WASHINGTON PUBLIC POWER SUPPLY SYSTEM

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WNP-2
PLANT PROCEDURES MANUAL

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SECTION
ELECTRICAL MAINTENANCE PROCEDURES

TITLE
ONE HOUR - THREE HOUR FIRE BARRIER INSTALLATION

TABLE OF CONTENTS

Page No.


1.0 PURPOSE . . . . . 5

2.0 REFERENCES . . . . . 5

3.0 PREREQUISITES . . . . . 7

4.0 PRECAUTIONS AND LIMITATIONS . . . . . 7

5.0 MATERIALS, TOOLS, AND TEST EQUIPMENT . . . . . 8

6.0 PROCEDURE (THERMO-LAG) . . . . . 10

6.1 Fabrication and Installation . . . . . 10

6.1.1 Cable Tray Application . . . . . 10

a. Direct Spray or Trowel Application Over Stress Skin . . . . . 10

b. Prefabricated Board . . . . . 12

6.1.2 Conduit and Instrument Tubing . . . . . 12

a. Direct Spray or Trowel Application Over Stress Skin . . . . . 12

b. Prefabricated Board . . . . . 13

c. Installation of the One Hour/Three Hour Fire Barrier Design Utilizing Pre-Shaped Conduit Sections . . . . . 13

TABLE OF CONTENTS (Continued)


Page No.

d. Installation of a One-Hour/Three-Hour Preshaped Conduit Section Design Mounted Immediately Adjacent to a Concrete Wall . . . . . 13

e. Direct Spray Application . . . . . 14

f. Interface Application with 3M. 3 Hour Rated Wrap . . . . . 14

6.1.3 Cable Drops . . . . . 15

a. Direct Spray or Trowel Application Over Stress Skin . . . . . 15

6.1.4 Cable Drop Junction With Cable Tray Or Conduit . . . . . 16

a. Conduit Junction . . . . . 16

b. Cable Tray Junction - Open End (Attachment 9.2, Page 6) . . . . . 16

6.1.5 Cable Drop/Conduit Junction With Bottom or Side of Cable Tray . . . . . 17

a. Direct Spray or Trowel Application Over Stress Skin . . . . . 17

6.1.6 Cables Within Cable Trays - Direct Spray . . . . . 17

a. Cleanliness . . . . . 17

b. Fire Break or RG 1.75 Barrier Application . . . . . 18

c. Application as a One Hour Barrier . . . . . 19

d. Coating Procedure . . . . . 19

e. Vertical Fire Stops . . . . . 19

6.1.7 Junction Box . . . . . 20

a. Direct Spray or Trowel Application Over Stress Skin . . . . . 20

b. Prefabricated Board . . . . . 20

6.1.8 Structural Steel Supports or Cable Tray Hangers . . . . . 20

a. Direct Spray or Trowel Application . . . . . 21

b. Areas of Support Steel/Hangers to be Covered . . . . . 21

c. Typical Application for Instrument Tubing Supports . . . . . 22

TABLE OF CONTENTS


Page No.

6.1.9 Coating Procedure . . . . . 23

a. Fire Retardant Thermo-Lag 270 . . . . . 23

b. One-Hour Barriers . . . . . 23

c. Three-Hour Barriers . . . . . 24

d. Spray Application . . . . . 24

e. Required Wet Film Thickness . . . . . 24

6.1.10 Fire Stops . . . . . 25

a. Examples of fire stops . . . . . 25

6.2 Repair - Thermo-Lag 330-1 or Prefab Application . . . . . 26

6.2.1 Thermo-Lag 330-1 or Prefab Application . . . . . 26

6.2.2 Thermo-Lag 270 . . . . . 26

6.3 Repair - Structural Steel, Hangers or Supports . . . . . 26

6.4 Inspection . . . . . 27

6.4.1 Cleanliness - Structural Steel . . . . . 27

6.4.2 Cleanliness - Fire Walls . . . . . 27

6.4.3 In-Process Inspection . . . . . 27

6.4.4 Final Inspection . . . . . 28

6.4.5 Identification . . . . . 28

7.0 PROCEDURE (3M FIRE PROTECTION SYSTEM - 3 HOUR) . . . . . 28

7.1 Preparation . . . . . 28

7.2 Material . . . . . 29

7.2.1 Supports . . . . . 29

7.2.2 E-50 Series Mat . . . . . 30

7.2.3 Facing Tape (T-49) . . . . . 30

7.2.4 Caulk (CP-25) (98-0400-0250-7) . . . . . 30

7.2.5 Putty (303) . . . . . 30

7.2.6 Composite Sheet (CS-195) . . . . . 30

TABLE OF CONTENTS

Page No.

7.2.7 Banding Straps . . . . . . . . . . 30

7.2.8 Wire Mesh . . . . . . . . . . 30

7.2.9 Washers . . . . . . . . . . 30

7.3 Inspection . . . . . . . . . . 30

7.4 Installation . . . . . . . . . . 31

7.5 Proper Repair of Any Gaps or Cuts in the System . . . . . . . . . . 31

8.0 DOCUMENTATION . . . . . . . . . . 31

9.0 ATTACHMENTS . . . . . . . . . . 31

9.1 Inspection Form . . . . . . . . . . 36

9.2 Specific Applications/Thermo-Lag . . . . . . . . . . 37

9.3 Thickness Requirements for Thermo-Lag . . . . . . . . . . 66

9.4 Fire Stops/Thermo-Lag 35 . . . . . . . . . . 72

9.5 3M 3 Hour Fire Protection Figures . . . . . . . . . . 74

## 1.0 PURPOSE

The purpose of this procedure is to provide the basic steps involved in the fabrication and installation of a Thermo-Lag type fire barrier and/or a 3M Flexible Wrap 3 HR type fire barrier. Drawing E948 defines the 1 and 3 hour fire barrier requirements. △ {2.11}

## 2.0 REFERENCES

2.1 Factory Mutual Bulletin OE6A5.AF (Factory Mutual Approval of TSI Thermo-Lag 270)

2.2 TSI Technical Note 1130-83A, CVI 02-999-00-6

2.3 Interim Fire Protection Products Flexible Wrap System

2.4 Contract 215 Specification, Section 15S, Appendix 6, Technical Specifications for 3M Fire Protection System

2.5 WPTS1-C20610-F-001 through 0025, Requests for Clarification from TSI

2.6 Engineering Calculation No. NE-02-86-23, Temperature Response of Structural Components to Appendix R Fire

2.7 Engineering Calculation No. NE-02-86-44, Temperature Response of Cables in One Hour Fire Areas

2.8 Engineering Calculation No. NE-02-86-39, Evaluation of Structural Supports to One Hour Fire Barriers

2.9 Engineering Calculation No. NE-02-88-10, Appendix R Analysis - Vital Instrument Sensing Line Supports

2.10 Engineering Calculation No. CE-02-89-20, Tubing Support Under Apprendix R-Fire

2.11 PER 291-0217 △ {2.11}

2.12 PER 292-026, Potential Thermo-Lag Installation Deficiencies

2.13 WPBR-F-82-239, IOM, Use of Self Adhesive Insulation Pins and 14 Gauge Wire as a Construction Aid

2.14 E948 APP. R Conduit Tray Plans and Sections

2.15 ITL Report 82-11-80, One Hour Fire Endurance Tests Conducted on Test Articles Containing Generic Cables Protected With Thermo-Lag 330-1 Subliming Coating Envelope System

2.16 ITL Report 82-11-81, Three Hour Fire Endurance Tests Conducted on Test Articles Containing Generic Cables Protected With Thermo-Lag 330-1 Subliming Coating Envelope System

2.17 ITL Report 82-11-240, One Hour Fire Endurance Tests Conducted on the Thermo-Lag 330-1 Subliming Coating System Applied by Direct Spray-on Design to 4-inch Diameter Standard Electrical Conduit for Washington Public Power Supply System

2.18 ITL Report 82-5-355A, One Hour ASTM E119 Fire Simulation Facility Fire Tests Water Hose Stream Impacts Tests and Electrical Circuity Continuity Tests on Nuclear Facility Class IE Cable Trays and Conduit Test Assemblies Protected With a One Hour Fire Rated Design of the Thermo-Lag 330-1 Subliming Coating Envelope System

2.19 ITL Report 82-5-355B, Three Hour Fire Endurance Tests on Thermo-Lag 330-1 Subliming Coating Envelope System for Washington Public Power Supply System Nuclear Projects

2.20 ITL Report 83-5-472, One Hour Fire Endurance Tests Conducted on the Thermo-Lag 330-1 Subliming Fire Barrier System Applied by Direct Spraying, Rolling and Troweling Methods to Class IE Electrical Cables in a Modified Ladder Cable Tray Test Article for Washington Public Power Supply System Nuclear Plants

2.21 ITL Report 84-12-181, Three Hour Fire Endurance Tests Conducted on a Ladder Cable Tray with a P-1000 Unistrut Attachment and Transition Section Protected with the Thermo-Lag 330 Fire Barrier System

2.22 ITL Report 87-5-77, One Hour ASTM Fire Endurance Test Conducted on a Ladder Cable Tray with a P-1000 Unistrut Attachment Protected with the Thermo-Lag 330 Fire Barrier System

Test performed to demonstrate the fire barrier design meets the 325°F cable surface temperature limitation, and that a protection of a 9" heat flow path will not degrade the electrical integrity of the protected assembly.

2.23 ITL Report 87-5-76, Three Hour Fire Endurance Test Conducted on a Two Inch Diameter Conduit Test Section Protected with the Thermo-Lag 330 Fire Barrier System Interfacing with Interam E-50D/E-54A Series Flexible Wrap System

2.24 ITL Report 87-4-3, One Hour Fire Endurance Test Conducted on Four Inch Diameter Washington Public Power Supply System "In-Situ" Steel Conduit Sections Protected With the Thermo-Lag 330 Fire Barrier System Previously Applied by Washington Public Power Supply System Using a Low Pressure Extrusion Procedure

2.25 ITL Report 84-5-235, Three Hour ASTM E199 Fire Endurance Conducted on a Fire Wall Test Assembly Protected with the Thermo-Lag 330 Fire Barrier System

Test provided by TSI in 6-14-88 letter per TSI recommendation for protection of block wall by use of 1/2" dry film thickness of Thermo-Lag 330-1 applied to the proposed fire exposed side of the wall.

2.26 PPM 1.3.7, Maintenance Work Request

2.27 PPM 1.3.10, Supply System Fire Protection Program

2.28 PPM 1.11.8, Radiation Work Request

2.29 PPM 10.2.23, Concrete Anchors

2.30 PPM 10.25.54, Cable Pulling Instruction and Inspection

## 3.0 PREREQUISITES

3.1 Obtain permission and signature from the Shift Manager before starting work.

3.2 As applicable, follow the requirements of the Radiation Work Permit per PPM 1.11.8.

3.3 Installers must be trained and certified to apply Thermo-Lag and/or 3M Fire Protection System.

3.4 Quality Control Inspectors must be trained and certified in the application of Thermo-Lag and/or 3M Fire Protection System.

## 4.0 PRECAUTIONS AND LIMITATIONS

4.1 When attaching materials together, always make sure you can see the wire/mechanical fastener being used. "Do not work in the blind". Do not probe installation materials with sharp tools such as awls, nails or stiff wire.

4.2 Thermo-Lag 330-1 trowel or spray grade requires 30 day cure after installation to achieve a 1-hour or 3-hour fire rating. Fire impairments shall not be removed until the material has fully cured.

4.3 Spraying of material may cause skin and/or eye irritation on contact. Therefore, the use of eye goggles is required, protective gloves, and long sleeve clothing is recommended where exposure exists.

4.4 All discrepancies encountered during installation shall be noted and reported to your immediate Supervisor and the Shift Manager.

## 5.0 MATERIALS, TOOLS, AND TEST EQUIPMENT

### 5.1 Thermo-Lag

5.1.1 Airless Spray Equipment

5.1.2 Hand Trowels

5.1.3 Fastening Material

- Tie Wire, 18 gauge minimum stainless steel
- Staples, industrial grade △ {2.11}

### 5.2 3M Fire Protection System

5.2.1 Razor Knife

A razor knife shall be used to cut the 3M mat material to the required configurations.

NOTE: Large scissors or snips may be used. Also, electric scissor-blade shears may be used to cut straight or curved pieces of the 3M mat material.

5.2.2 Rubber Roller

A rubber roller or approved equal shall be used to insure the proper adhesion of the aluminum foil tape.

NOTE: A plastic scraper or pliable straight-edge may be used to insure the proper adhesion of the aluminum foil tape.

5.2.3 Straight-Edge

A straight-edged implement shall be used to aid in cutting straight pieces of 3M mat material.

5.2.4 Marking Pen

Marking pens shall be used to identify each layer of the 3M mat material by individual number.

NOTE: Only those marking pens approved by the Chemistry group shall be used in the Power-block area of WNP-2.

5.2.5 Measuring Tape

A measuring tape or equal shall be used to properly size the pieces of 3M mat material.

5.2.6 Electric Drill

An electric drill with carbide drill bits or approved equal shall be used to drill holes into the 3M CS-195 composite sheet and into the concrete.

5.2.7 Electric Saw

An electric hand jigsaw or sabre saw with metal cutting blade shall be used to cut the 3M CS-195 composite sheet.

NOTE: Bandsaws, hacksaws, bench saws and the like may be used to cut the 3M CS-195 composite sheet.

5.2.8 Band Tensioner

A band tensioner or approved equal may be used as an aid in securing the banding straps around the 3M three (3) hour fire protection system.

NOTE: Should crimp-type seals be used to secure the bands, a crimping tool or approved equal shall be used.

## 6.0 PROCEDURE (THERMO-LAG)

### 6.1 Fabrication and Installation

> CAUTION: All 1 HOUR and 3 HOUR Thermo-Lagging requires that a support analysis for extra loads has been completed and approved.

> CAUTION: When attaching materials together, always make sure you can see the wire/mechanical fastener being used. "Do not work in blind". Do not probe installation materials with sharp tools such as awls, nails or stiff wire.

NOTE: A ONE HOUR Thermo-Lag raceway fire barrier consists of prefabricated board with a (dry film) thickness of 0.625 ± 0.125 inches, with the stress skin facing inwards towards the protected raceway.

NOTE: A THREE HOUR Thermo-Lag raceway fire barrier may consist of one prefabricated panel with a (dry film) thickness of 1.250 ± 0.125 inches with embedded inner and outer layers of Stress Skin Type 330-69. Alternately, a THREE HOUR raceway barrier may consist of two one hour prefabricated panels, with thickness as described above, applied to the raceway such that the embedded Stress Skin forms the innermost and outermost layers of the barrier.

NOTE: THREE HOUR Thermo-Lag raceway fire barriers consisting of an inner layer of Stress Skin 330-69, a dry film thickness of 0.625 ± 0.125 inches, a second layer of Stress Skin 330-69, and a second layer of Thermo-Lag with a dry film thickness of 0.625 ± 0.125 inches are installed in the plant. These barriers have a third layer of hardware cloth or stress skin without V-stiffeners attached by staples as the outermost layer. This configuration MAY NOT be used for the installation of new barriers.

#### 6.1.1 Cable Tray Application

a. Direct Spray or Trowel Application Over Stress Skin (Attachment 9.2, Pages 1, 2, and 7)

1) Stress Skin 330-69 material shall be cut to ensure a sealed envelope around the applicable cable tray. This application shall be in accordance with approved drawings.

2) Stress Skin shall be cut in sections as depicted in Attachment 9.2, Page 1, or molded around the tray with a minimum overlap of one (1) inch to facilitate fastening.

3) Stress Skin may be applied around the cable tray and attached directly to the fire rated wall as discussed in item 5 below.

4) All edges, flanges or overlapping surfaces of Stress Skin shall be fastened together by using mechanical fasteners or minimum size 18 ga. stainless steel (SS) tie wire placed no greater than on twelve (12) inch centers.

5) When the fire rated wall is used as a portion of the fire barrier installation, Stress Skin shall be attached to the wall by the use of mechanical fasteners as noted below.

- Hilti Kwik Bolts and Hilti Drop-in Concrete Anchors shall be installed per PPM 10.2.23.
- Fastener penetration depth shall be 1-1/8" minimum. The fasteners shall be of such length to give at least this penetration while accommodating various thicknesses of material being fastened.
- Fastener installation to be in accordance with manufacturer's recommendations and approved fastener installation procedures.
- The minimum distance between the two pin fastener's shall be 3" with a desired spacing of 12" center to center.
- Fastener edge distance from concrete shall be 2" minimum and minimum 1-1/2" from stress skin edges.
- Use 1/4" Hilti Kwik Bolts/HDIs and PPM 10.2.23 or attach to existing embedded unistrut with 1/4" diameter spring nuts, bolts and washers. Self adhesive insulation pins are acceptable for holding the Thermo-Lag until it has cured. Self adhesive insulation pins may be used only for installations that are supported by the covered unit.

6) Apply required thickness(es) of Thermo-Lag 330-1 subliming coating in accordance with Section 6.1.9.

b. Prefabricated Board (Attachment 9.2, Pages 7, 8, 9, 18, and 19)

1) Prefabricated board may be cut into individual pieces or scored for ease of mounting to the applicable cable tray. Precoat edges on adjoining sections with a 1/4 to 1/2 inch bead of Thermo-Lag 330-1 subliming trowel grade material as necessary to ensure joints are filled to full depth of the prefabricated panel.

2) Prefabricated board may be temporarily held in place with the use of 14 ga. stainless steel tie wire spaced no greater than two (2) feet on center.

3) Prefabricated boards shall be attached to each other by use of mechanical fasteners or minimum size 18 ga. stainless steel tie wire placed no greater than on twelve (12) inch centers.

4) When a fire wall is used as a portion of the fire barrier envelope, the material shall be attached to the wall using approved fasteners and installed in accordance with Section 6.1.1.a.5.

6.1.2 Conduit and Instrument Tubing (Attachment 9.2, Pages 14, 15, 21, and 22)

NOTE: Instrument tubing shall be covered under direction of Design Engineering. A support analysis shall have been completed prior to any installation.

a. Direct Spray or Trowel Application Over Stress Skin (Attachment 9.2, Page 14)

1) To achieve a fire barrier envelope around conduit, Stress Skin may be formed in sections and attached or molded around the conduit in one (1) piece.

2) Stress Skin flanges, edges or overlapping sections shall be fastened with mechanical fasteners or minimum size 18 ga. stainless steel tie wire placed no greater than on 12 inch centers.

3) Stress Skin may be formed to fit around the conduit and attached to the fire wall by using approved mechanical fasteners per Section 6.1.1.a.5.

4) Apply required thickness(es) of Thermo-Lag 330-1 subliming coating in accordance with Section 6.1.9.

b. Prefabricated Board (Attachment 9.2, Page 14)

1) Prefabricated board shall be cut to allow the material to surround the conduit. The fire wall may be used as any portion of the fire barrier envelope.

2) When the fire wall is used as one side of the envelope, the prefabricated board shall be attached to the wall using mechanical fasteners in accordance with Section 6.1.1.a.5.

c. Installation of the One Hour/Three Hour Fire Barrier Design Utilizing Pre-Shaped Conduit Sections (Attachment 9.2, Pg 21)

1) Precoat the edges on one (1) of the Thermo-Lag Preshaped Conduit Sections with a 1/4 to 1/2 inch bead of Thermo-Lag 330-1 Subliming Trowel Grade Material.

2) Mount the coated section and one (1) other section on the conduit, cable drop or instrument tube with the edges flush with each other to form a cylindrical section around the conduit, cable drop or instrument tube. Fasten the two sections together using 18 ga. minimum stainless steel tie wires at a maximum of twelve (12) inch intervals as shown in Attachment 9.2, Page 20.

3) Apply a 1/4 to 1/2 inch bead of Thermo-Lag 330-1 Subliming Trowel Grade Material to the end of the installed section, and attach the next section, making sure that the ends are butted and flush.

d. Installation of a One-Hour/Three-Hour Preshaped Conduit Section Design Mounted Immediately Adjacent to a Concrete Wall (Attachment 9.2, Page 22)

1) Cut one (1) of the Thermo-Lag Preshaped Conduit Sections to fit flush with the surface of the concrete wall, and then cut this section in half to facilitate installation.

2) Precoat the edges on the other section with a 1/4 to 1/2 inch bead of the Thermo-Lag 330-1 Subliming Trowel Grade Material.

3) Mount the coated section and the cut to fit section on the conduit, cable drop or instrument tubing with the edges flush with each other and the concrete wall, to form a cylindrical shaped section around the conduit, cable drop or instrument tube. Fasten the two (2) sections together with 18 ga. minimum stainless steel tie wires at a maximum of twelve (12) inch intervals as shown in Attachment 9.2, Page 22.

4) In those cases where the conduit, cable drop or instrument tubing make a 90 degree turn into the concrete wall rather than running between floors, cut an end cap section from an equally rated Thermo-Lag Prefabricated Panel and attach the cap section to the installed Thermo-Lag Preshaped Conduit Sections using machine screws.

5) Apply a 1/4 to 1/2 inch bead of Thermo-Lag 330-1 Subliming Trowel Grade Material to the end of the installed section and attach the next section, making sure that the ends are butted and flush.

6) Caulk all joints and the transition area between the installed Preshaped Conduit Sections and the concrete wall using the Thermo-Lag 330-1 Subliming Trowel Grade Material.

e. Direct Spray Application

1) Conduit may have Thermo-Lag 330-1 sprayed directly to the unit until the required thickness is achieved. This application is approved for one-hour areas only.

NOTE: Be careful when spraying conduit to avoid overspray onto other equipment and materials, shield these areas.

f. Interface Application with 3M, 3 Hour Rated Wrap (Attachment 9.2, Page 23)

1) When interfacing TSI Thermo-Lag 330-1 with 3M 3 hour rated wrap, E-50D/E-54A MAT, refer to Attachment 9.2, Page 23. This detail applies to conduit only in 3 hour areas.

2) Overlap the last two layers of Interim E50D/E-54A by two (2) inches at the interface with the Thermo-Lag 330-1.

3) Secure the 3M material with 0.5" x 0.020" minimum stainless steel banding material spaced at approximately six (6) inch intervals.

4) Caulk the third and fourth layer 3M material with 3M-CP-25 caulk around the entire perimeter of the seam interface.

6.1.3 Cable Drops (Attachment 9.2, Pages 4 and 16)

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|---|
| CAUTION: Stress skin should NOT be allowed to come into direct contact with reactor safe shutdown cables. "Butter" cables with 330-1 Thermo-Lag before applying the Stress Skin or wrap 1 hour prefabricated board around these cables. This will provide the proper mechanical protection. |

| |
|---|
| CAUTION: No sharp edges are allowed next to or near cable(s). |

a. Direct Spray or Trowel Application Over Stress Skin Application (Attachment 9.2, Page 4)

1) Cables shall be wrapped with Stress Skin and fastened at a maximum of six (6) inch intervals with minimum size 18 ga. stainless steel wire.

2) The first coat of Thermo-Lag 330-1 shall be sprayed or trowelled onto the Stress Skin to a depth of approximately 1/8th inch (3-hour only) and then let dry. Apply remaining layers in 1/8th inch increments until the maximum fill is obtained, let each layer dry between coats.

3) Conformable blanket 330-70 shall be wrapped tightly around the coated Stress Skin and secured in place with minimum size 18 gauge stainless steel tie wire.

4) A layer of Stress Skin shall be applied around the cable drop and secured with mechanical fasteners or minimum size 18 ga. stainless steel wire and coated with the required thickness of Thermo-Lag 330-1 coating material.

6.1.4 Cable Drop Junction With Cable Tray Or Conduit
(Attachment 9.2, Pages 5 and 6)

a. Conduit Junction (Attachment 9.2, Page 5)

1) Thermo-Lag Stress Skin shall be applied to both the conduit and cable drop in accordance with Sections 6.1.2 and 6.1.3.

2) A minimum of twelve (12) inches of Stress Skin shall be wrapped around the junction with approximately six (6) inches overlapping the conduit.

3) Cut and place pieces of conformable blanket 330-70 into the open end and around the cable drops to insure that the open end is relatively sealed.

4) Fasten Stress Skin to cable drop using mechanical fasteners or minimum size 18 ga. stainless steel tie wire and coated with the required thickness of Thermo-Lag 330-1 coating material.

b. Cable Tray Junction - Open End (Attachment 9.2, Page 6)

1) Apply Stress Skin to the cable tray and cable drop in accordance with Sections 6.1.2 and 6.1.3.

