY : _____ RATING : _____		
BARRIER	**AS BUILT CONFIGURATION**	**TESTED CONFIGURATION(S) UTILIZED FOR EVALUATION**	**EVALUATION**
UNSUPPORTED SPAN			
JOINT REINFORCEMENT			
STRUCTURAL AND INTERVENING STEEL PROTECTION			

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AS-BUILT TO TESTED EVALUATION

PERFORMANCE PARAMETERS	FIRE RESISTIVE BARRIER: _____ COMMODITY : _____ RATING : _____		
BARRIER	**AS BUILT CONFIGURATION**	**TESTED CONFIGURATION(S) UTILIZED FOR EVALUATION**	**EVALUATION**
BOX ENCLOSURE PERFORMANCE			

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AS-BUILT TO TESTED EVALUATION

Thermo-Lag Fire Barrier System:_____

Segment Nos: _____

Required Rating: _____

Additional Evaluation: _____

APPENDIX H

EXAMPLES

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Appendix A
Tested Assemblies

3 HOUR
BOXED COMMODITIES (OTHER THAN CABLE TRAYS)

Commodity Tested	Fire Resistive Barrier Construction	Test Acceptance Basis	Test Number
22 in.. x 12 in. x 9 in. Steel Junction Box (12 in. side vertical)	1 in. V-rib panels with post-buttered joints. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces. Additional overlay of 5/8 in. V-rib panels with pre-buttered joints. Outer panel layer joints stitched with tie wire and reinforced with trowel grade and stress skin. Trowel grade buildup and stress skin reinforcement at joints and conduit interfaces.	Satisfactory surface temperatures Satisfactory barrier condition	NUMARC 1-7
6 in. x 4 in. Aluminum Ladder Back with Radial Bend (4 piece)	1/2 in. V-Rib panels with pre-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Baseline application with no upgrades applied.	Single point temperature criterion exceeded at 48 minutes on the conductor below the rungs Satisfactory barrier condition	NUMARC 2-7
6 in. x 4 in. Aluminum Ladder Back with Radial Bend (Score & Fold)	1/2 in. V-rib panels with pre-buttered joints score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend. Baseline application with no upgrades	Satisfactory raceway temperatures at 48 minutes when test was terminated Through opening in barrier developed	NUMARC 2-7
6 in. x 4 in. Aluminum Ladder Back with Radial Bend (4 piece)	1/2 in. V-rib panels with post-buttered joints, V-ribs parallel to tray rails on top and bottom of tray. Separate mitered panel pieces on inside and outside face of radial bend. Baseline barrier reinforced with external trowel grade and stress skin fastened with staples and tie-wires.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 2-8
6 in. x 4 in. Aluminum Ladder (Score & Fold)	1/2 in. V-rib panels with post-buttered joints. Score and fold single panel for bottom and sides on horizontal and vertical tray commodities with separate top panel. V-ribs parallel to tray rails. Separate mitered panel pieces on inside and outside of radial bend with post-buttered joints. Baseline barrier reinforced with external trowel grade and stress skin fastened with staples and tie-wires.	Satisfactory raceway temperatures Satisfactory barrier condition	NUMARC 2-8