2) A minimum of twenty-four (24) inches of Stress Skin shall be wrapped around the junction with approximately six (6) inches covering the cable tray secured with minimum size 18 ga. stainless steel wire at five (5) inch intervals.

3) Cut and place pieces of conformable blanket 330-70 into the open end and around the cable drops to insure the end is sealed.

4) Place approximately six (6) inches of conformable blanket 330-70 into the cable tray to protect the installed cables.

5) Fasten the Stress Skin to the cable drop with minimum size 18 ga. stainless steel tie wire and coated with the required thickness of Thermo-Lag 3310-1 coating material.

6.1.5 Cable Drop/Conduit Junction With Bottom or Side of Cable Tray (Attachment 9.2, Pages 10, 11, 16 and 17)

a. Direct Spray or Trowel Application Over Stress Skin

1) Apply Stress Skin to the cable drop, conduit and cable tray in accordance with Sections 6.1.2, 6.1.3 and 6.1.4.

2) The Stress Skin shall be applied to the conduit/cable drops so that it extends into the cable tray.

3) Cut a section of Stress Skin, form a collar flange of sufficient length to go around the conduit/cable drop and butt to the cable tray installation.

4) Attach the collar to both the conduit/cable drop and the cable tray with mechanical fasteners or minimum size 18 ga. stainless steel tie wire.

5) Apply required thickness of Thermo-Lag 330-1.

6.1.6 Direct Spray Application to Cables Within Cable Trays (Attachment 9.2, Page 24 and Attachment 9.2, Page 25)

Type A, B, C - Attachment 9.2, Page 24 - Application of Thermo-Lag 330-1 as fire break to non-dedicated trays in Cable Spreading Room

Type D - Attachment 9.2, Page 24 - Application of Thermo-Lag 270 as RG 1.75 barrier.

Attachment 9.2, Page 25 - Application of Thermo-Lag 330-1 as a one-hour barrier to dedicated or non-dedicated trays.

a. Cleanliness

1) Prior to the application of the Thermo-Lag coating, the cables and adjacent surfaces, including the outside and bottom of the tray, shall be cleaned of excessive dirt, dust, pulling compound or gross foreign material.

b. <u>Fire Break or RG 1.75 Barrier Application</u>
(Attachment 9.2, Pages 24, Type A,B,C,D)

1) The bottom and sides of solid trays may be used as a portion of the fire break of a solid bottom tray.

2) As a field option prefabricated board may be used at bottom or sides of the fire break for ladder trays.

3) Boards shall be held in place by attaching to the trays approximately every two feet with minimum size 18 gauge stainless steel wire.

4) Individual cables or cable bundles held in place within the cable trays by use of tie downs shall not be cut loose from the cable tray rungs unless realignment of cables is necessary to minimize Thermo-Lag application, in this case refer to PPM 10.25.54 for tie-wrap spacing.

5) Cable bundles shall not be separated, but sprayed as a single unit.

6) When installing Thermo-Lag 270, where open tray interfaces with covered tray, the Thermo-Lag 270 shall be installed beyond the covered tray a minimum of:

a) 6'-0" for 24" tray

b) 4'-6" for 18" tray, and/or

c) 3'-0" for 12" tray

per Attachment 9.2, Page 24, Type C. The tray cover shall be removed, the Thermo-Lag installed to the required distance and then have the tray cover reinstalled.

7) On ladder trays both the top and bottom of cables require spray, to form a complete encapsulation. Refer to Attachment 9.2, Page 24, Type C and D of this PPM.

c. Application as a One Hour Barrier

1) Cables shall be sprayed in place per Section 6.1.6.b.4 and 6.1.6.4.b.5 above.

2) All steel components that penetrate the raceway barrier for dedicated safe shutdown cables require Design Engineering and Fire Protection Engineering evaluation for heat flow path protection.

3) Thermo-Lag 330-1 material for Attachment 9.2, Page 25 shall be applied in a dry film thickness of 5/8" ± 1/8" to provide a fire barrier rating of 1 hour.

d. Coating Procedure

1) Thermo-Lag shall be sprayed directly on cables and adjacent surfaces.

2) The Thermo-Lag shall be applied to meet the requirements of Section 6.1.9.e.

3) Measurements of the wet film thickness shall be made between the outer edge of the cable or cable bundle and the outer surface of the protective envelope.

e. Vertical Fire Stops

1) Designated cable trays shall have a five (5) foot area of Thermo-Lag 330-1 applied directly to the cables at locations to be specified by Design Engineering.

2) The Thermo-Lag material shall be sprayed directly on the cables to a thickness of 1/4" ± 1/8".

6.1.7 Junction Box (Attachment 9.2, Page 12)

a. Direct Spray or Trowel Application Over Stress Skin

1) Stress Skin shall be cut to form an envelope around the junction box. Holes may be cut to allow material to be formed around conduits or cables.

2) Stress Skin, as required, may be attached to the wall with the use of self-adhesive insulation pins.

b. Prefabricated Board

1) Prefabricated board may be cut to fit around the junction box and conduits/cable in accordance with Section 6.0.2 and 6.0.3.

2) Precoat edges on adjoining sections with a 1/4 to 1/2 inch bead of Thermo-Lag 330-1 subliming trowel grade material as necessary to ensure joints are filled to full depth of prefabricated panel.

3) Prefabricated board shall be attached to the wall using mechanical fasteners in accordance with Section 6.1.1.a.5.

6.1.8 Structural Steel Supports or Cable Tray Hangers (Attachment 9.2, Page 13 and Attachment 9.3)

a. Direct Spray or Trowel Application (Attachment 9.2, Page 13)

NOTE: Stress skin is NOT required to be installed on structural steel.

1) Stress Skin may be used to enclose cable tray hanger units in accordance with approved drawings.

2) Stress Skin sections shall be held in place by mechanical fasteners or minimum size 18 ga. stainless steel tie wire placed no greater than on twelve (12) inch centers.

3) Stress Skin may be attached to a fire wall in accordance with Section 6.1.1.a.5.

b. Required Protection of Support Steel - Three Hour Raceway Fire Barriers

1) All support steel necessary to support the gravity loading shall be covered with the designated thickness of Thermo-Lag in accordance with Attachment 9.3

EXCEPTION: Analysis has been performed to demonstrate that certain embedded steel plates and embedded unistrut for existing Thermo-Lag installations do not require Thermo-Lag protection (Reference 2.6).

2) Attachments to, or extensions of, the gravity loading supports shall be covered with the designated thickness of Thermo-Lag in accordance with Attachment 9.3. The length of the attachment or extension to be covered shall be the GREATER OF:

a) A minimum distance of eighteen (18) inches from the outer surface of the barrier on the dedicated raceway.

b) A minimum length of nine (9) inches from the point of attachment or extension.

3) Thermo-Lag shall be applied along ALL heat transfer paths. Where the heat flow path changes direction, the minimum coverage length shall be measured along the centroid of the structural members. Refer to Attachment 9.2, pages 28 and 29, for clarification.

4) All open ends of tubular or box members of the protected steel shall be capped or sealed with a minimum thickness of one (1) inch of Thermo-Lag.

5) Anti-sweat insulation which penetrates a three-hour rated raceway barrier shall have the insulation removed and replaced with Thermo-Lag for the distance necessary to meet the heat flow path protection requirements specified in Items 6.1.8.b.2 and 6.1.8.b.3.

c. Required Protection of Support Steel - One Hour Raceway Fire Barriers

1) All support steel necessary to support the gravity loading shall be covered with the designated thickness of Thermo-Lag in accordance with Attachment 9.3 for a minimum distance of nine (9) inches from the point of attachment to the dedicated raceway fire barrier.

2) Attachments to, or extensions of, the gravity loading supports shall be covered with the designated thickness of Thermo-Lag in accordance with Attachment 9.3 for a minimum distance of nine (9) inches from the outer surface of the barrier on the dedicated raceway.

3) Thermo-Lag shall be applied along ALL heat transfer paths. Where the heat flow path changes direction, the minimum coverage length shall be measured along the centroid of the structural members.

4) All open ends of tubular or box members of the protected steel shall be capped or sealed with a minimum thickness of one-half (1/2) inch of Thermo-Lag.

5) Anti-sweat insulation which penetrates a one-hour rated raceway barrier shall have the insulation removed and replaced with Thermo-Lag for the distance necessary to meet the heat flow path protection requirements specified in Items 6.1.8.c.2 and 6.1.8.c.3.

d. Required Protection of Support Steel - Three Hour Instrument Sensing Line Fire Barriers

1) Application of Thermo-Lag 330-1 Panel/Trowel Grade/ Spray Grade, shall conform to Attachment 9.3 thickness requirements for three-hour rated assemblies.

2) No Thermo-Lag 330-1 shall encapsulate or in anyway capture or inhibit the movement of the instrument tubing.

3) Should there be more than one (1) Stainless Steel Block Clamp, end to end, apply 330-660 flex blanket to the support such that the blanket extends, as a minimum, to the end of the row of block clamps (Attachment 9.2, Page 27 of 29).

4) Thermo-Lag 330-1 panel may butt up to the ends of the block clamp(s), however it may not encapsulate the instrument tubing. (Refer to paragraph 2.)

5) The 330-660 flex blanket may be overlapped and secured by using Thermo-Lag 330-1 panels and securing the panel with stainless steel tire wire, minimum 18 ga.

6) Use 330-660 bulk grade caulk to fill any voids/joints in the areas of the flex blanket to block clamp/panel interface.

7) Upon completion of the Thermo-Lag installation the tubing support shall be identified as dedicated per Section 6.4.5.

6.1.9 Coating Procedure

a. Fire retardant Thermo-Lag 270 direct spray application to electrical cables:

1) The minimum dry film thickness of Thermo-Lag 270 shall be 1/16".

2) For wet film thickness refer to Section 6.1.9.e.1 of this PPM.

b. One-Hour Barriers

For all installations except those for structural steel members, the MINIMUM required dry coating thickness of Thermo-Lag 330-1 is 1/2 inch with a tolerance of -0.00 inch, and an average thickness of no greater than 5/8 inch, and a maximum thickness of 3/4 inch, except locations immediately adjacent to, and including, any joints or flanges.

c. Three-Hour Barriers

For all installations except those for structural steel members, the MINIMUM required dry coating thickness of Thermo-Lag 330-1 is one inch, with a tolerance of -0.00 inch, and an average thickness of no greater than 1-1/8 inch, and a maximum thickness of 1-1/4 inch, except locations immediately adjacent to, and including, any joints or flanges.

1) Three-hour barriers may be constructed of two (2) separate layers of prefabricated board or a minimum of 1" 330-1 Subliminal Thermo-Lag Coating, with total thickness tolerance as stated above.

2) All three-hour barriers will have Stress Skin mounted to the outside of the final installation, except for structural steel applications or where Thermo-Lag material has a factory applied Stress Skin on both sides. Refer to Notes, Section 6.1.

d. Spray Application

1) Thermo-Lag 330-1 removed from warehouse shall be agitated or stirred for fifteen (15) minutes prior to application. No further mixing is required.

2) Apply the material in as many passes as required to provide the required film buildup of the coating thickness, taking care to avoid slumping or sagging of the coating.

3) Take wet film thickness measurements every five (5) square feet or every two (2) running feet of coated surface.

e. Required Wet Film Thickness

1) Fire Retardant Thermo-Lag 270

a) Minimum of 3/32" (2.4 mm)

b) Maximum of 1/4" is desired for economy

2) <u>One (1) Hour Thermo-Lag 330-1</u>

a) Minimum of 5/8"

b) Normal Maximum of 15/16"

c) Average thickness between 5/8" and 13/16"

3) <u>Three (3) Hour Thermo-Lag 330-1</u>

a) Minimum of 1-1/4"

b) Normal Maximum of 1-9/16"

c) Average thickness between 1-1/4" and 1-7/16"

4) <u>Structural Steel (Spray Application of Thermo-Lag 330-1)</u>

a) Wet film thickness for one (1) hour and three (3) hour shall be no less than that listed in Attachment 9.3.

6.1.10 <u>Fire Stops</u>

a. Examples of fire stops used in dedicated cable trays and/or conduits are shown in Attachment 9.4. Also shown are typical fire barrier terminations inside of a non-dedicated tray in lieu of total tray coverage.

6.2 Repair - Thermo-Lag 330-1 or Prefab Application

6.2.1 Thermo-Lag 330-1 or Prefab Application

> CAUTION: Do not cut cables located inside the Thermo-Lag.

a. Remove damaged and loose materials using a knife and scraper. Cut area until sound adhering material is reached.

b. The edges should be undercut to form a beveled edge as in plaster repair.

c. Remove all foreign matter from the substrate using a wire brush.

d. If the Stress Skin material is found to be damaged, enough 330-1 material shall be removed to allow for repair or replacement.

e. Spray or trowel Thermo-Lag 330-1 into the patch area, per Section 6.1.6.e. Thermo-Lag 330-1 will be applied in accordance with Section 6.1.9.b or 6.1.9.c.

f. For acceptable repair of pre-formed panel removed from Thermo-Lag cable trays, see Attachment 9.2, Page 3.

6.2.2 Thermo-Lag 270

a. Remove all loose material at damaged area. Use only a bristle brush or similar tool to ensure cable insulation is not damaged.

b. Spray or brush Thermo-Lag 270 over the damaged area to the proper thickness as specified in Section 6.1.9.a of this PPM.

6.3 Repair - Structural Steel, Hangers or Supports

6.3.1 Remove all damaged matter to a surface that meets the requirements of Section 6.4.1, dovetail the edges to be followed by caulking with Thermo-Lag 330-1 at the edges and filling in the space required to be repaired, by either spraying (which is the preferred method), or trowelling, where the areas are smaller.

### 6.4 Inspection

#### 6.4.1 Cleanliness - Structural Steel

Ensure that the surfaces of the structural steel, hangers or conduits are free of gross dirt, scale, rust, grease, oil or other contaminants prior to applying Thermo-lag 330-1 Subliming material. Surfaces that are galvanized are suitable for direct application of Thermo-Lag 330-1.

#### 6.4.2 Cleanliness - Fire Walls

Ensure that applicable surface area of any fire rated wall is free of gross dirt, grease or other contaminants prior to the application of Stress Skin and 330-1 materials.

#### 6.4.3 In-Process Inspection

a. For every installation, ensure that the Stress Skin has been applied in accordance with this procedure and applicable figures. Areas to check as a minimum shall be as follows:

   1) Overlap distances

   2) Fastener distances

   3) No open or damaged areas

   4) No loose application

b. Perform wet film thickness tests during the spray application of the Thermo-Lag 330-1 Coating to ensure uniform application. Wet film thickness is required when dry film thickness is not practical.

   1) Wet thickness tests shall be performed every five (5) square feet or two (2) running feet of surface area using a scaled penetrating measuring device.

c. Ensure that prefabricated boards are installed in accordance with approved details.

   1) Prefabricated boards shall be checked for thickness, damage and unsealed areas.

   2) Ensure all edges or joints between installed boards are sealed full depth of the prefabricated panel.

6.4.4 Final Inspection

a. Ensure edges and joints are closed and sealed.

b. Ensure all released structures are covered or filled to the requirements of the applicable fire rating.

c. Quality Control (QC) shall document all phases of the Thermo-Lag application on the Inspection Form, Attachment 9.1.

d. All gaps or cracks in the Thermo-Lag envelope shall be repaired.

e. Verify dry film thicknesses per Section 6.0 where such measurements may be taken without damage to the installed barrier.

6.4.5 Identification

a. All Thermo-Lag applied to dedicated trays and conduit shall be identified with a red painted stripe. Instrument tubing supports shall be identified with a red painted stripe. The painted stripe shall be visible from the floor elevation, if possible.

7.0 PROCEDURE (3M FIRE PROTECTION SYSTEM - 3 HOUR)

7.1 Preparation

7.1.1 Prior to any 3M fire protection mat material being applied to an open top cable tray greater than twelve (12") inches wide, a strapping system shall be applied around or across the cable tray at a maximum spacing of twelve (12") inches on center and underneath all seams. This strapping system shall be used to minimize sagging of the 3M three (3) hour fire protection mat material. Any strapping system used shall have a minimum tensile strength of five hundred pounds (500 lbs.). The following are possible options:

a. A minimum of two (2) wraps of three-quarters (3/4") inch wide or wider filament type tape.

b. Most one-half (1/2") inch wide or wider polyester or nylon strapping.

c. Metal strapping.

d. Metal or plastic bridging across the top of the cable tray.

7.1.2 Prior to any installation of 3M E-50D mat material to the safe shutdown conduit(s), the support steel and attached steel base plate shall have the required layers of E-50D mat material installed. When this process has been completed, the E-50D mat material and the concrete beneath shall have the required bolt holes drilled to accept concrete fasteners (i.e. at least one and one-half (1-1/2") inches perpendicular penetration into the concrete).

7.1.3 Supports and Heat Transfer Items

a. Partial Length Protection - 5 layers for 12"

If the final user of the 3M Interim E-50D 3-hour Fire Protection System has determined that the strength of the bare supports holding a critical fire protected item would be sufficient if exposed to an ASTM E-119 time-temperature fire curve, then the supports and any heat transferring item must be fire protected with five layers of E-50D a minimum of 12" from the point of contact to the critical item. Also, any heat transferring item within a 12" conductive heat transfer path from the critical item must also be fire protected with five layers of E-50D.

b. Full Length Protection - 3 layers entire length and baseplate

If the above criteria for the high temperature strength of bare supports is not met, or as an alternative the above partial length protection, the entire length of the support and the baseplate must be fire protected with three layers of E-50D. Also, any heat transferring item that physically contacts the support must be fire protected with three layers of E-50D a minimum of 12" from the point of contact along the heat transfer path.

7.2 Material

7.2.1 Supports

a. Unistrut P1000 series, P5000 series and Unistrut accessories as manufactured by the Unistrut Corporation, Wayne, Michigan or approved equal.

b. Structural steel members shall be manufactured and fabricated per ASTM A-36 or approved equal.

c. Concrete fasteners shall be Hilti Drop-Ins (HDI), or Kwik-Bolt II as manufactured by the Hilti Fastening Systems, Stramford, Conn. or approved equal.

7.2.2 E-50 Series Mat

7.2.3 Facing Tape (T-49)

7.2.4 Caulk (CP-25) (98-0400-0250-7)

7.2.5 Putty (303)

7.2.6 Composite Sheet (CS-195)

7.2.7 Banding Straps

a. Straps shall be one-half (1/2) inch by 0.020 inches thick, ASTM A-240 stainless steel or approved equal.

b. Straps attached to concrete elements shall be five-eighths (5/8) inches by 0.020 inches thick.

7.2.8 Wire Mesh

a. Wire mesh shall be a minimum of two (2) by two (2) mesh (nominal 1/2 inch square opening) with a wire diameter of 0.060 inches or larger.

b. Wire mesh shall be stainless steel or approved equal.

7.2.9 Washers

a. Washers shall be a minimum one and one-quarter (1-1/4) inches in diameter with a one-quarter (1/4) inch concentric hole.

b. Washers shall be fabricated from ASTM A-36 steel or approved equal.

7.3 Inspection

7.3.1 Inspections shall be performed as follows but not necessarily in this order:

a. Cleanliness before the start of E-50D mat material installation (i.e., cleanliness of dedicated item).

b. Verify the installation of each layer of E-50D mat material and number each layer.

c. After all caulk or putty is applied, verify application.

d. Verify the entire restraining system is installed.

e. After the concrete fastener bolt holes are drilled, verify minimum depth one inch per Attachment 9.5.

f. After the concrete fasteners are installed and set, verify sub-set of 1/4 inch Ø HDI per Attachment 9.5.

7.4 Installation

Installation of the 3M Interim TM three (3) hour fire protection system shall be performed in accordance with 3M installation drawings and instructions and the alternate details provided as Attachment 9.5.

7.5 Proper Repair of Any Gaps or Cuts in the System

7.5.1 For foil tears, holes, rips, or gaps in the mat less than 1/4", simply cover the area with aluminum foil tape.

7.5.2 For tears, holes, rips, or gaps in the mat 1/4" or greater in the first four inner layers, fill the void with a piece of E-50D mat with butt joints and cover with aluminum foil tape.

7.5.3 For tears, holes, rips, or gaps in the mat 1/4" or greater in the last layer, either (a) fill the void with Interim ™ CP-25 caulk and cover with aluminum foil tape; or (b) cover the void with E-50D mat following the 2" overlap rules for the last layer and hold in place with stainless steel banding.

## 8.0 DOCUMENTATION

The completed inspection form shall be filed in Maintenance Work Request File per PPM 1.3.7.

## 9.0 ATTACHMENTS

9.1 Inspection Form

9.1.1 Fill in all blanks of Attachment 9.1, Inspection Form. N/A (Non-Applicable) shall be placed in areas that would otherwise be left blank.

9.1.2 Attachment 9.1 shall be filled out according to the following steps:

a. Section A

1) Thermo-Lag Barrier Rating - Place the number of the MWR that directed the work and the BDC/PVR that identified the barrier rating required.

2) QC Inspection Plan No. - QC will enter the appropriate IPR number upon completion of their hold-point review.

3) Thermo-Lag P.O. - For material traceability and qualification, the P.O. number/lot number/expiration date shall be entered.

4) Component Identification - Enter component type, i.e., cable tray, conduit hanger, etc. Enter identification number.

5) Drawing Number - Place the applicable drawing number here.

b. Section B

1) Inspection Requirements - As required.

NOTE: N/A shall be entered on all lines not applicable to the installation being inspected.

2) Quality Control Inspector - Enter QC signature and date inspected.

c. Section C

1) Responsible Engineer - Signature of the Supply System engineer responsible for a final acceptance. The responsible engineer must be trained in 3M or Thermal Lag installation or have 1 year experience in fire protection requirements. △ {2.11}

2) Reviewed By - Signed by the person responsible for review of the documentation prior to closing the MWR.

9.1.3 All areas not numbered are self-explanatory and shall be filled out with the required information.

9.2 Specific Applications/Thermo-Lag

Page No.


1. Thermo-Lag Stress Skin Type 330-69, Typical Lay-out for Cable Tray Sections.

2. Cross Sectional View of Thermo-Lag 330-1, Applied to a Typical Cable Tray.

3. Typical Repair of Prefabricated Board Removed from Cable Tray.

4. Cross Sectional View of Thermo-Lag 330-1 Subliming Coating Envelope System Applied to Cable Drops.

5. Cross Sectional View of Thermo-Lag 330-1 Subliming Coating Envelope System, Applied to Conduit and Cable Drop Junctions.

6. Cross Sectional View of Thermo-Lag 330-1 Subliming Coating Envelope System, Applied to Conduit and Cable Tray and Cable Drop Junctions.

7. Typical Raceway Thermo-Lag Interfacing with Penetration Seal, (1-Hour Rating, Spray Application).

8. Typical Thermo-Lag Raceway Interfacing with Penetration Seal, (1-Hour Rating, Prefabricated Panel).

9. Typical Thermo-Lag Tray Covering Interface with Penetration Seal, (1-Hour Rating).

10. Typical Non-Protected Conduit Interface with Protected Tray (1-Hour Rating).

11. Typical Non-Protected Cable Interfacing with Protected Tray.

12. Thermo-Lag 330-1 Applied to Junction Box Assembly.

13. Cross Sectional View of Thermo-Lag 330-1 Subliming Coating Envelope System, Applied to Structural Steel Members.

14. Typical Prefab Panel Conduit Covering, 1-Hour Rating, 1/2" Thick Thermo-Lag 330-1.

15. Typical Tray Spray Application Barrier with Wall as Portion of Barrier, (3-Hour Rating).

16. Typical Non-Protected Conduit Interface with Protected Tray, (3-Hour Rating).

Page No.

17. Cable Drop Typical Non-Protected Cable Interfacing with Protected Tray, (3-Hour Rating).

18. Typical Tray with Thermo-Lag Covering Interfacing with Penetration Seal, (3-Hour Rating).

19. Typical Tray with Thermo-Lag Covering Interfacing with Penetration Seal, (3-Hour Rating).

20. Typical Instrument Tubing or Conduit Covering, 3-Hour Rating (2) - 1/2" Thick Thermo-Lag 330-1 Panel with Outer Layer of Stress Skin 330-69.

21. Typical One-Hour and Three-Hour Prefabricated Conduit Section Application Techniques for Conduit and Cable Drops.

22. Typical One-Hour and Three-Hour Conduit/ Instrument Tubing Using Premolded Conduit Sections with a Wall as a Portion of the Barrier.

23. Cross-Sectional View of Three-Hour TSI Thermo-Lag 3301-1 Interface with 3-M Interim E-50D/E-54A Applied to Conduit.

24. Four Typical Insulation Styles for Cables on Trays.

25. Typical Cable Tray Thermo-Lag 330-1 Covering 1 Hour Rating Applied By Direct Spray, Rolling or Troweling Application Methods.

26. Typical Structural Steel Shapes Covered With Thermo-Lag Prefabricated Panel Configurations.

27. Typical Thermo-lag installation for instrument tubing, supports only.

28. Cable tray and support steel Thermo-Lag per criteria.

29. Clarification for measuring conduit 18" requirement (typ).

9.3 Thickness Requirements for Thermo-Lag

1. Thermo-Lag Dry Thickness Requirements for Structural Steel (Pages 1-3)

2. Thermo-Lag Wet Thickness Requirements for Structural Steel (Pages 4-6)

9.4 Fire Stops/Thermo-Lag

Page No.

1. Fire Barrier Termination Inside of Non-Dedicated Tray in lieu of Total Tray Coverage (Page 1)

2. Dedicated Cable Tray and Conduit Fire (Page 2)

9.5 3M 3 Hour Fire Protection Figures

1. Alternate Rework of Unistrut Supports.

2. Alternate Rework of Unistrut Supports.

3. Alternate Base Plate Detail.

4. Detail for Cabletray and Dedicated Conduit for 3-Hour Fire Rating.

5. Detail for Junction Box and Dedicated Conduit for 3-Hour Fire Rating.

6. Detail for Dedicated or Non-Dedicated Conduit Intruding into the 3-Hour Fire Protection System.

7. Detail for Structural Member Intruding into the 3-Hour Fire Protection System.

8. Alternate Detail for 3-Hour Fire Protection System of Unistrut Conduit Support Attached to Concrete.

9. Internal Detail for 3-Hour Fire Protection System of Unistrut Conduit Support Attached to Concrete.

10. Detail of Required Layers of 3M Mat Material Intruding Elements Intruding in the 3-Hour Fire Protection System.

11. Alternate Methods of Securing 3M Mat Material for 3-Hour Fire Rating.

12. 3M/TSI Conduit Interface Details.

13. Detail of Conduit Support of Dedicated Conduit for 3-Hour Fire Rating.

14. Detail of Conduit Support of Dedicated Conduit for 3-Hour Fire Rating.

# WNP-2: THERMO-LAG INSTALLATION/INSPECTION FORM

SECTION A

THERMO-LAG BARRIER RATING:________________ QC INSPEC. PLAN NO:__________

MWR/BDC/PMR No.: ____________________

THERMO-LAG P.O./RCPT. INSP. RPT. NO.: ____________ BATCH NO:__________

NAME(S) OF TSI CERTIFIED INSTALLER(S) EXPIRATION DATE:__________

__________________________________ __________________________________

__________________________________ __________________________________

__________________________________ __________________________________

__________________________________ __________________________________

COMPONENT TYPE/IDENTIFICATION NO.: ________________________________

LOCATION: BUILDING:_______ ELEVATION:_______ COLUMN LINE:_________

REFERENCE DRAWING NUMBER: ________________________ FIRE AREA: ________

| SECTION B | QC INSPECTOR'S SIGNATURE/DATE |
|---|---|
| INSPECTION FOR CABLE DAMAGE (IF REQUIRED) | |
| COMPONENT CLEANLINESS INSPECTION | |
| PROPER INSTALLATION OF THERMO-LAG 270 | |
| PROPER INSTALLATION OF STRESS SKIN 330-69 | |
| PROPER INSTALLATION OF THERMO-LAG 330-1 | |
| PROPER INSTALLATION OF 330-1 PREFAB PANEL | |
| PROPER WET COAT THICKNESS (SPRAY APPL. ONLY) | |
| PROPER DRY COAT THICKNESS | |
| OTHER (SPECIFY) _________________________ | |

SECTION C

RESPONSIBLE SUPPLY SYSTEM ENGINEER: ____________________ DATE: __________

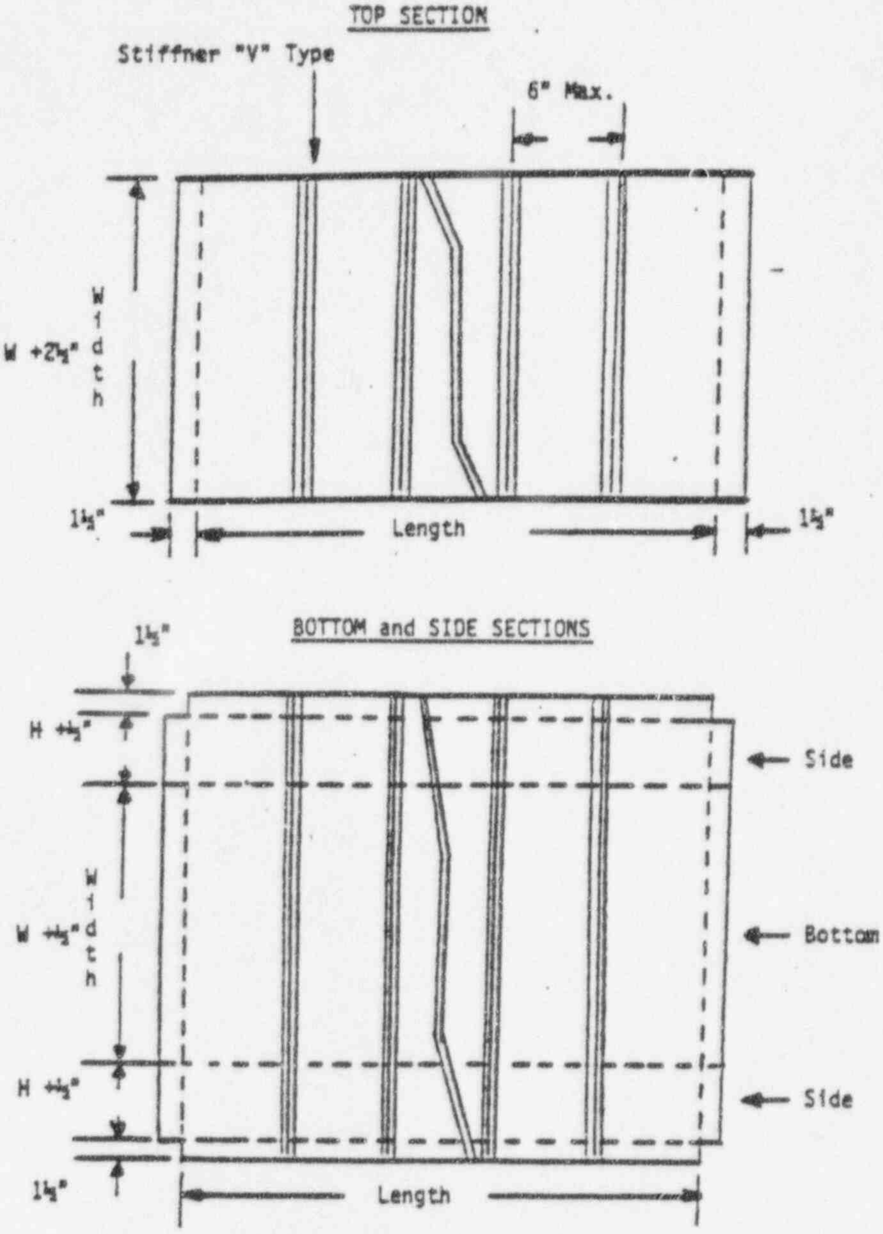
REVIEWED BY: ____________________________________ DATE: __________

COMMENTS: ________________________________________________________________

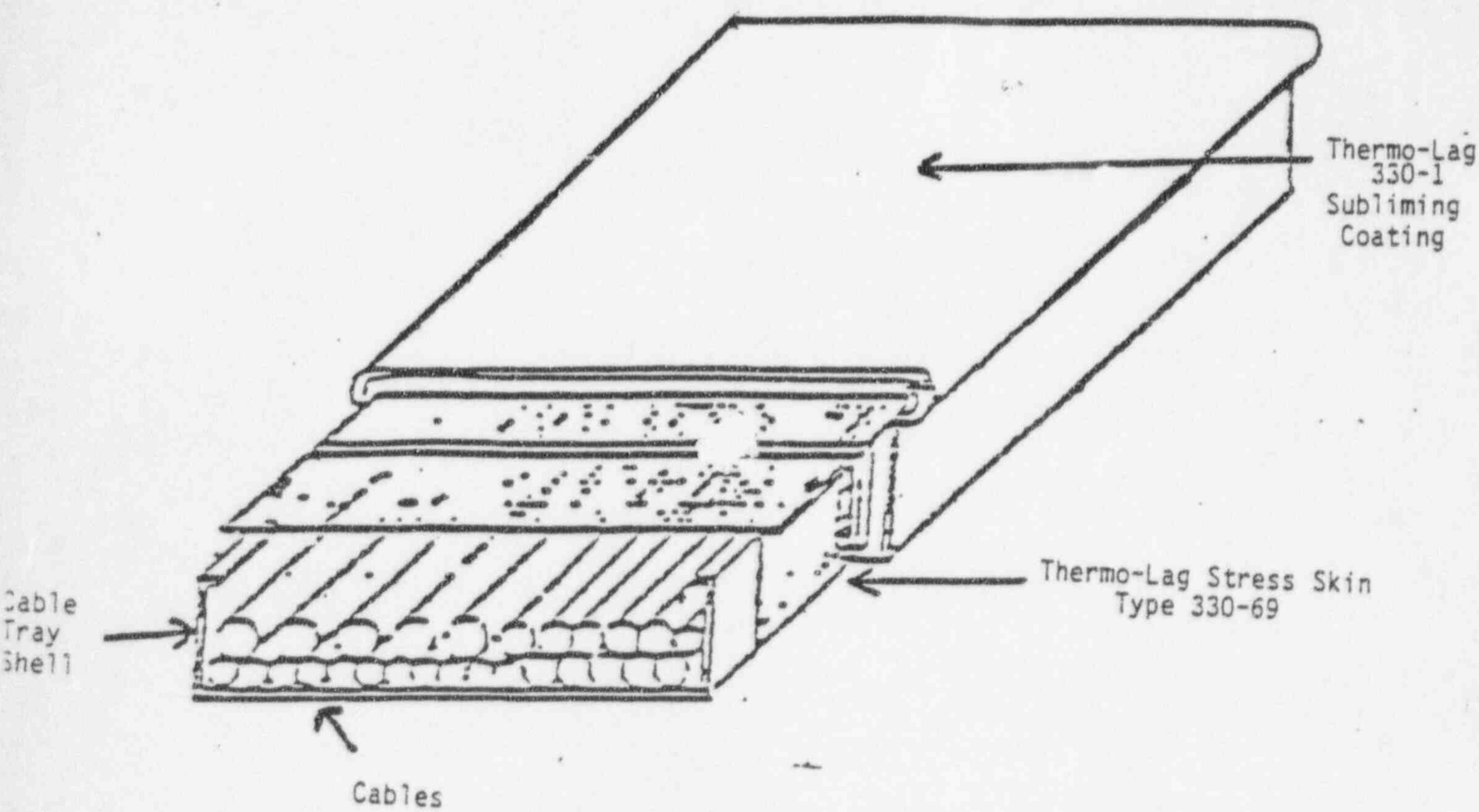
__________________________________________________________________________

Attachment 9.1

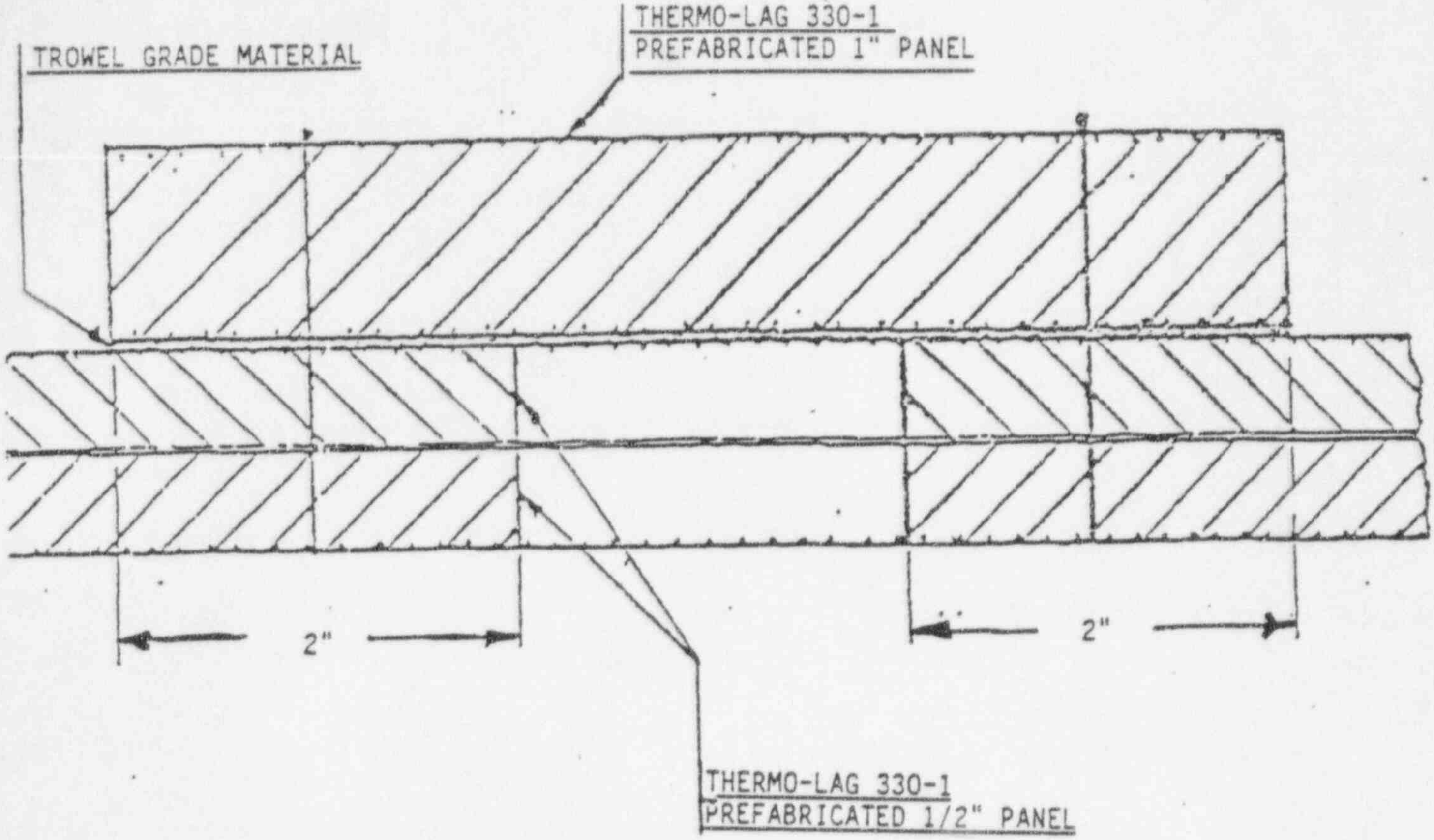
THERMO-LAG STRESS SKIN TYPE 330-69
TYPICAL LAYOUT FOR CABLE TRAY SECTIONS.

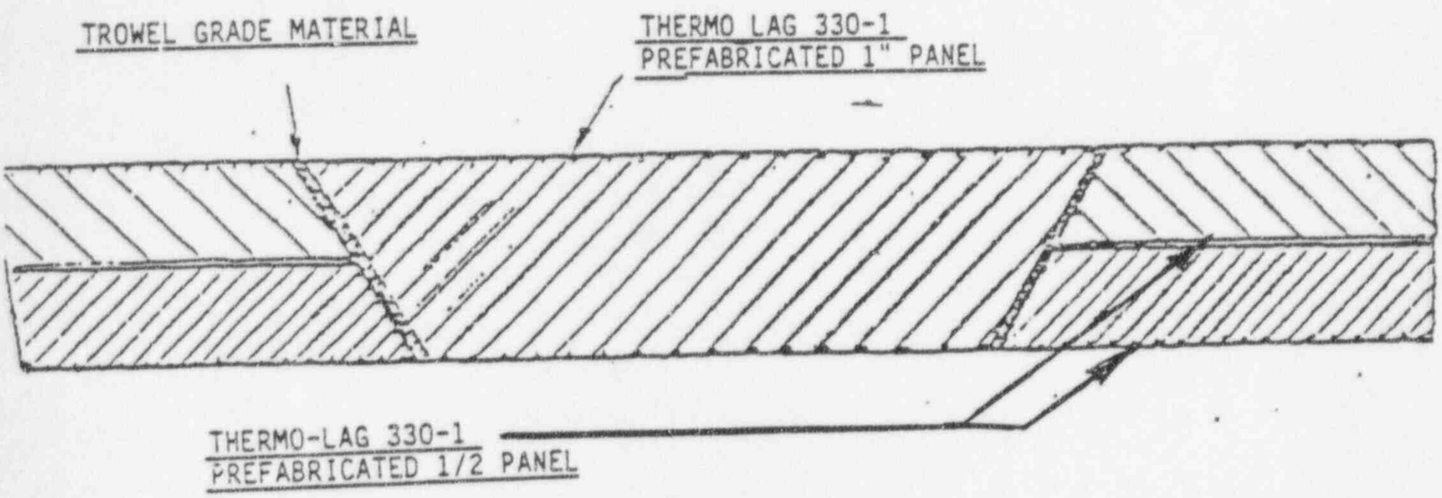


CROSS SECTIONAL VIEW OF THERMO-LAG 330-1
SUBLIMING COATING ENVELOPE SYSTEM APPLIED TO A TYPICAL CABLE TRAY



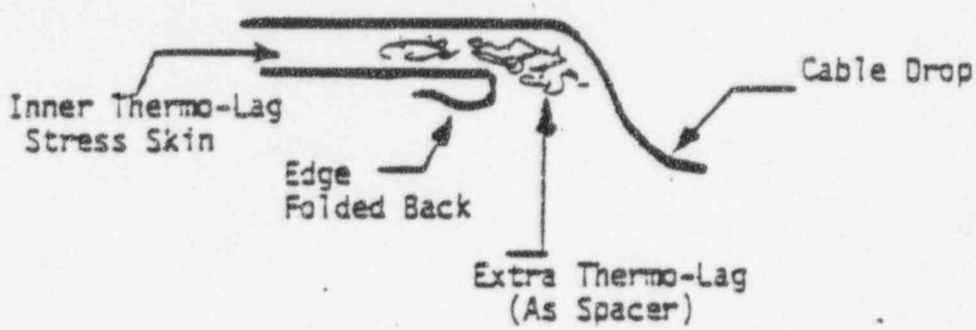
REPAIR OF PRE-FABRICATED PANEL DESIGN ON CABLE TRAYS

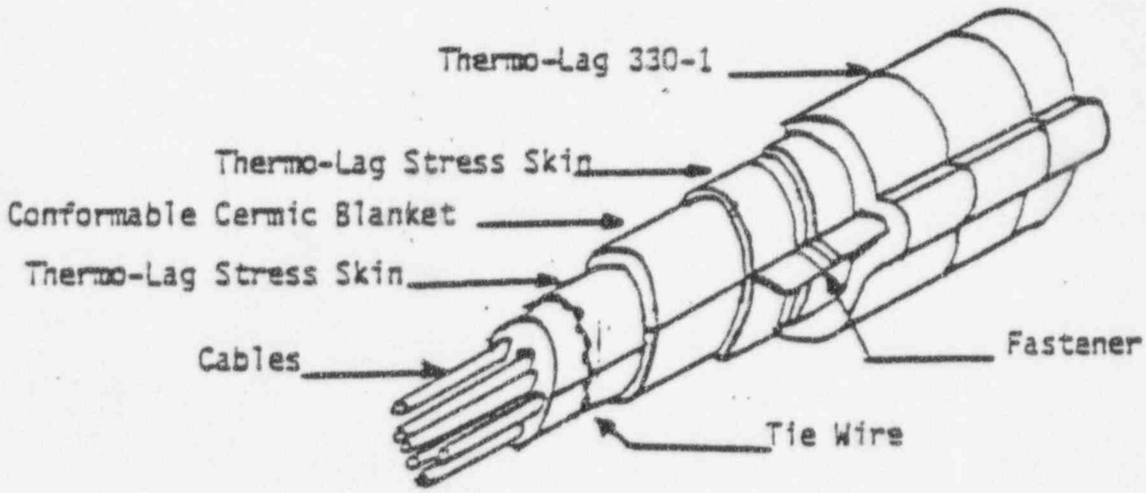


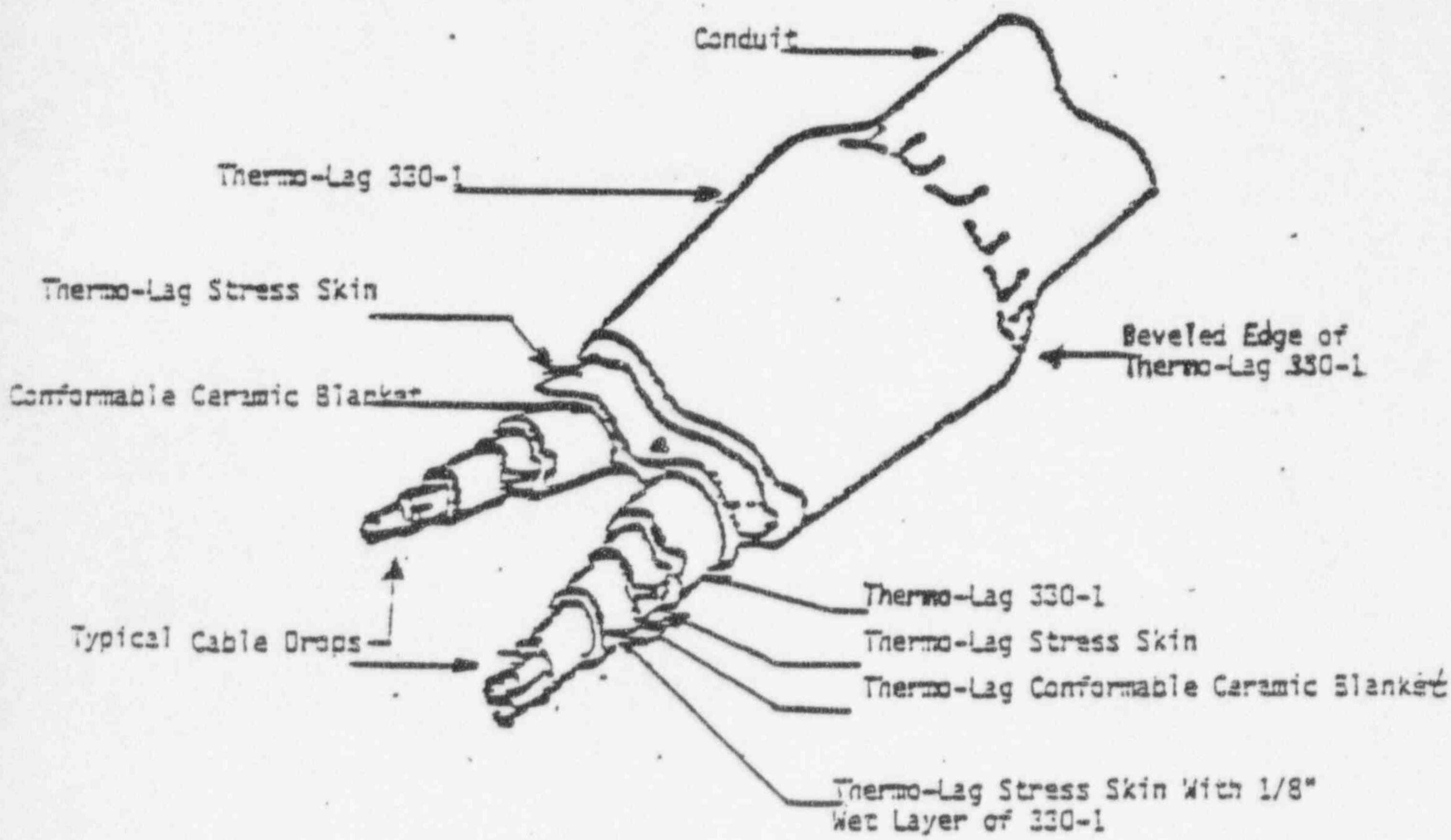

Attachment 9.2
Page 3 of 29

CROSS SECTIONAL VIEW OF THERMO-LAG 330-1
SUBLIMING COATING ENVELOPE SYSTEM APPLIED TO CABLE DROPS



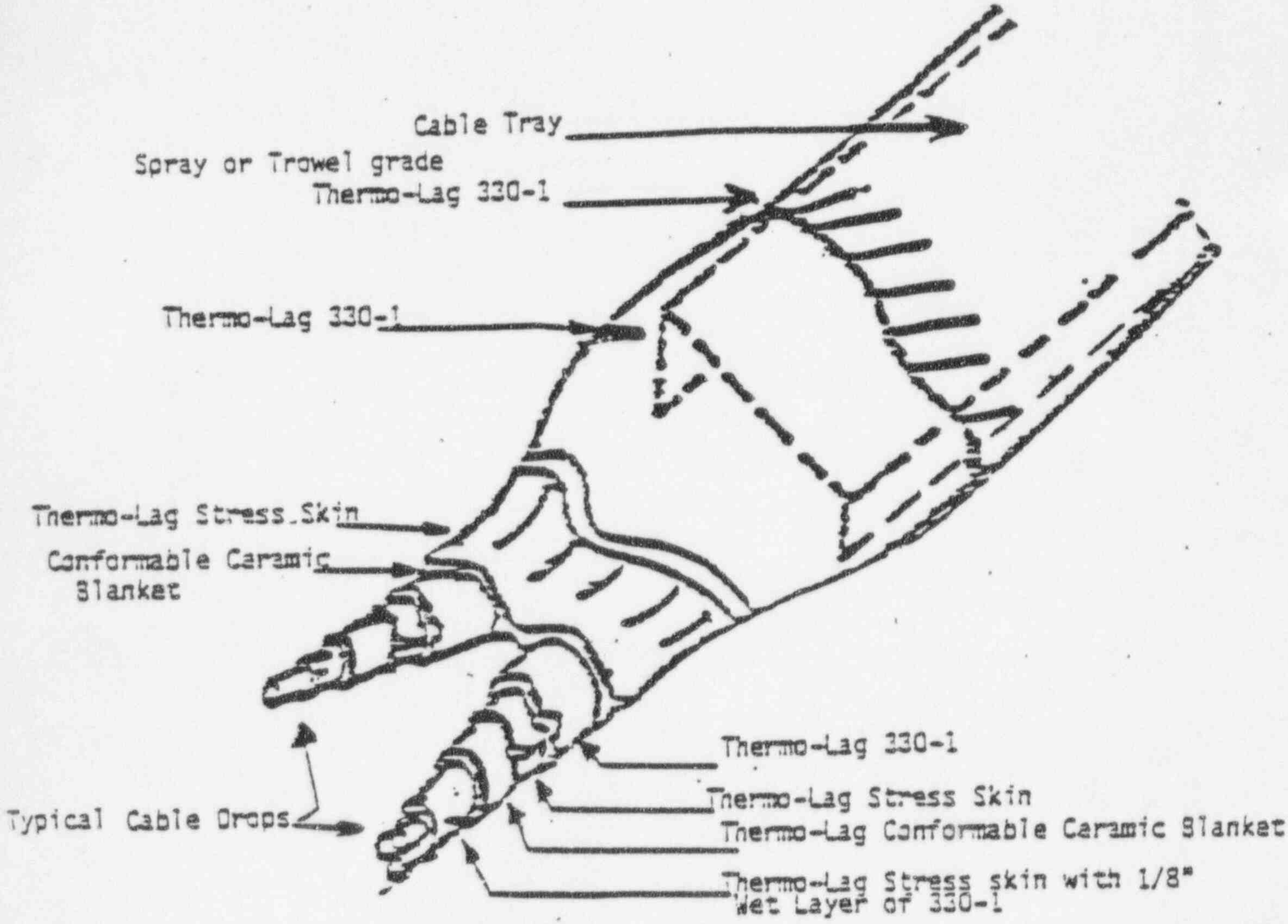



CROSS SECTIONAL VIEW OF THERMO-LAG 330-1
SUBLIMING COATING ENVELOPE SYSTEM
APPLIED TO CONDUIT AND CABLE DROP JUNCTIONS



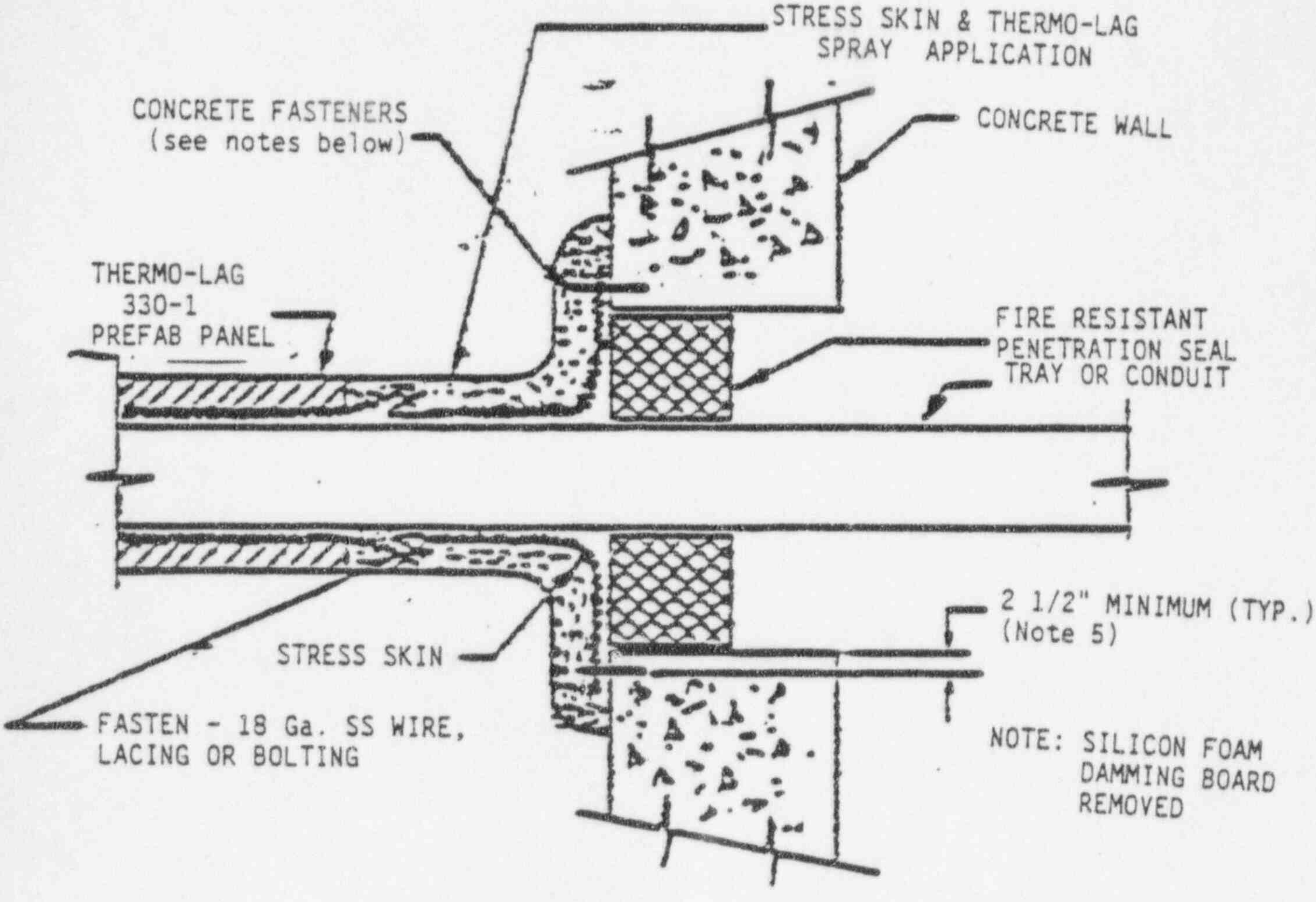

NOTE: Protect cable insulation from damage by stress skin by inserting approximately six inches of Thermo-Lag conformable blanket into the conduits.

CROSS SECTIONAL VIEW OF THERMO-LAG 330-1
SUBLIMING COATING ENVELOPE SYSTEM
APPLIED TO CONDUIT AND CABLE TRAY AND CABLE DROP JUNCTIONS



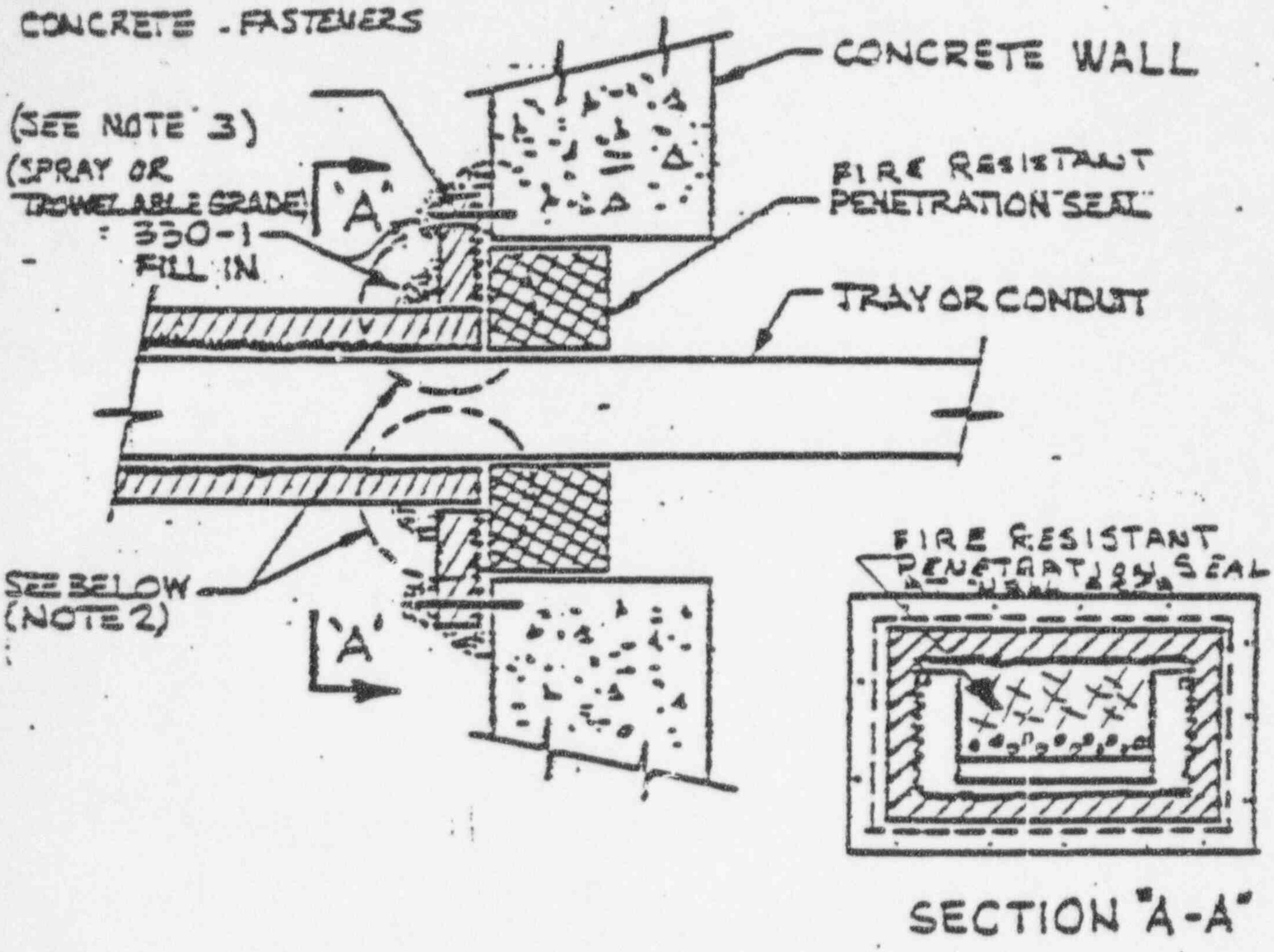

NOTE: Protect cable insulation from damage by stress skin by inserting approximately six inches of Thermo-Lag conformable blanket into the cable tray.

TYPICAL RACEWAY THERMO-LAG INTERFACING WITH PENETRATION SEAL
(1-HOUR RATING SPRAY APPLICATION)




Refer to Section 6.1.1.a.5 for concrete fastener installation notes.

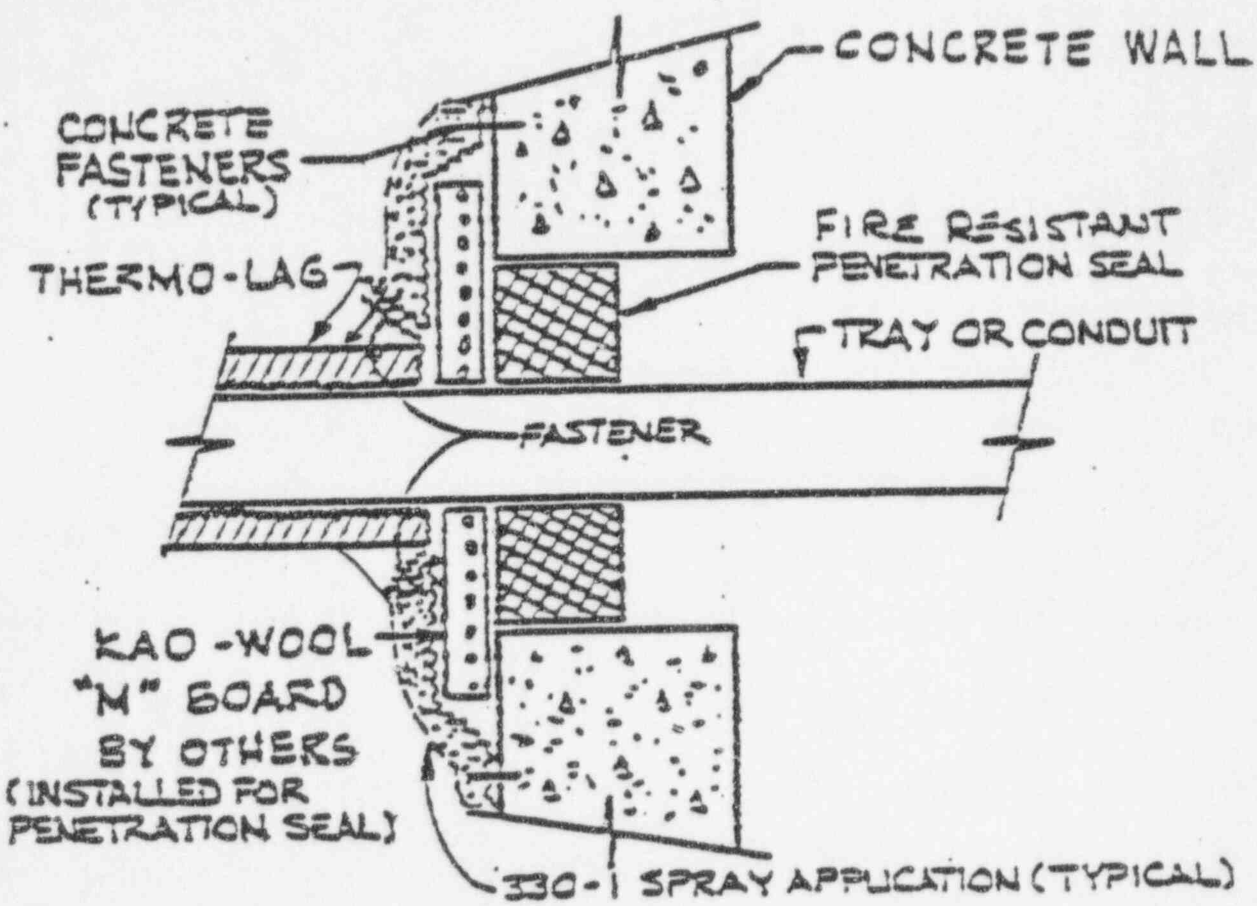
TYPICAL THERMO-LAG RACEWAY INTERFACING WITH PENETRATION SEAL
(1-HOUR RATING PREFABRICATED PANEL)




NOTE:

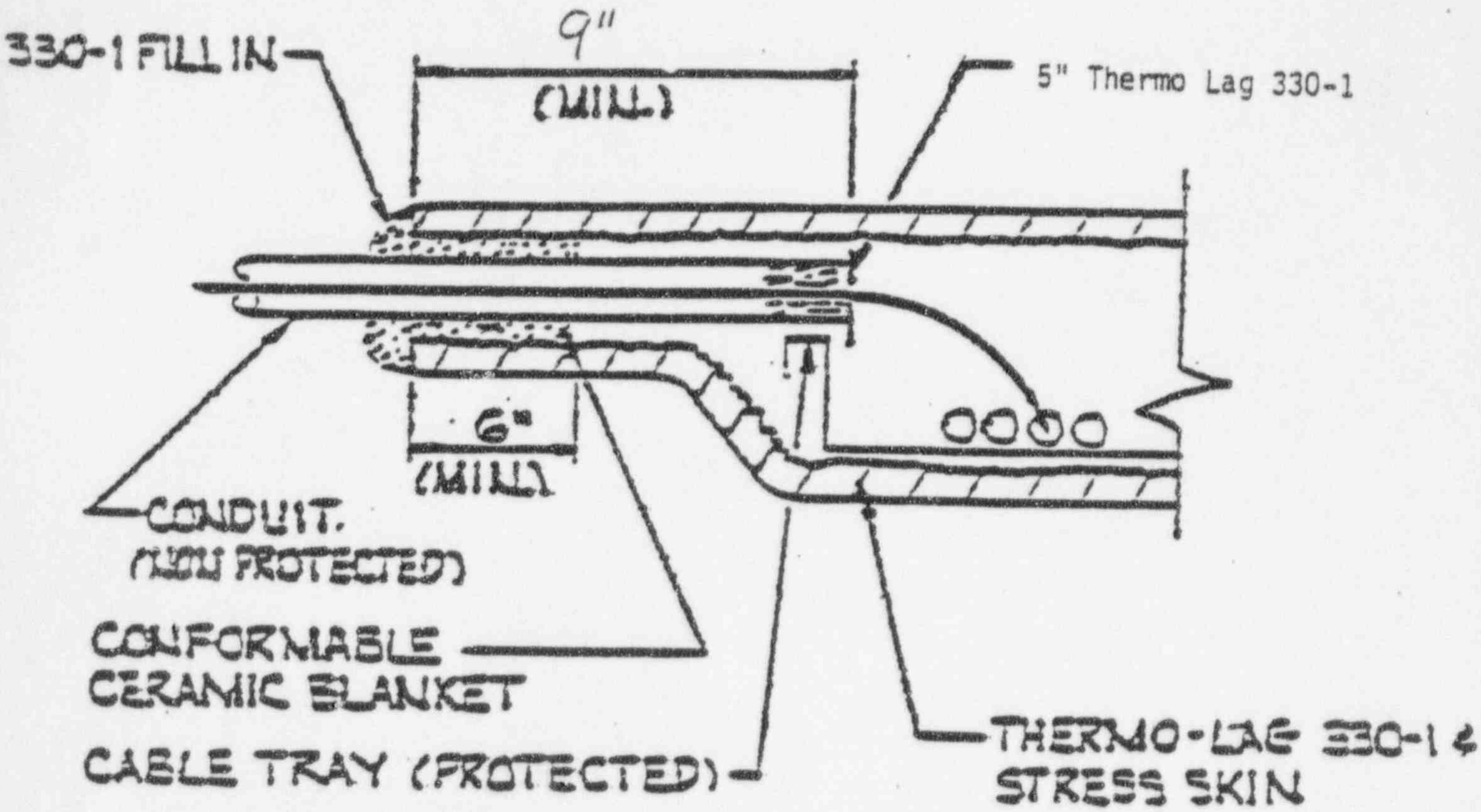
1. Damming Board Removed.
2. Mechanical Fasteners required at stress skin joint if stress skin is cut.
3. All joints and fill ins shall be sprayed with Thermo-Lag 330-1 wherever possible (Typ. for all details).

TYPICAL THERMO-LAG TRAY COVERING INTERFACE WITH PENETRATION SEAL
(1-HOUR RATING)



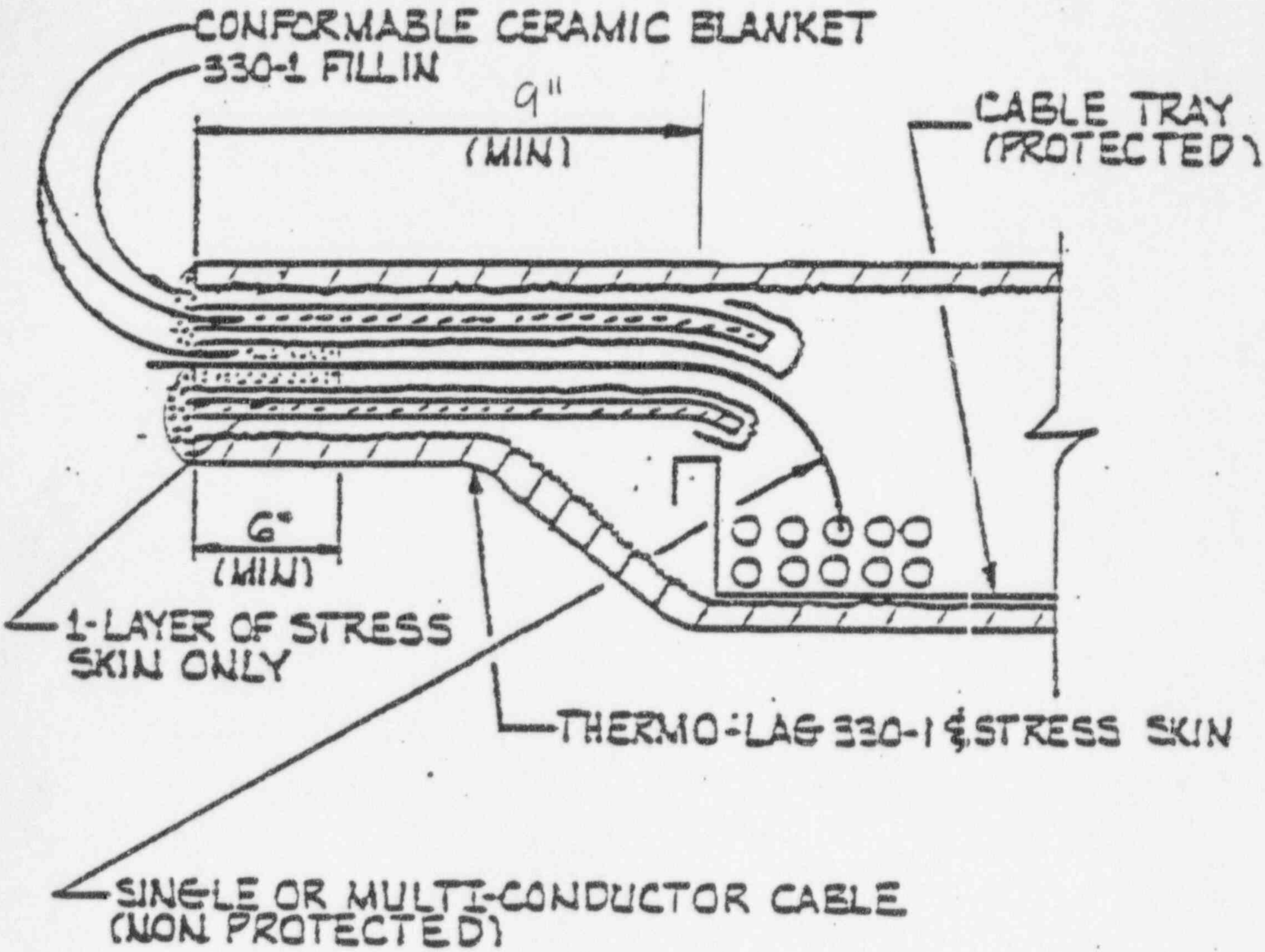

NOTE: Damming board for silicone foam installation left in place.

TYPICAL NON-PROTECTED CONDUIT INTERFACE WITH PROTECTED TRAY
(1-HOUR RATING)



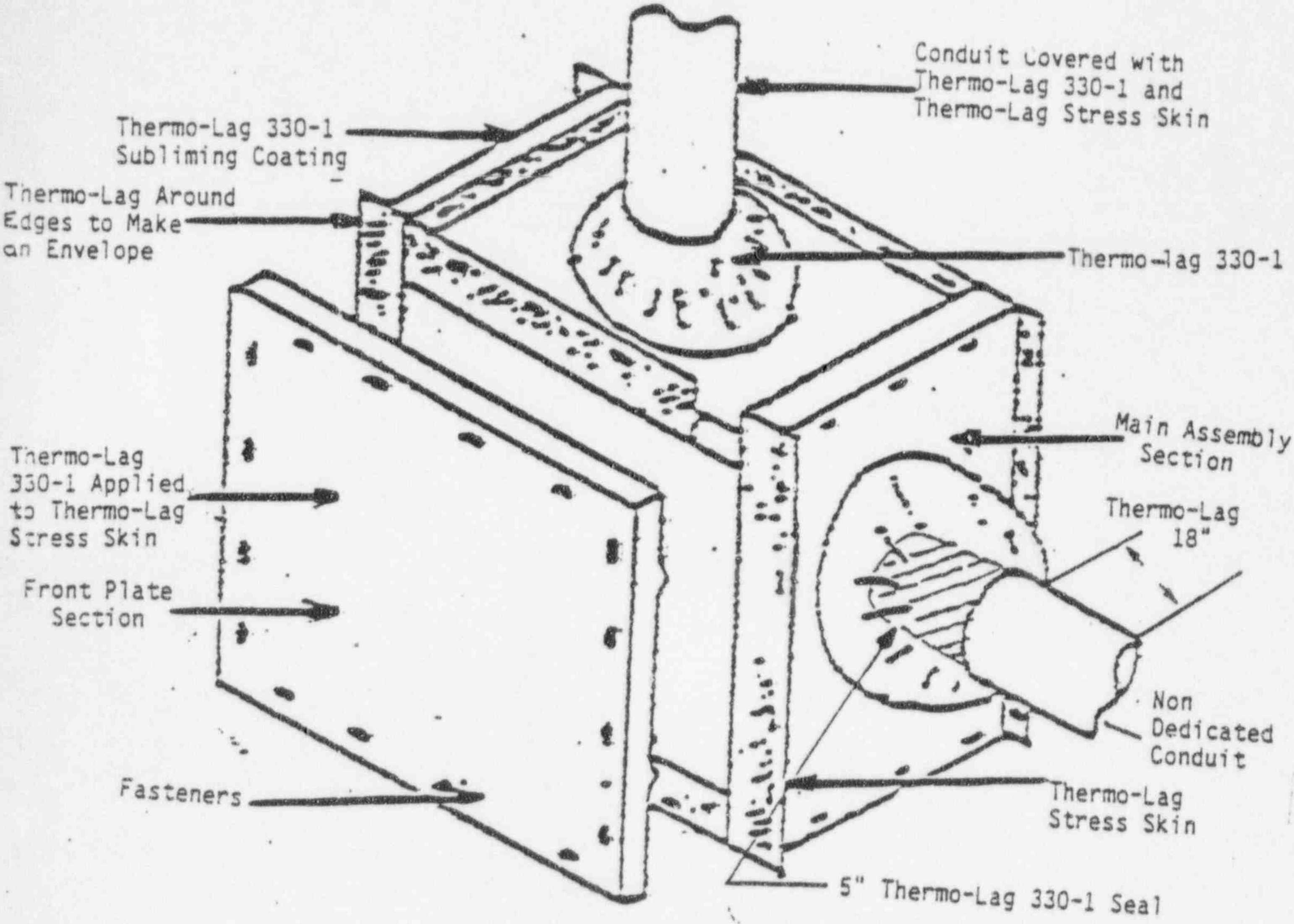

NOTE: Flex conduit, Thermo-Lag coverage shall completely cover the flex up to and including the rigid conduit attachment.

CABLE DROP TYPICAL NON-PROTECTED CABLE INTERFACING
WITH PROTECTED TRAY (1-HOUR RATING)



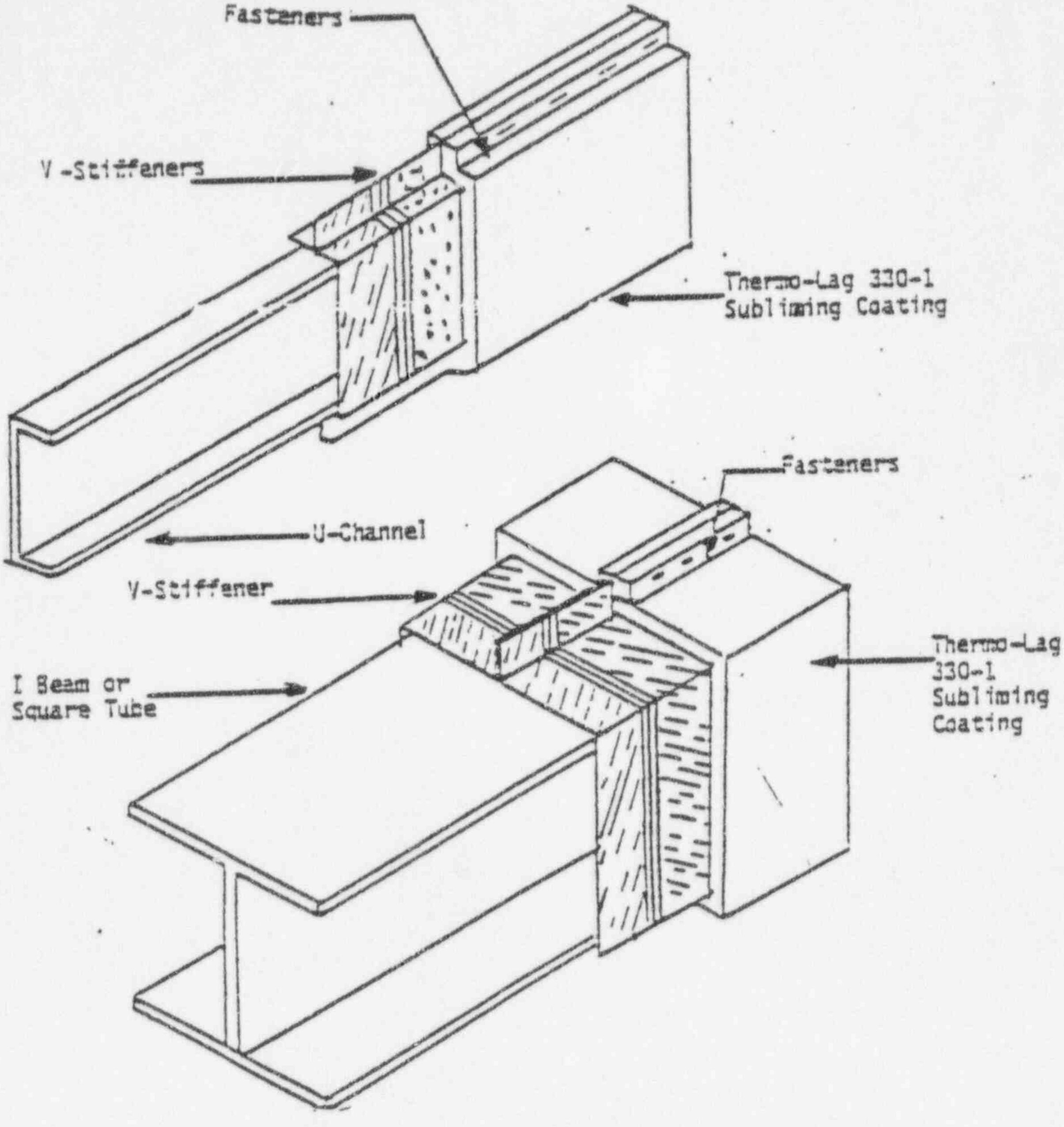

Attachment 9.2
Page 11 of 29

CROSS SECTIONAL VIEW OF THERMO-LAG 330-1
SUBLIMING COATING ENVELOPE SYSTEM APPLIED TO JUNCTION BOX ASSEMBLY



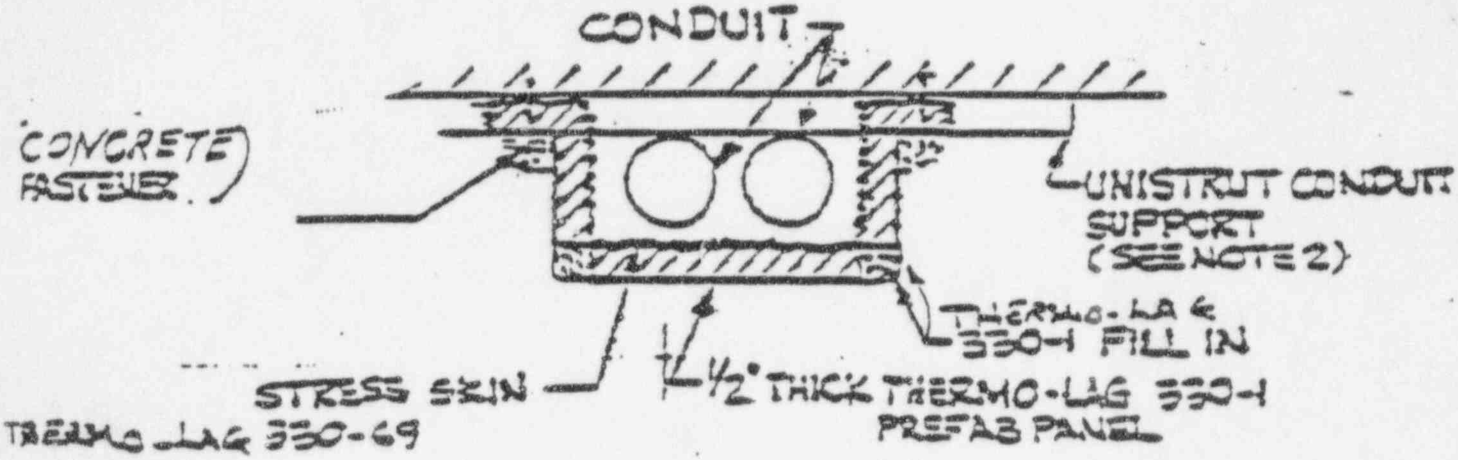

NOTE: All non-dedicated conduits penetrating a dedicated junction box shall receive Thermo-Lag coverage rated equal to that required on the junction box for a minimum of 18". In addition a minimum 5" deep Thermo-Lag 330-1 seal shall be installed in the interior of all non-dedicated conduits at the point of penetration into the junction box.

# CROSS SECTIONAL VIEW OF THERMO-LAG 330-1 SUBLIMING COATING ENVELOPE SYSTEM APPLIED TO STRUCTURAL STEEL MEMBERS




NOTE: As an acceptable option, Thermo-Lag 330-1 may be directly sprayed over hot dipped galvanized structural members using the thicknesses provided in Table 4A. When painted surfaces are to be Thermo-Lagged by the direct spray application, Thermo-Lag 351-2 primer must be applied per manufacturer's recommendations.

TYPICAL PREFAB PANEL CONDUIT COVERING
1-HOUR RATING, 1/2" THICK THERMO-LAG 330-1



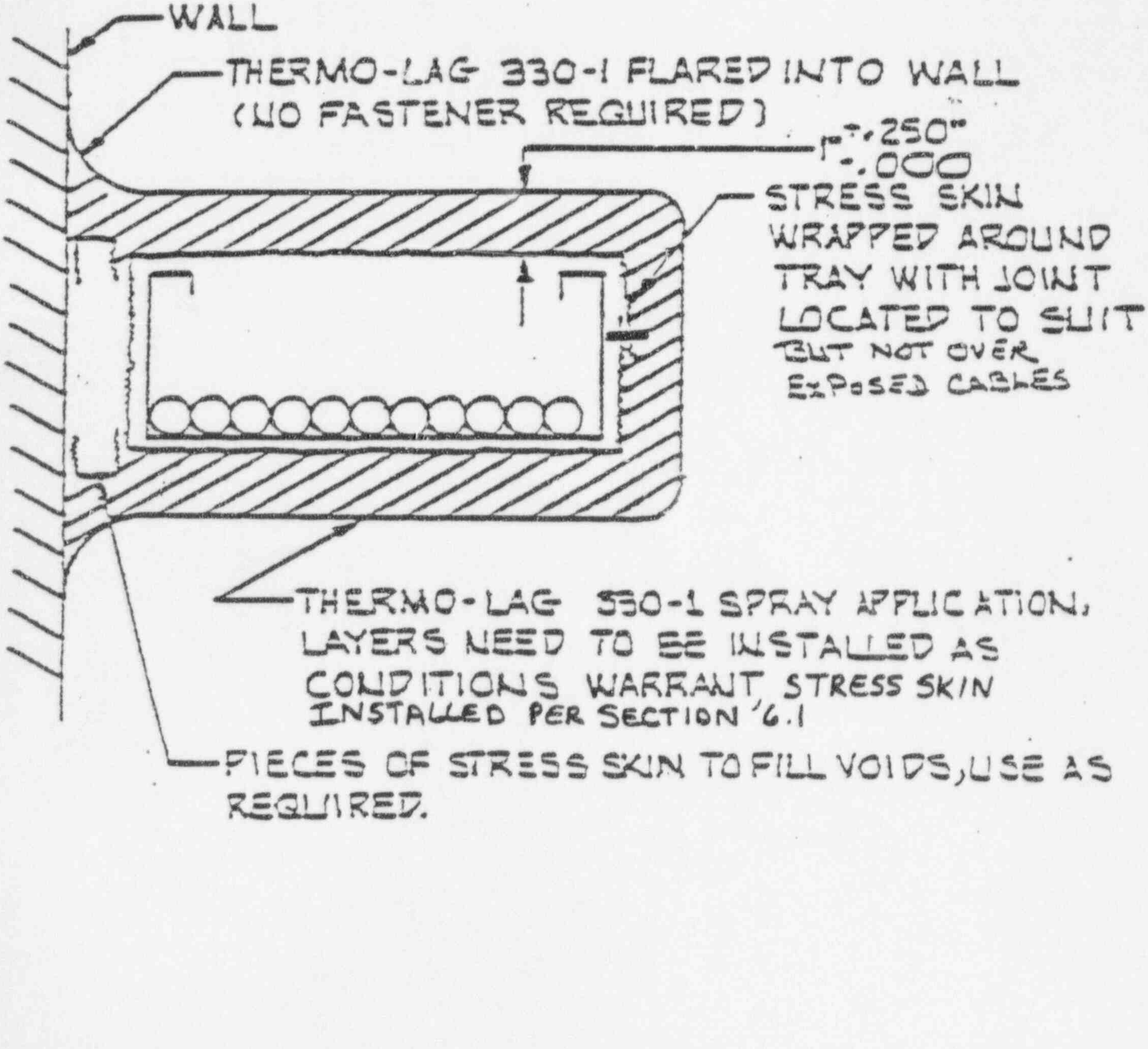

NOTE:

1. Thermo-Lag 330-1 fill in can be spray application grade or trowelable grade.

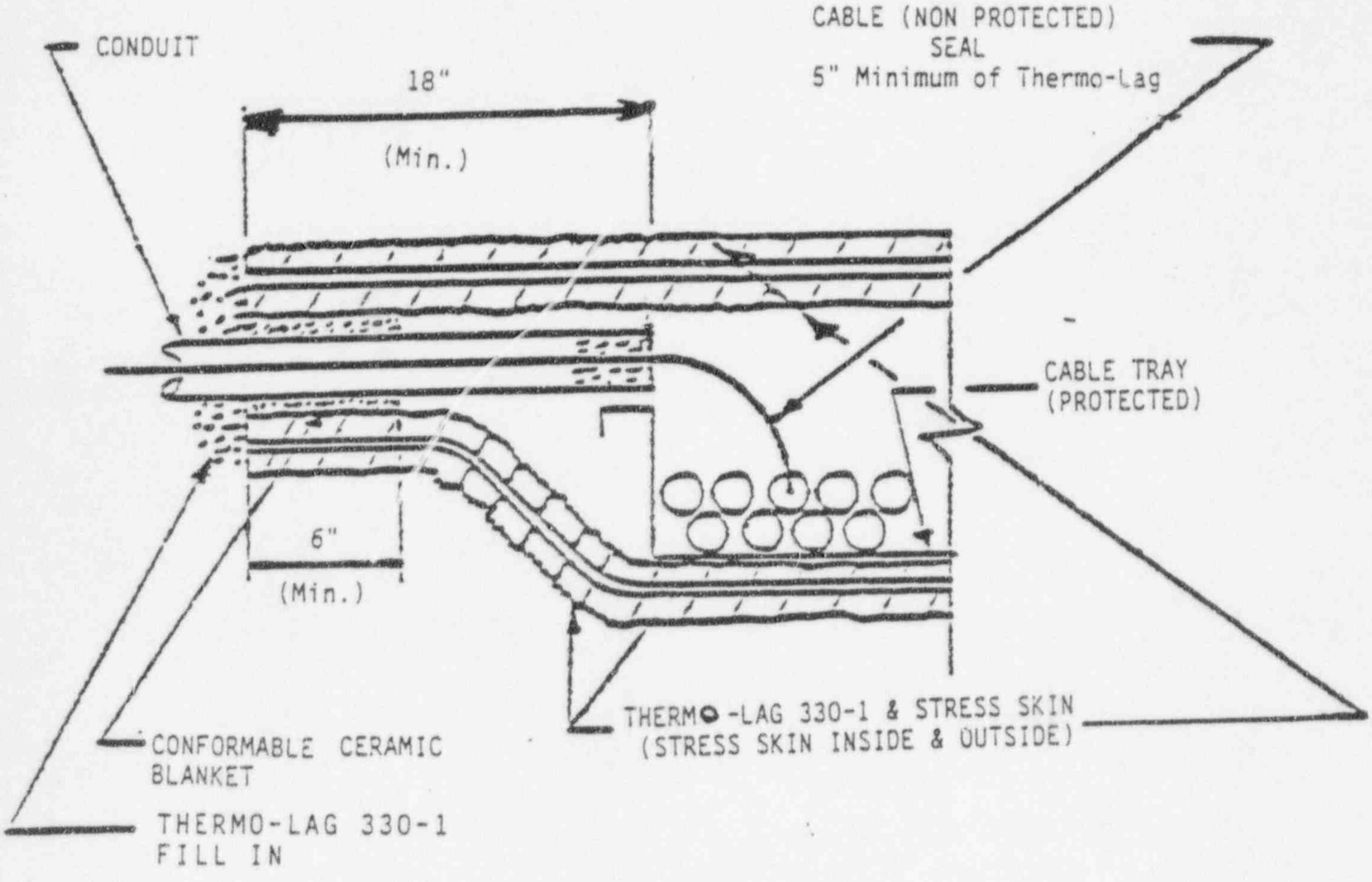
2. Extend Thermo-Lag 330-1 envelope to unistrut and support bolt. Continue envelope 18 inches beyond support bolts for thickness, see Attachment 9.3.

3. For an acceptable option, see Attachment 9.2, Figure 19B.

TYPICAL TRAY SPRAY APPLICATION BARRIER WITH WALL AS PORTION OF BARRIER
(3-HOUR RATING)

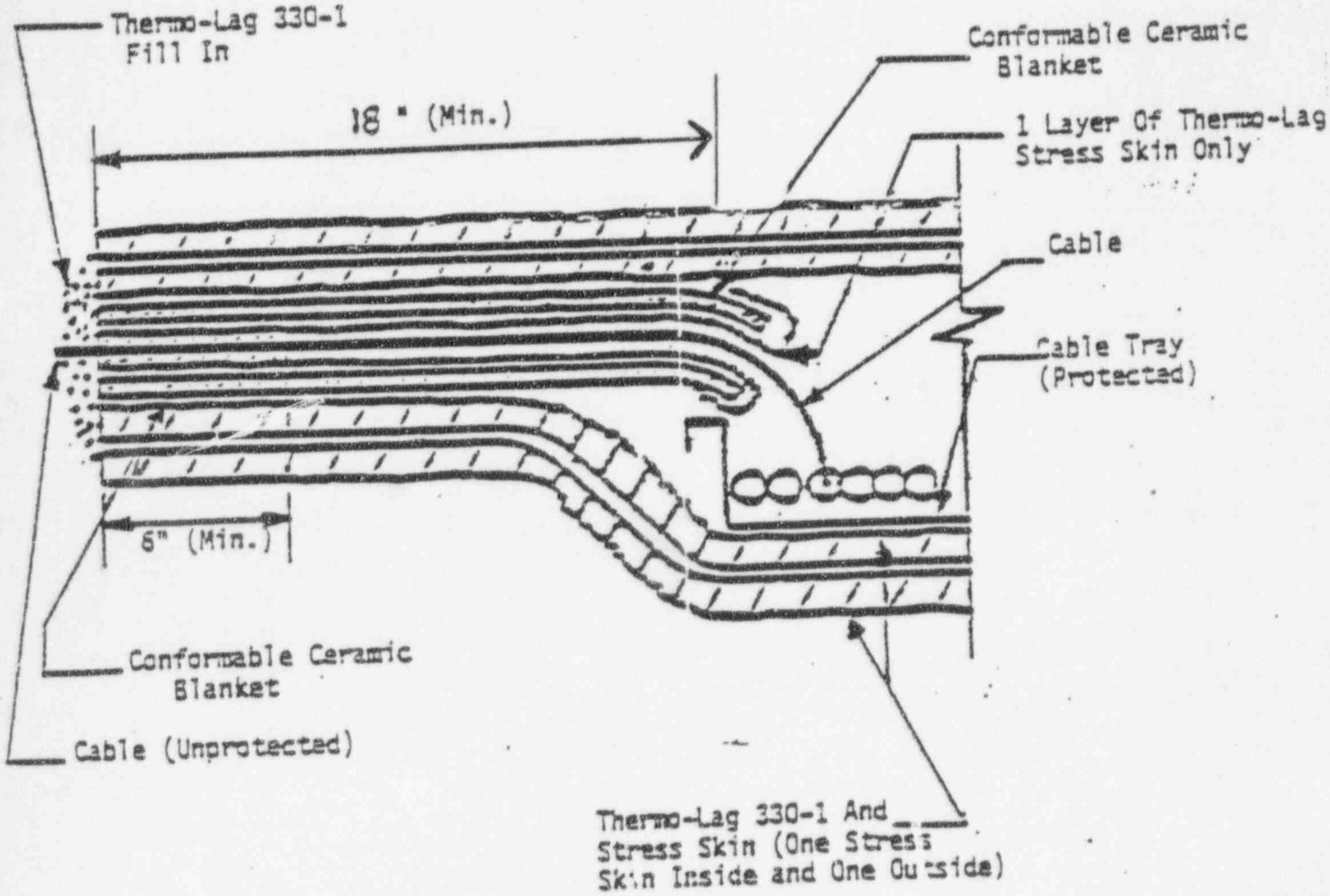


TYPICAL NON-PROTECTED CONDUIT INTERFACE WITH PROTECTED TRAY
(3-HOUR RATING)



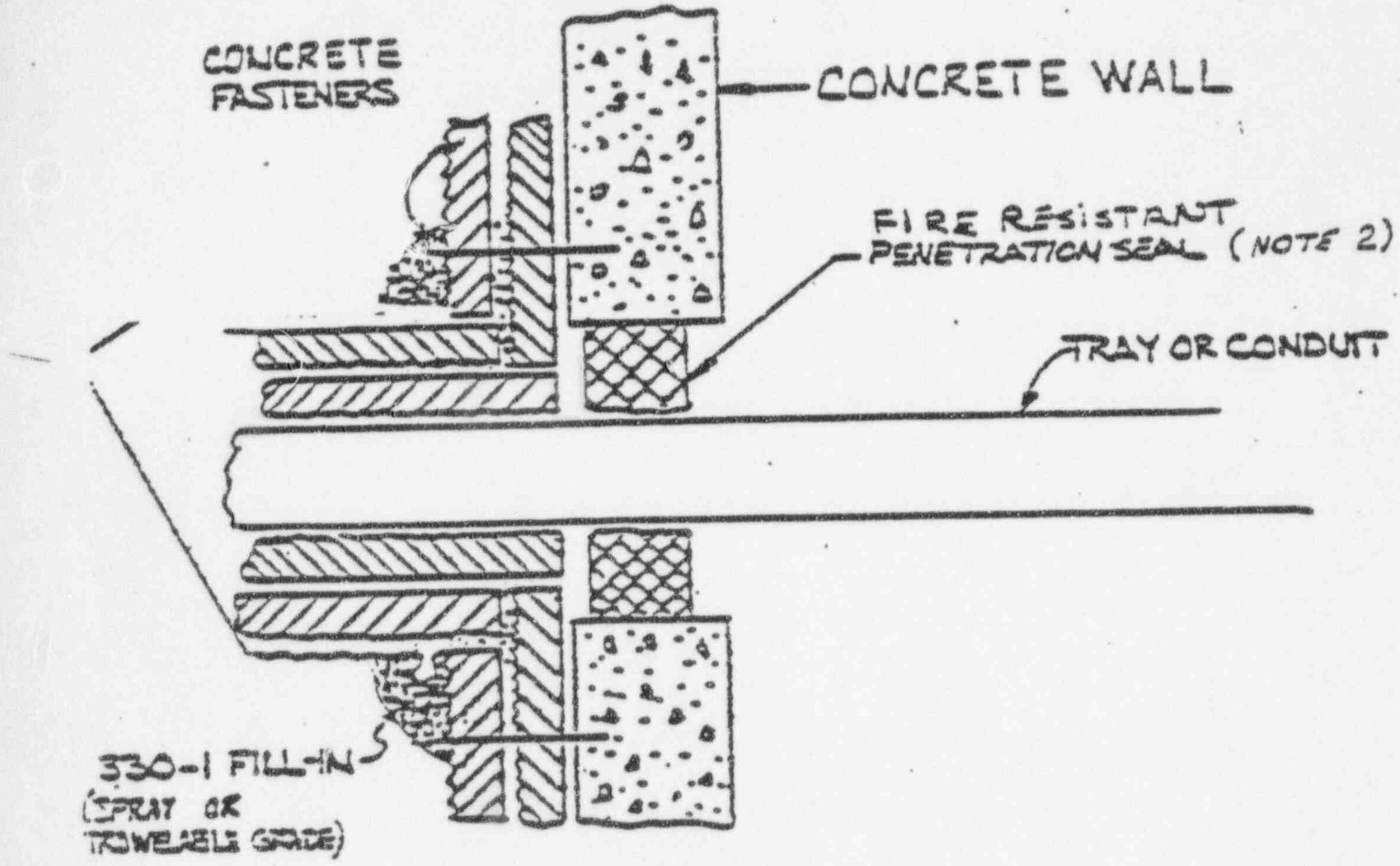

Attachment 9.2
Page 16 of 29

CABLE DROP
TYPICAL NON-PROTECTED CABLE INTERFACING WITH PROTECTED TRAY
(3-HOUR RATING)




Attachment 9.2
Page 17 of 29

TYPICAL THERMO-LAG TRAY COVERING INTERFACING WITH PENETRATION SEAL
(3-HOUR RATING)



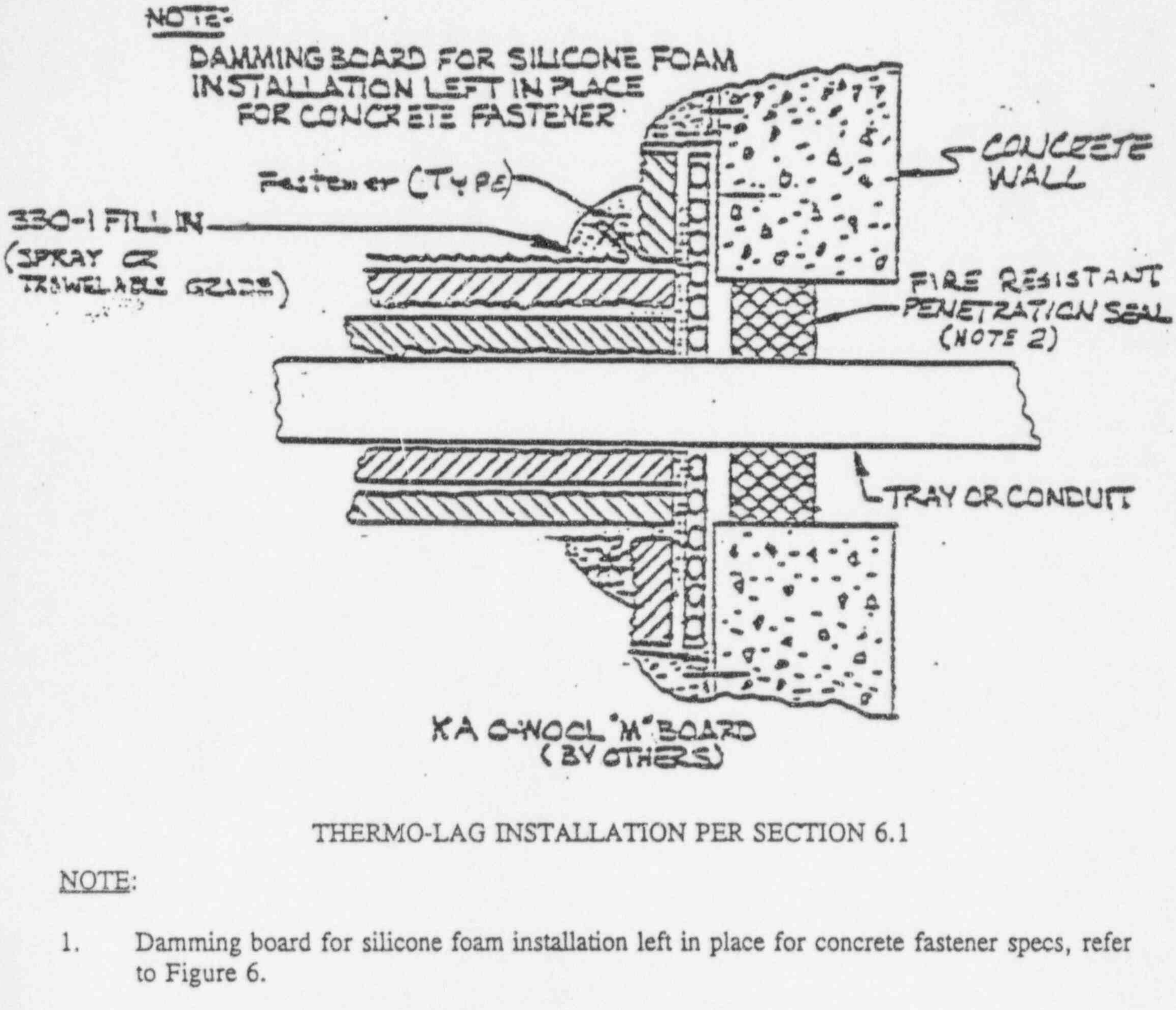

THERMO-LAG INSTALLED PER SECTION 6.1

NOTE:

1. Damming board removed.

2. Fire resistant penetration seal is to be installed to fully block/seal the penetration.

TYPICAL THERMO-LAG TRAY COVERING INTERFACING WITH PENETRATION SEAL
(3-HOUR RATING)



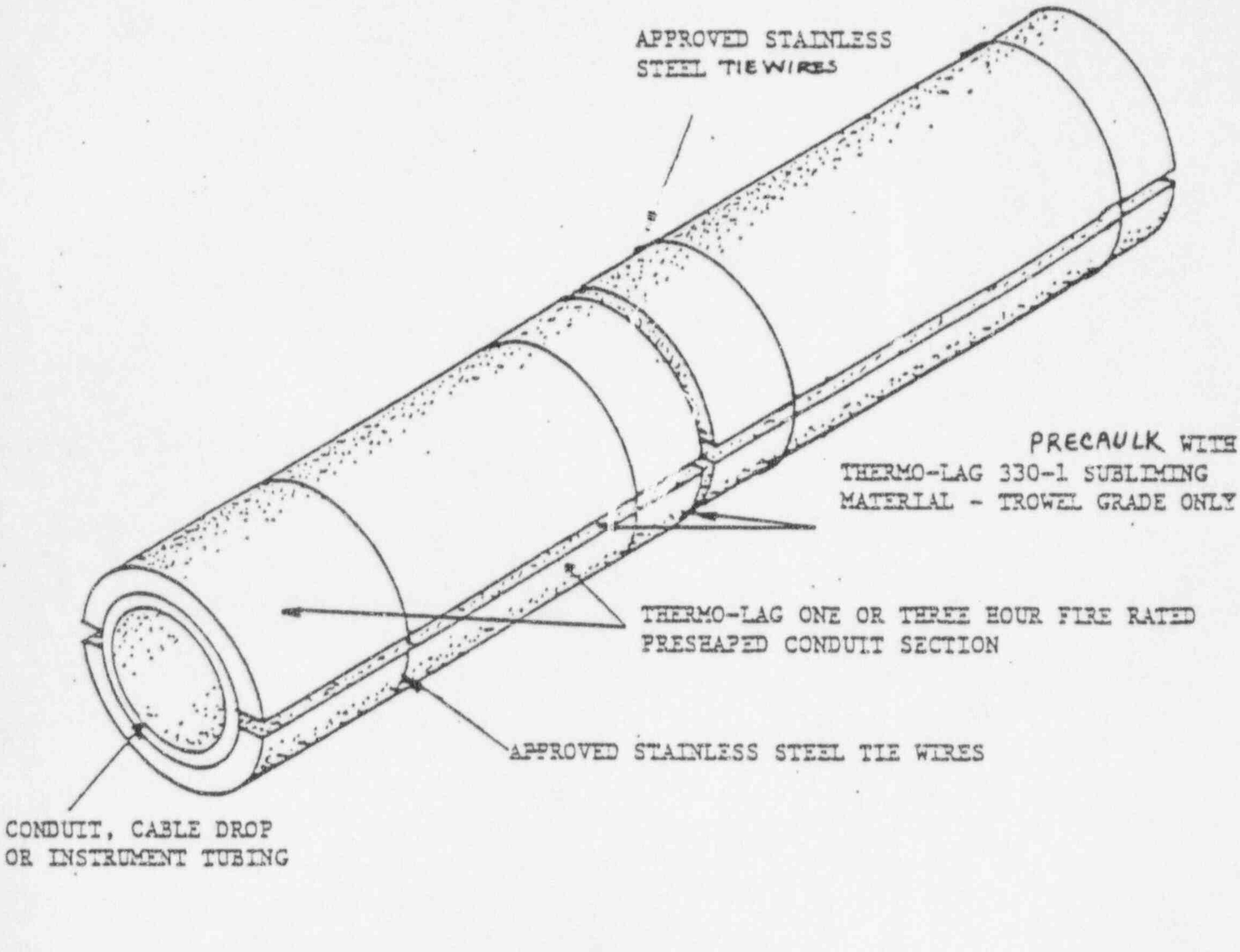

THERMO-LAG INSTALLATION PER SECTION 6.1

NOTE:

1. Damming board for silicone foam installation left in place for concrete fastener specs, refer to Figure 6.

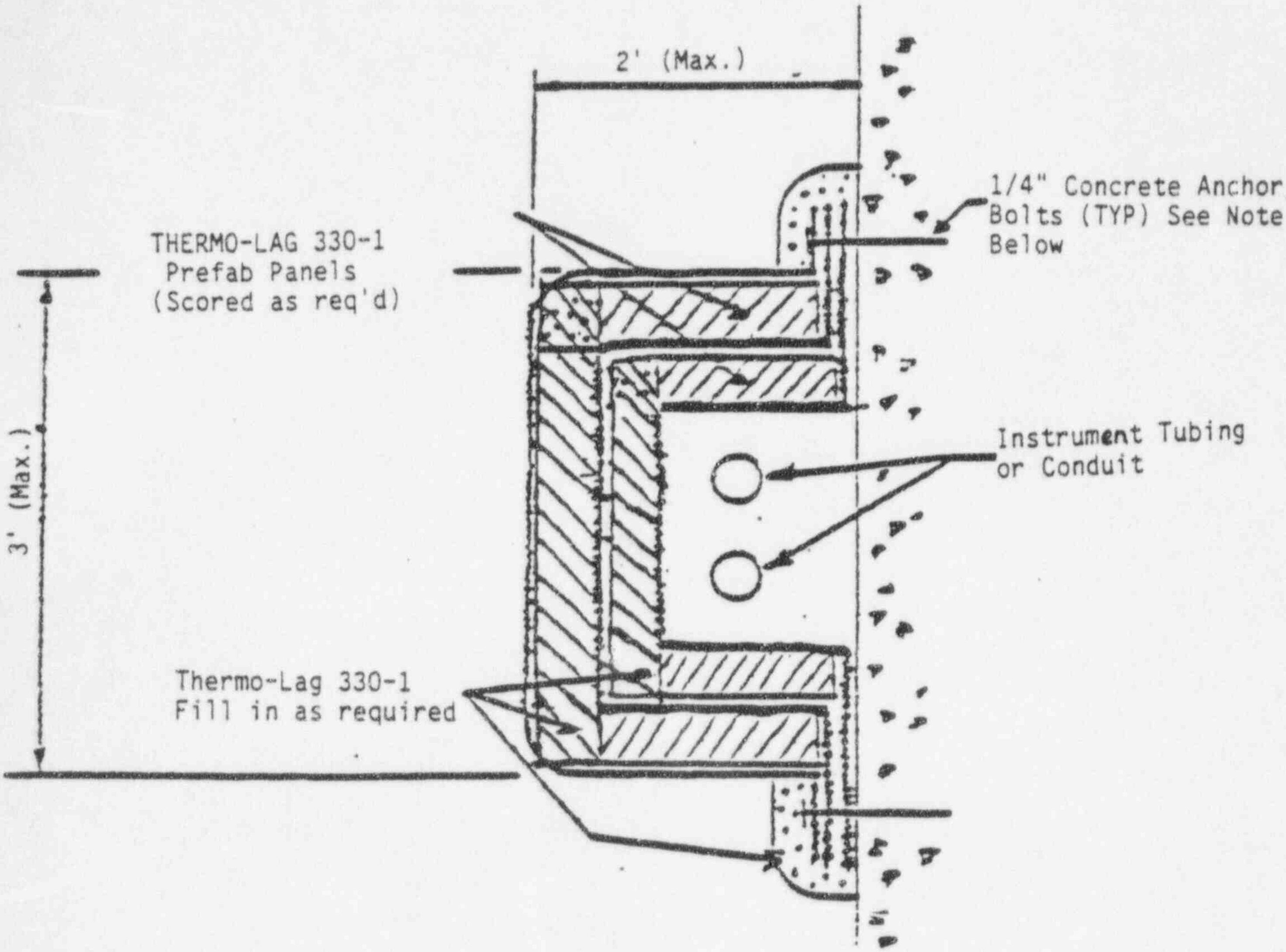
2. Fire resistant penetration seal is to be installed to fully block/seal the penetration.

TYPICAL INSTRUMENT TUBING OR CONDUIT COVERING
3-HOUR RATING (2) - 1/2" THICK THERMO-LAG 330-1 PANEL
WITH OUTER LAYER OF STRESS SKIN 330-69




Attachment 9.2
Page 20 of 29

THERMO-LAG 330 FIRE BARRIER SYSTEM
PRESHAPED CONDUIT SECTION DESIGN
FOR CONDUIT, CABLE DROPS AND INSTRUMENT TUBING

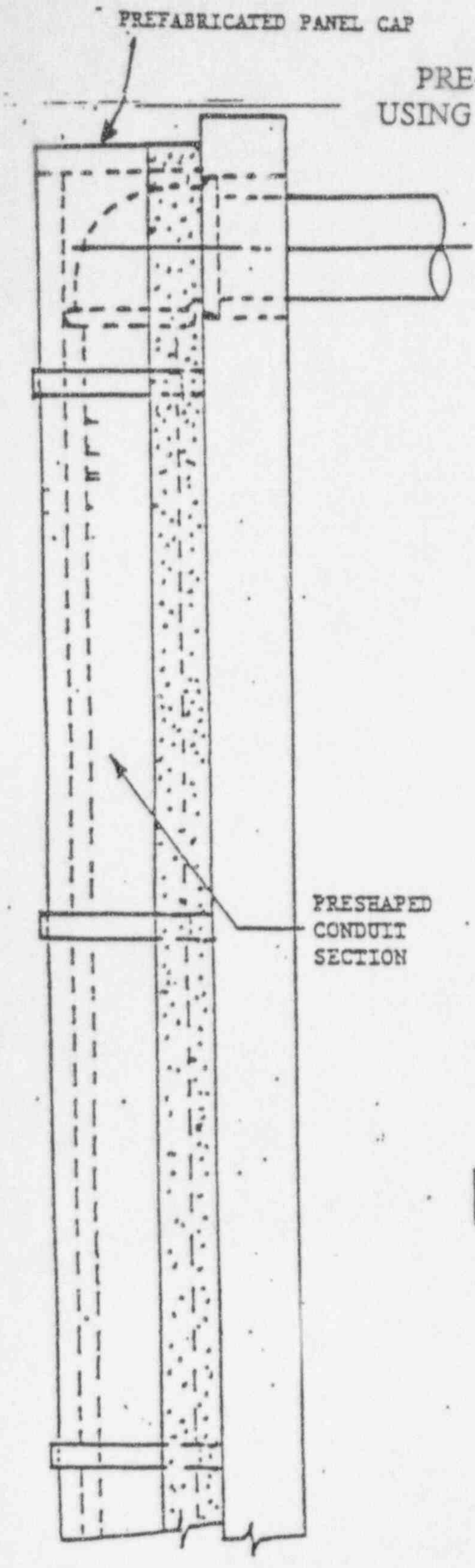


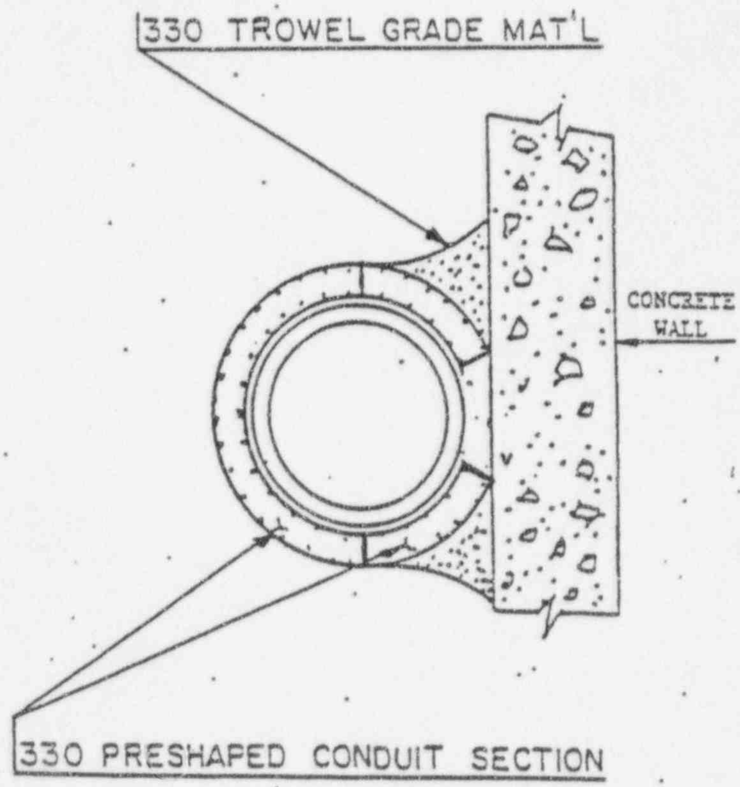

THERMO-LAG INSTALLATION PER SECTION 6.1

(SELF SUPPORTING THERMO-LAG SYSTEM THAT CANNOT BE SUPPORTED FROM CONDUIT. INSTRUMENTATION TUBING OR ITS SUPPORTS. THIS APPLICATION IS FOR WALL OR CEILING USE.)

Attachment 9.2
Page 21 of 29

## PRE-MOLDED CONDUIT SECTION USING WALL AS PORTION OF BARRIER



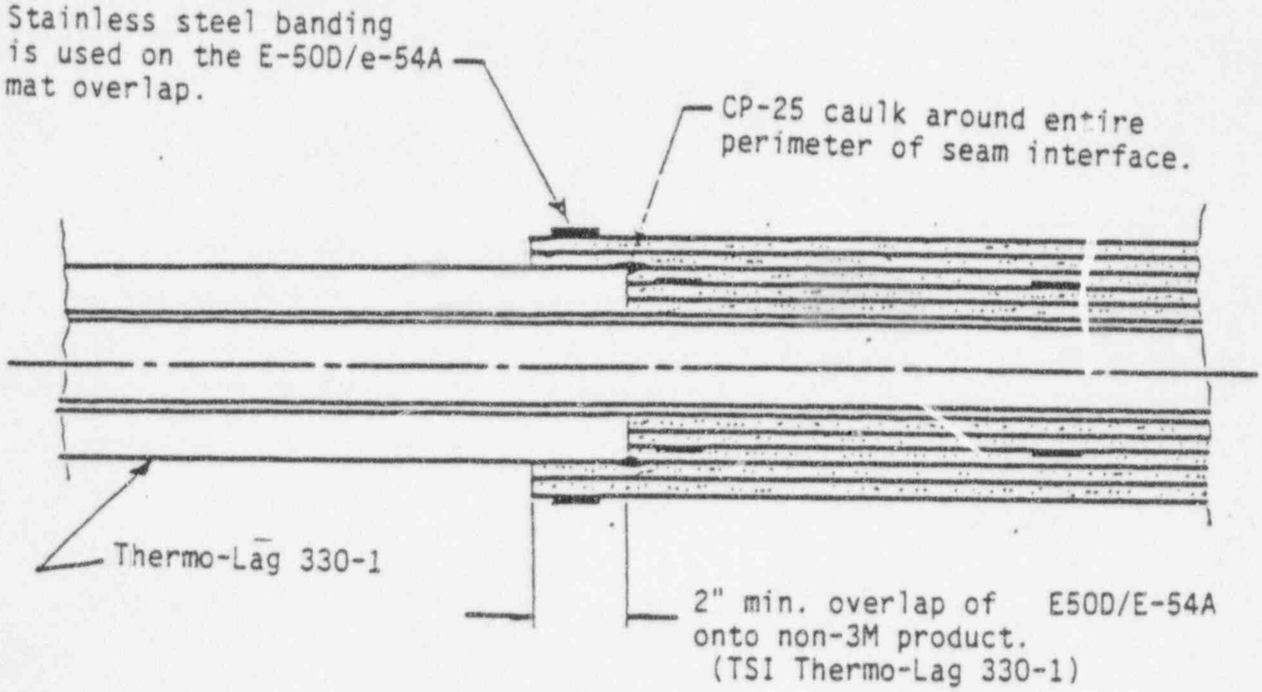




<u>NOTE</u>: Fasten system together with 18 ga. minimum stainless steel tie wire. The wall must have a rating greater than or equal to the Thermo-Lag Barrier rating.

"Typical Installation Details"

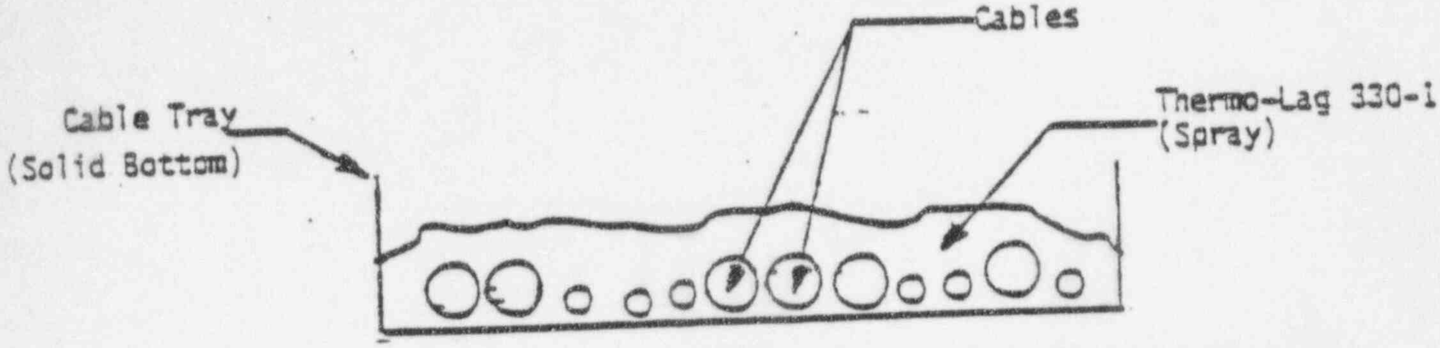
Attachment 9.2
Page 22 of 29

CROSS SECTIONAL VIEW OF TSI THERMO-LAG 330-1
INTERFACE WITH 3-M INTERIM E-50D/E-54A APPLIED TO CONDUIT
3 HOUR RATING

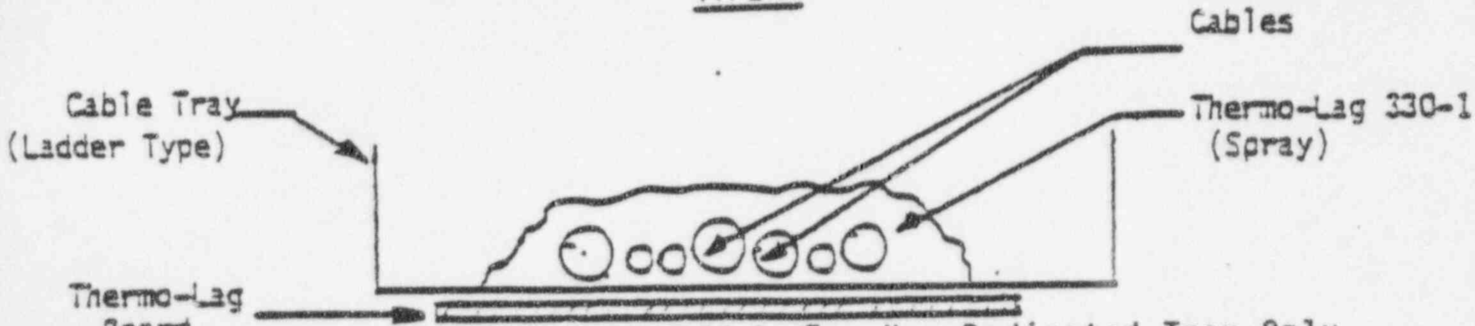



Attachment 9.2
Page 23 of 29

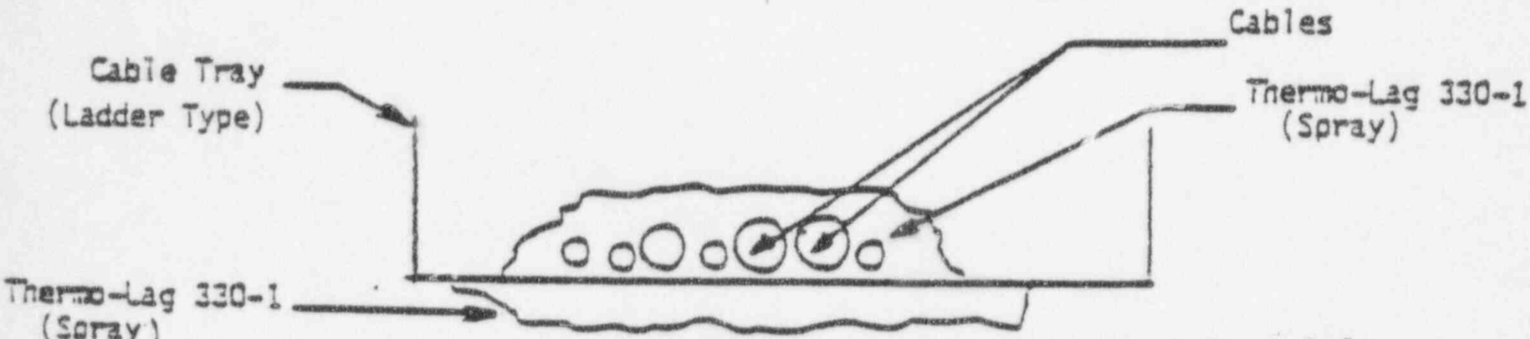
## DIRECT SPRAY APPLICATION



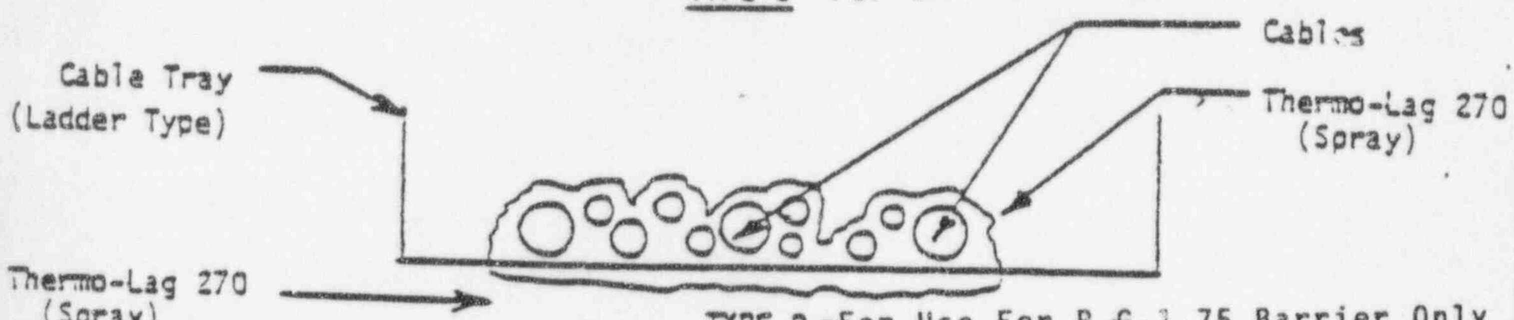

TYPE A -For Non-Dedicated Tray Only




TYPE B -For Non-Dedicated Tray Only

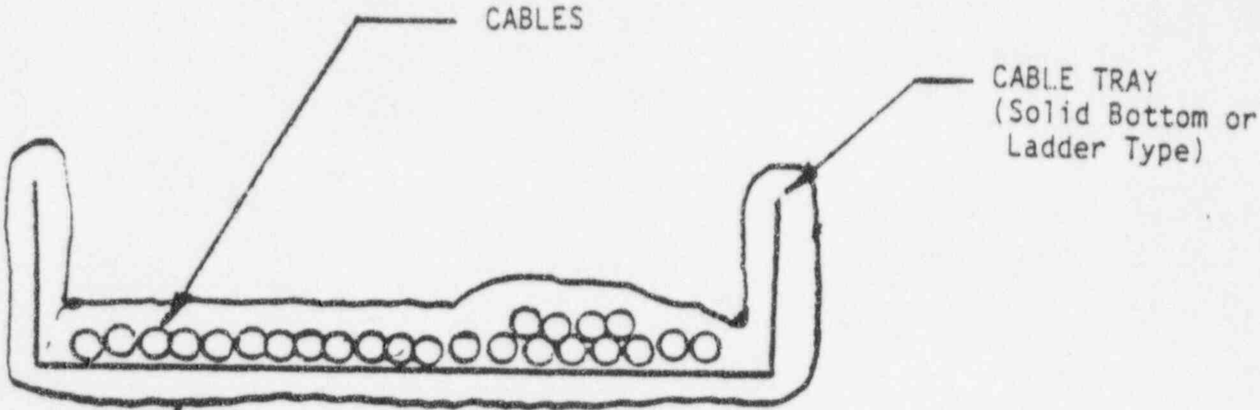



TYPE C -For Non-Dedicated Tray Only

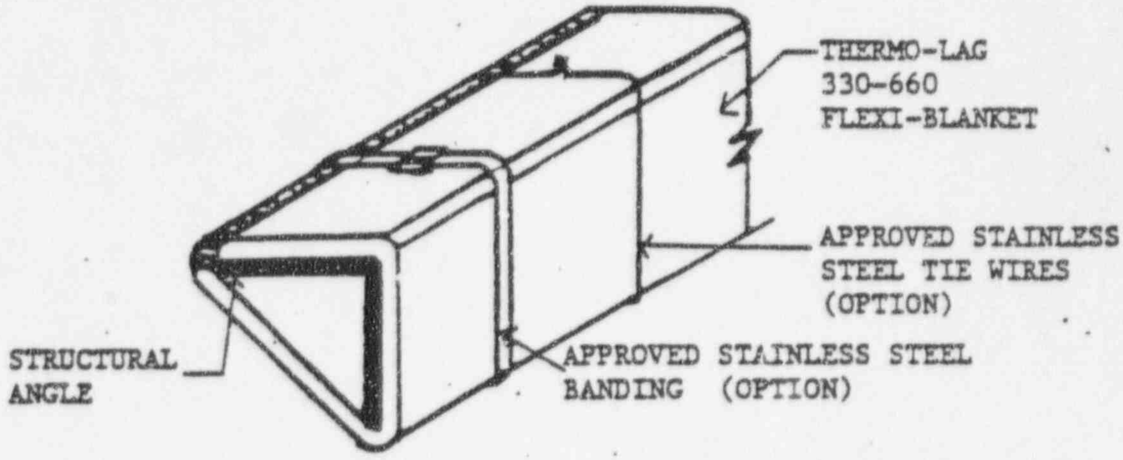


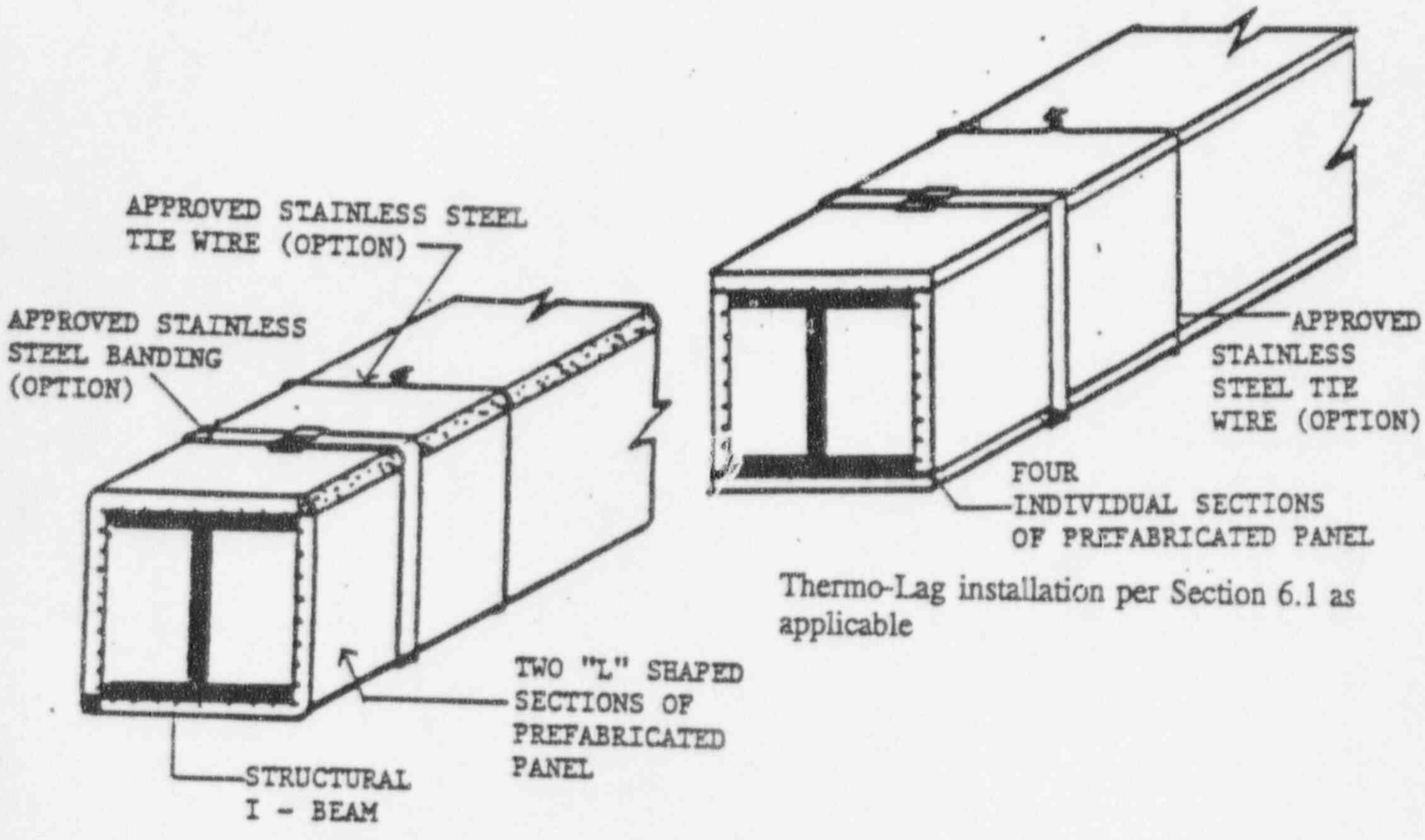

TYPE D -For Use For R.G.1.75 Barrier Only

TYPICAL CABLE TRAY THERMO-LAG 330-1 COVERING,
1 HOUR RATING APPLIED BY DIRECT SPRAY,
ROLLING OR TROWELING APPLICATION METHODS



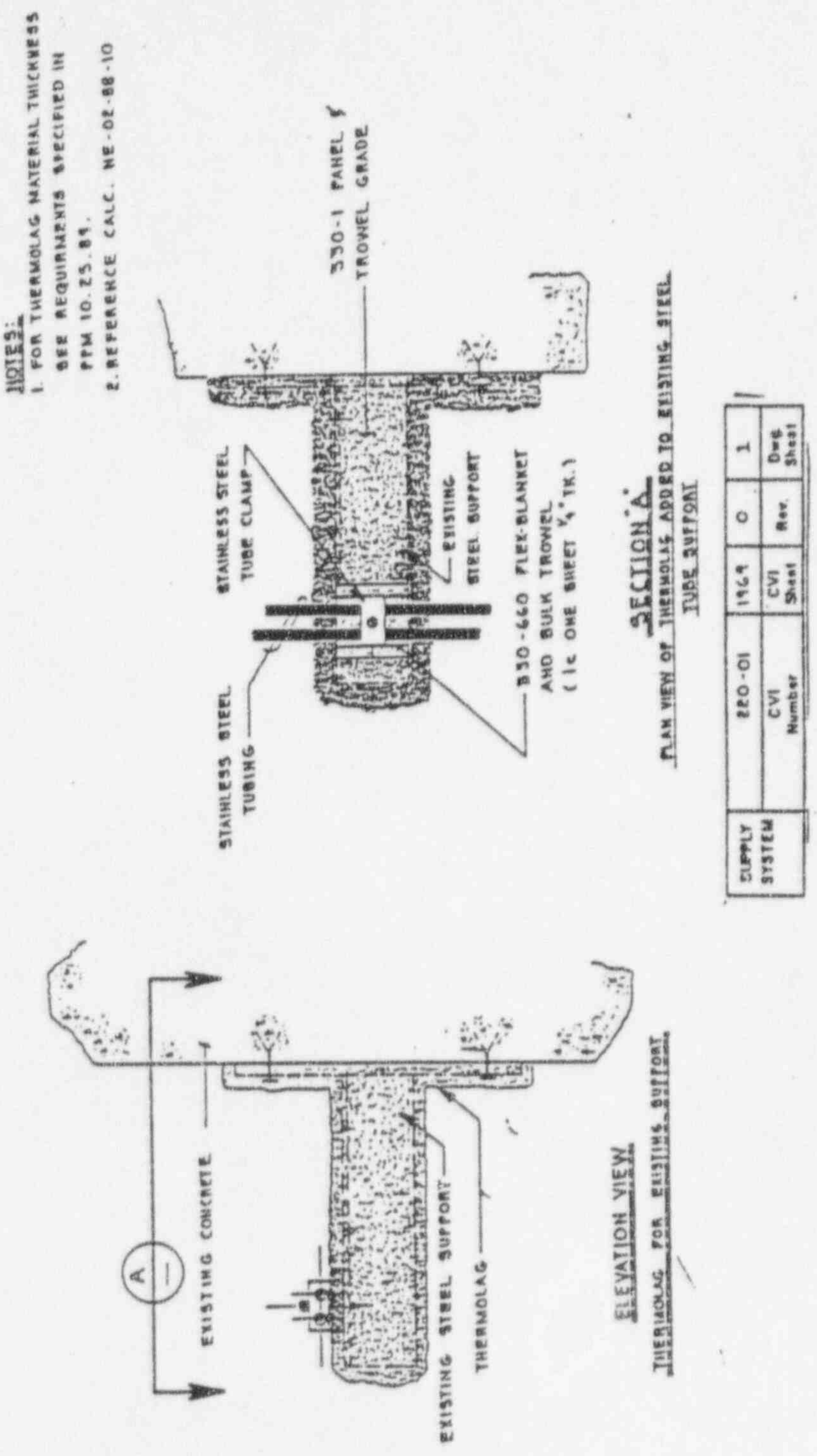
THERMO-LAG PREFABRICATED PANEL CONFIGURATIONS
FOR STRUCTURAL STEEL SHAPES
1-HOUR AND 3-HOUR APPLICATION



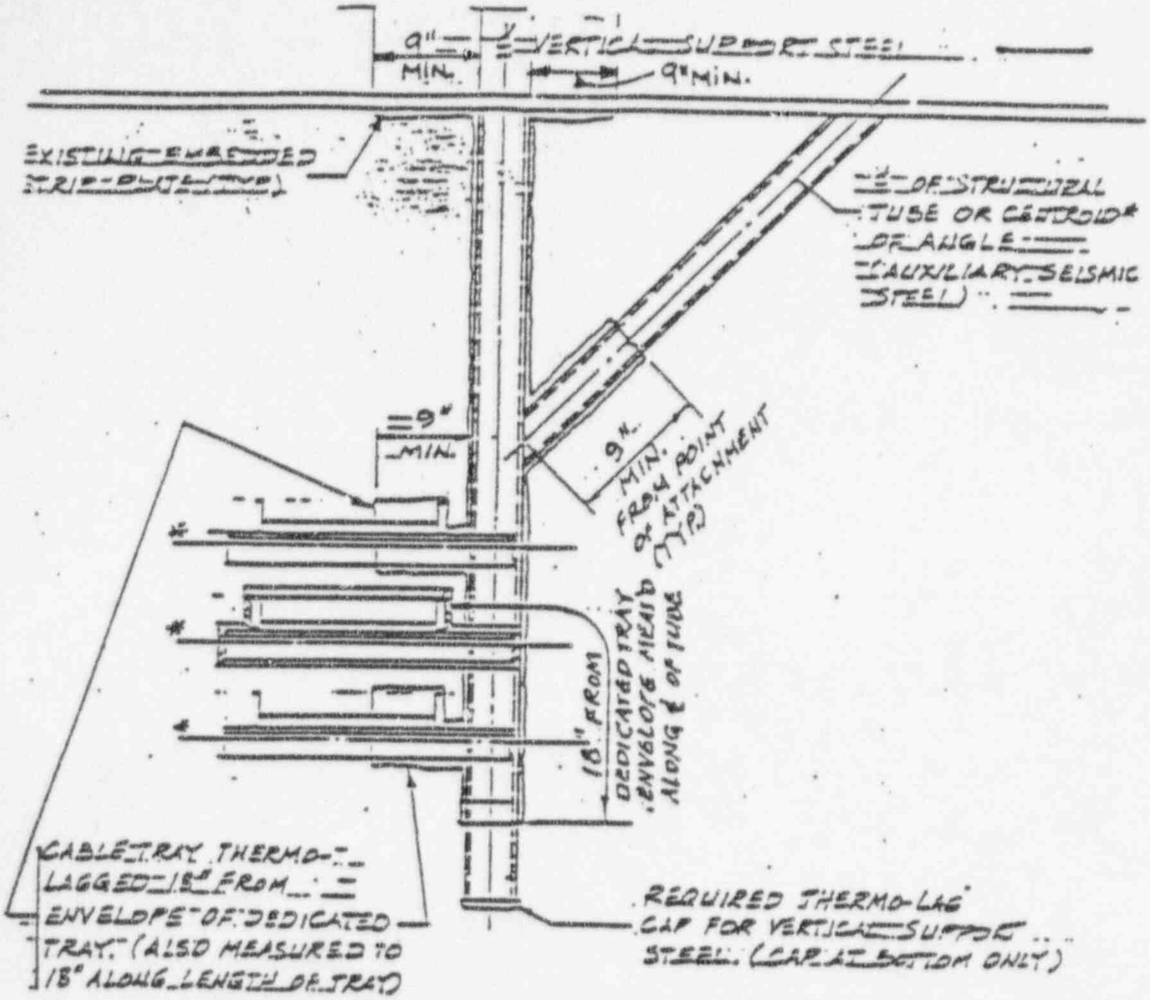




Thermo-Lag installation per Section 6.1 as applicable

TYPICAL THERMO-LAG INSTALLATION FOR INSTRUMENT TUBING, SUPPORTS ONLY



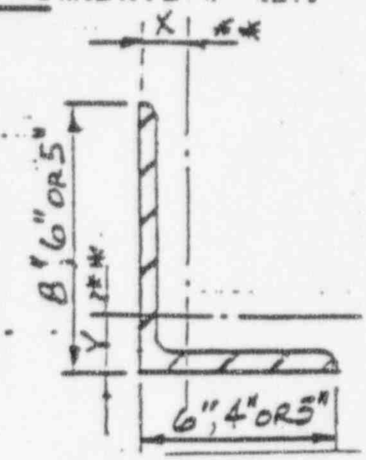

Attachment 9.2
Page 27 of 29

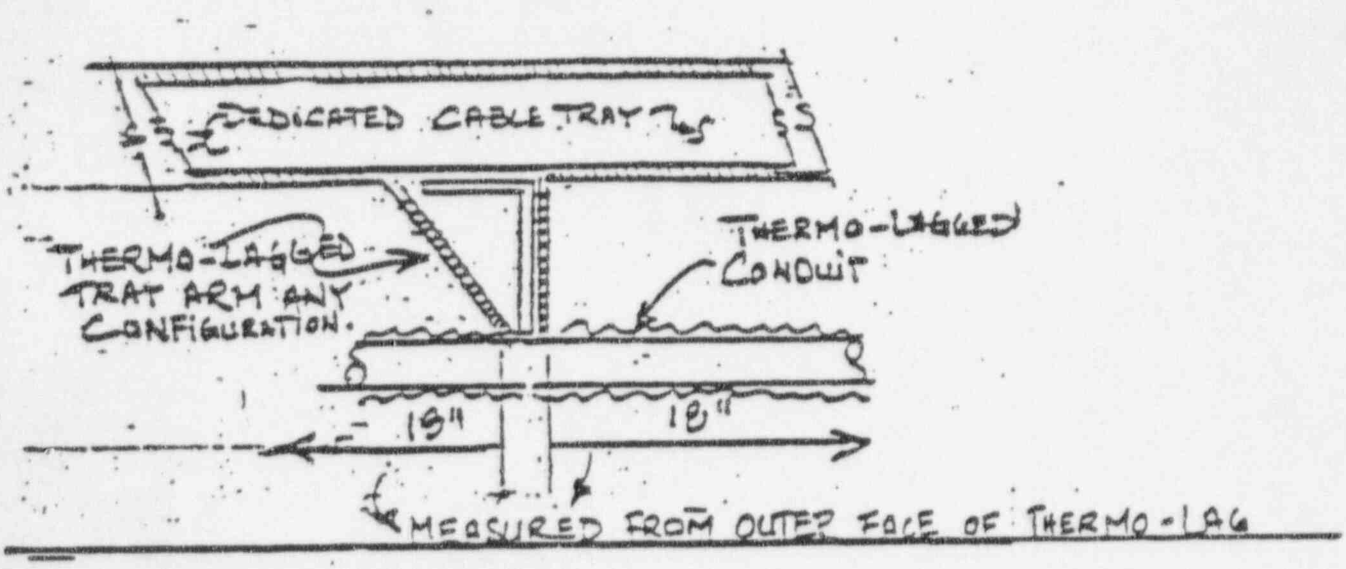



# CABLE TRAY AND SUPPORT STEEL

## THERMO-LAG PER CRITERIA

| ANGLE SIZE | * CENTROID DIMENSION | ANGLE SIZE | * CENTROID DIMENSION |
|---|---|---|---|
| 3 × 3 × 3/8 | 7/8" | 6 × 6 × 1 | 1 7/8" |
| 3½ × 3½ × 3/8 | 1" | 8 × 6 × ½ | Y=2½"; X=1½" ** |
| 3½ × 3½ × ½ | 1" | 8 × 6 × 1 | Y=2 5/8" X=1 [illegible] ** |
| 4 × 4 × 3/8 | 1 1/8" | 6 × 4 × 3/8 | Y=2" X=1" ** |
| 4 × 4 × ½ | 1 1/8" | 6 × 4 × ½ | Y=2" X=1" ** |
| 5 × 5 × 3/4 | 1 ½" | 6 × 4 × 1 | Y=2 1/8" X=1 1/8" ** |
| 5 × 5 × 1 | 1 5/8" | 5 × 3 × 3/8 | Y=1 3/4" X=3/4" ** |
| 6 × 6 × 3/4 | 1 3/4" | 5 × 3 × ½ | Y=1 3/4" X=3/4" ** |






LARIFICATION FOR MEASURING CONDUIT 18" REQUIREMENT. (TYP.)



| PROCEDURE NUMBER | REVISION | PAGE |
|---|---|---|
| 10.25.89 | 9 | 65 of 87 |

THERMO-LAG DRY THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL

1. SQUARE STRUCTURAL TUBING: DRY THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| 2 x 2 x 3/16 | 3/16 | 11/16 |
| x 1/4 | 3/16 | 5/8 |
| 3 x 3 x 3/16 | 3/16 | 5/8 |
| x 1/4 | 3/16 | 9/16 |
| 4 x 4 x 3/16 | 3/16 | 5/8 |
| x 1/4 | 3/16 | 9/16 |
| x 3/8 | 3/16 | 1/2 |
| 5 x 5 x 1/4 | 3/16 | 9/16 |
| x 5/16 | 1/8 | 1/2 |
| x 3/8 | 1/8 | 1/2 |
| 6 x 6 x 1/4 | 3/16 | 9/16 |
| x 5/16 | 1/8 | 1/2 |
| x 3/8 | 1/8 | 1/2 |
| 8 x 8 x 3/8 | 1/8 | 1/2 |
| x 1/2 | 1/8 | 9/16 |
| 10 x 10 x 1/2 | 1/8 | 7/16 |
| x 5/8 | 1/8 | 3/8 |

2. RECTANGULAR STRUCTURAL TUBING: DRY THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| 8 x 4 x 5/16 | 1/8 | 1/2 |
| x 3/8 | 1/8 | 1/2 |
| 6 x 4 x 3/8 | 1/8 | 1/2 |
| x 1/2 | 1/8 | 7/16 |

## THERMO-LAG DRY THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL (continued)

3. ANGLES: DRY THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| 3 x 3 x 1/4 | -- | 3/4 |
| 3 x 3 x 3/8 | 3/16 | 5/8 |
| 3½ x 3½ x 3/8 | 3/16 | 5/8 |
| x 1/2 | 3/16 | 9/16 |
| 3 x 3 x 3/8 | 3/16 | 5/8 |
| 4 x 4 x 3/8 | 3/16 | 5/8 |
| x 1/2 | 3/16 | 9/16 |
| 5 x 5 x 3/8 | 3/16 | 5/8 |
| 5 x 5 x 3/4 | 1/8 | 7/16 |
| x 1 | 1/8 | 3/8 |
| 6 x 6 x 3/4 | 3/16 | 7/16 |
| x 1 | 1/8 | 3/8 |
| 8 x 6 x 1/2 | 3/16 | 9/16 |
| x 1 | 1/8 | 3/8 |
| 6 x 4 x 3/8 | 3/16 | 5/8 |
| x 1/2 | 3/16 | 9/16 |
| x 1 | 1/8 | 3/8 |

4. CHANNELS: DRY THICKNESS (IN)

| | SIZE | 1-HOUR | 3-HOUR |
|---|---|---|---|
| MC | 3 x 7.1 | 3/16 | 11/16 |
| C | 3 x 4.1 | 1/4 | 7/16 |
| C | 4 x 5.4 | 1/4 | 7/8 |
| | x 7.25 | 3/16 | 11/16 |
| C | 6 x 8.2 | 1/4 | 13/16 |
| | x 10.5 | 13/16 | 11/16 |
| C | 8 x 11.5 | 1/4 | 13/16 |
| | 10 x 15.3 | 1/4 | 3/4 |

## THERMO-LAG DRY THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL (continued)

5. WIDE FLANGES: DRY THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| W 4 x 13 | 3/16 | 3/4 |
| W 5 x 16 | 3/16 | 11/16 |
| x 18.5 | 3/16 | 5/8 |
| W 6 x 8.5 | 1/4 | 15/16 |
| x 15.5 | 3/16 | 11/16 |
| W 8 x 10 | 1/4 | 7/8 |
| x 13 | 3/16 | 3/4 |
| x 15 | 3/16 | 9/16 |
| x 24 | 3/16 | 9/16 |
| x 28 | 3/16 | 1/2 |
| W 10 x 11.5 | 3/16 | 13/16 |
| x 15 | 3/16 | 11/16 |
| x 29 | 3/16 | 1/2 |

6. UNISTRUT SECTION: DRY THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| P 1000 | 5/16 | 1-1/8 |
| 1001 | 5/16 | 1-1/8 |
| 1001 C3 | 5/16 | 1-1/8 |
| 1004 A | 3/16 | 1-1/8 |
| P 3000 | 5/16 | 1-1/8 |
| 3001 | 5/16 | 1-1/8 |
| P 5000 | 5/16 | 1-1/8 |
| 5001 | 5/16 | 1-1/8 |

7. EMBEDDED PLATES: 3/8 IN. MINIMUM DRY FILM THICKNESS

## THERMO-LAG WET THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL

1. SQUARE STRUCTURAL TUBING: WET THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| 2 x 2 x 3/16 | 1/4 | 7/8 |
| x 1/4 | 1/4 | 13/16 |
| 3 x 3 x 3/16 | 1/4 | 13/16 |
| x 1/4 | 1/4 | 3/4 |
| 4 x 4 x 3/16 | 1/4 | 13/16 |
| x 1/4 | 1/4 | 3/4 |
| x 3/8 | 1/4 | 5/8 |
| 5 x 5 x 1/4 | 1/4 | 3/4 |
| x 5/16 | 3/16 | 5/8 |
| x 3/8 | 3/16 | 5/8 |
| 6 x 6 x 1/4 | 1/4 | 3/4 |
| x 5/16 | 3/16 | 5/8 |
| x 3/8 | 3/16 | 5/8 |
| 8 x 8 x 3/8 | 3/16 | 5/8 |
| x 1/2 | 3/16 | 9/16 |
| 10 x 10 x 1/2 | 3/16 | 9/16 |
| x 5/8 | 3/16 | 1/2 |

2. RECTANGULAR STRUCTURAL TUBING: WET THICKNESS (IN)

| SIZE | 1-HOUR | 3-HOUR |
|---|---|---|
| 8 x 4 x 5/16 | 3/16 | 5/8 |
| x 3/8 | 3/16 | 5/8 |
| 6 x 4 x 3/8 | 3/16 | 5/8 |
| x 1/2 | 3/16 | 9/16 |

## THERMO-LAG WET THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL (continued)

3. ANGLES:

| SIZE | WET THICKNESS (IN) 1-HOUR | 3-HOUR |
|---|---|---|
| 3 x 3 x 1/4 | --- | 1 |
| 3 x 3 x 3/8 | 1/4 | 13/16 |
| 3½ x 3½ x 3/8 | 1/4 | 13/16 |
| x 1/2 | 1/4 | 3/4 |
| 4 x 3 x 3/8 | 1/4 | 13/16 |
| 4 x 4 x 3/8 | 1/4 | 13/16 |
| x 1/2 | 1/4 | 3/4 |
| 5 x 3 x 3/8 | 1/4 | 13/16 |
| 5 x 5 x 3/8 | 1/4 | 13/16 |
| 5 x 5 x 3/4 | 3/16 | 9/16 |
| x 1 | 3/16 | 1/2 |
| 6 x 6 x 3/4 | 1/4 | 9/16 |
| x 1 | 3/16 | 1/2 |
| 8 x 6 x 1/2 | 1/4 | 3/4 |
| x 1 | 3/16 | 1/2 |
| 6 x 4 x 3/8 | 1/4 | 13/16 |
| x 1/2 | 1/4 | 3/4 |
| x 1 | 3/16 | 1/28 |

4. CHANNELS:

| SIZE | | WET THICKNESS (IN) 1-HOUR | 3-HOUR |
|---|---|---|---|
| MC | 3 x 7.1 | 1/4 | 7/8 |
| C | 3 x 4.1 | 5/16 | 1⅛ |
| C | 4 x 5.4 | 5/16 | 1⅛ |
| | x 7.25 | 1/4 | 7/8 |
| C | 6 x 8.2 | 5/16 | 1-1/16 |
| | x 10.5 | 1/4 | 7/8 |
| C | 8 x 11.5 | 5/16 | 1-1/16 |
| | 10 x 15.3 | 5/16 | 15/16 |

## THERMO-LAG WET THICKNESS REQUIREMENTS FOR STRUCTURAL STEEL (continued)

5. WIDE FLANGES: WET THICKNESS (IN)

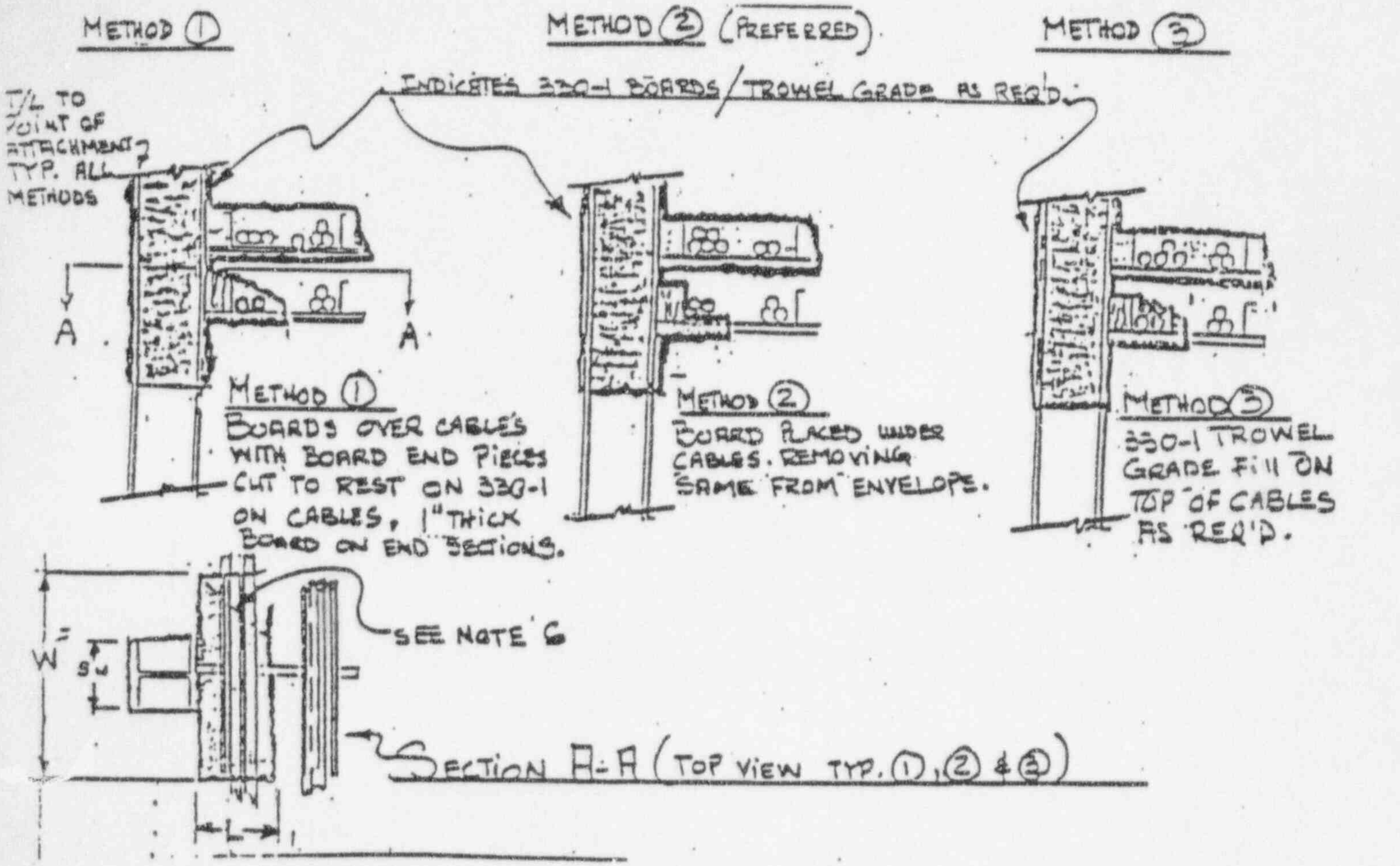
| SIZE | | 1-HOUR | 3-HOUR |
|---|---|---|---|
| W | 4 x 13 | 1/4 | 15/16 |
| W | 5 x 16 | 1/4 | 7/8 |
| | x 18.5 | 1/4 | 13/16 |
| W | 6 x 8.5 | 5/16 | 1-3/16 |
| | x 15.5 | 1/4 | 7/8 |
| W | 8 x 10 | 5/16 | 1-1/8 |
| | x 13 | 1/4 | 15/16 |
| | x 15 | 1/4 | 7/8 |
| | x 24 | 1/4 | 3/4 |
| | x 28 | 1/4 | 5/8 |
| W | 10 x 11.5 | 1/4 | 1-1/16 |
| | x 15 | 1/4 | 7/8 |
| | x 29 | 1/4 | 5/8 |

6. UNISTRUT SECTION: WET THICKNESS (IN)

| SIZE | | 1-HOUR | 3-HOUR |
|---|---|---|---|
| P | 1000 | 7/16 | 1-9/16 |
| | 1001 | 7/16 | 1-9/16 |
| | 1001 C3 | 7/16 | 1-9/16 |
| | 1004 A | 7/16 | 1-9/16 |
| P | 3000 | 7/16 | 1-9/16 |
| | 3001 | 7/16 | 1-9/16 |
| P | 5000 | 7/16 | 1-9/8 |
| | 5001 | 7/16 | 1-9/8 |

7. Refer to dry film thickness for embedded plates.

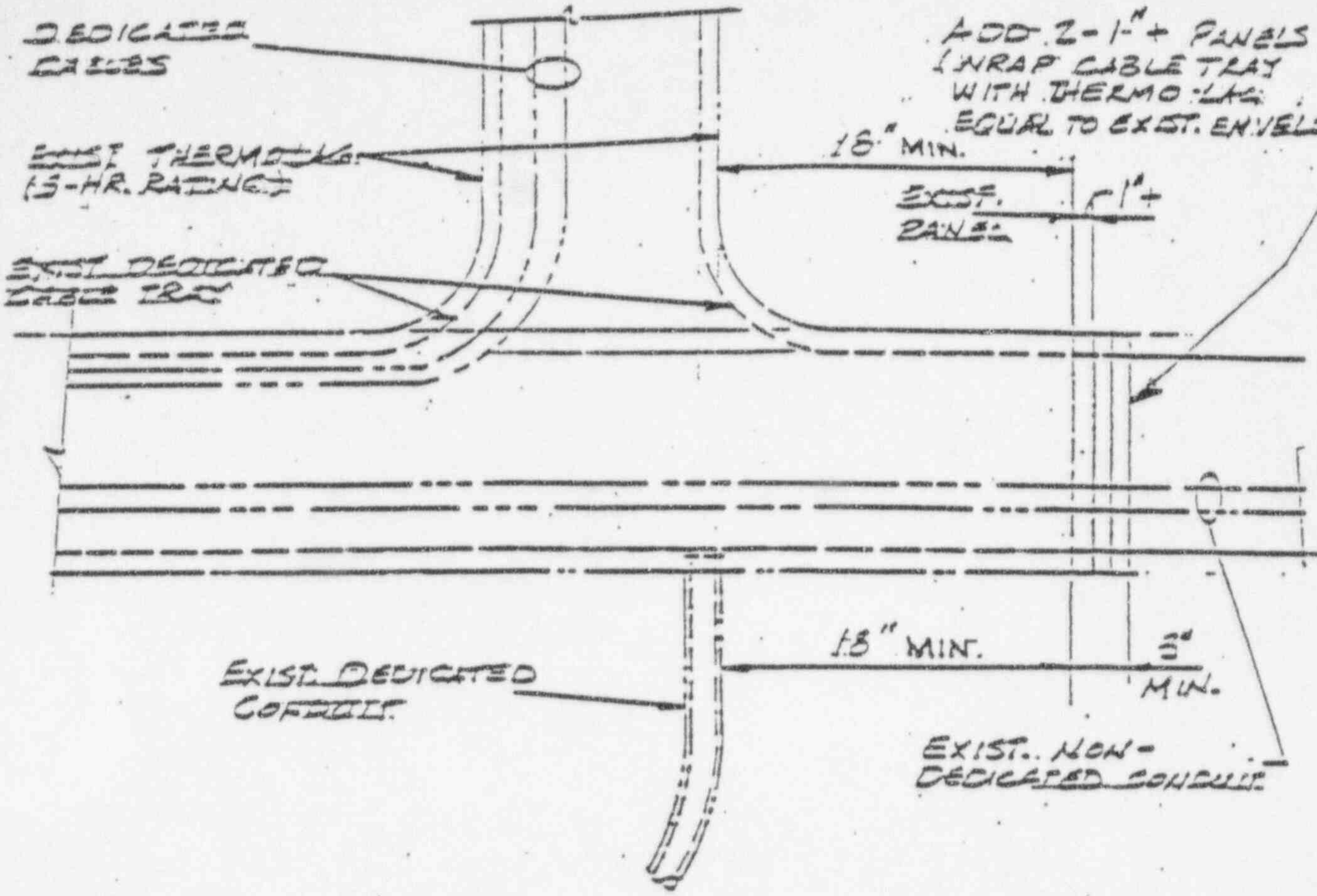
Attachment 9.3
Page 6 of 6



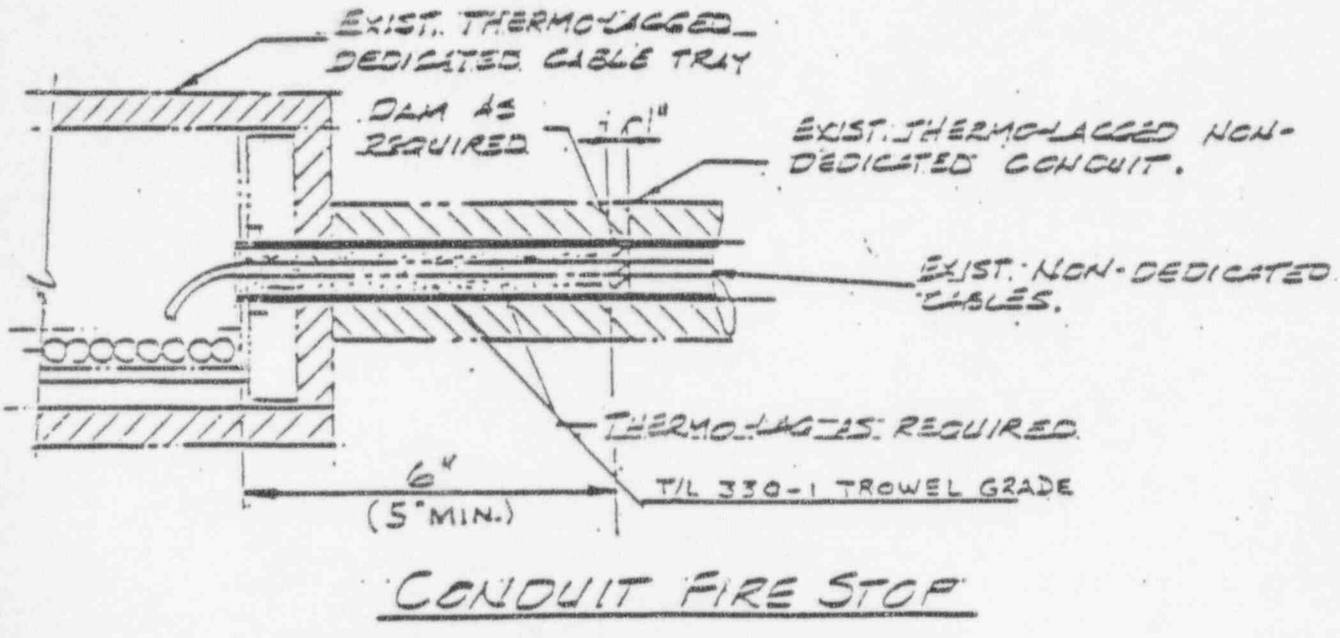

NOTES:

1-TOP TRAY DEDICATED.
2-LOWER TRAY FALLS INTO 18" RULE PROTECTED AREA.
3-ASSURE 18" COVERAGE AS REQ'D. EITHER SIDE OF SUPPORT. W=2L+SW.
4-TIE WIRES 18 GA SS MIN OR .020X½ SS BANDING PER TSI 20684.
5-TIE WIRES OR BANDS MAY GO IN AND OUT OF ENVELOPE WITHOUT CONCERN.
6-O.K. TO TAPER WIDTH FROM SUPPORT TO MIDTRAY AS LONG AS 18" IS MAINTAINED.
7-W=WIDTH
L=LENGTH
SW=SUPPORT WIDTH

Fire Barrier Termination inside of Non-Dedicated Tray in lieu of total tray coverage 18" Rule. (All three (3) methods shown above are acceptable, Method #② is preferre

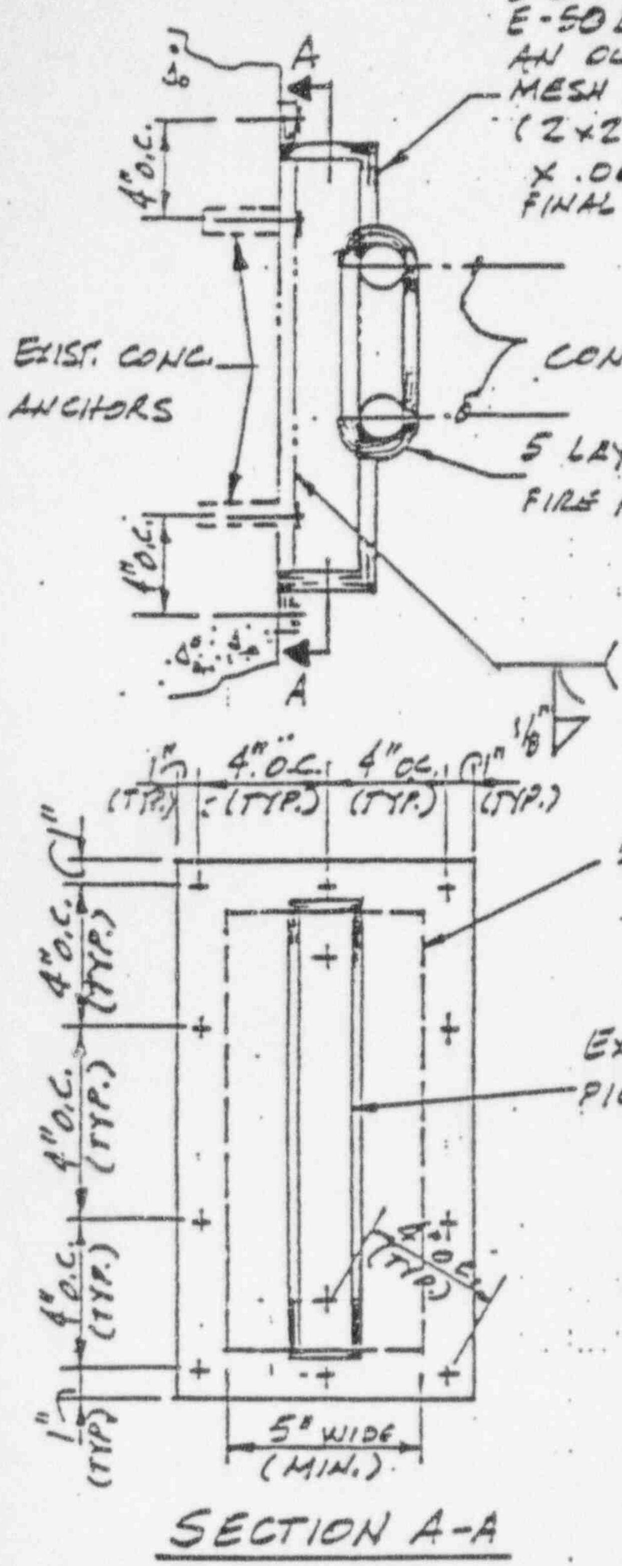



DEDICATED CABLE TRAY FIRE STOP
(MIN. 3" COVER)




CONDUIT FIRE STOP

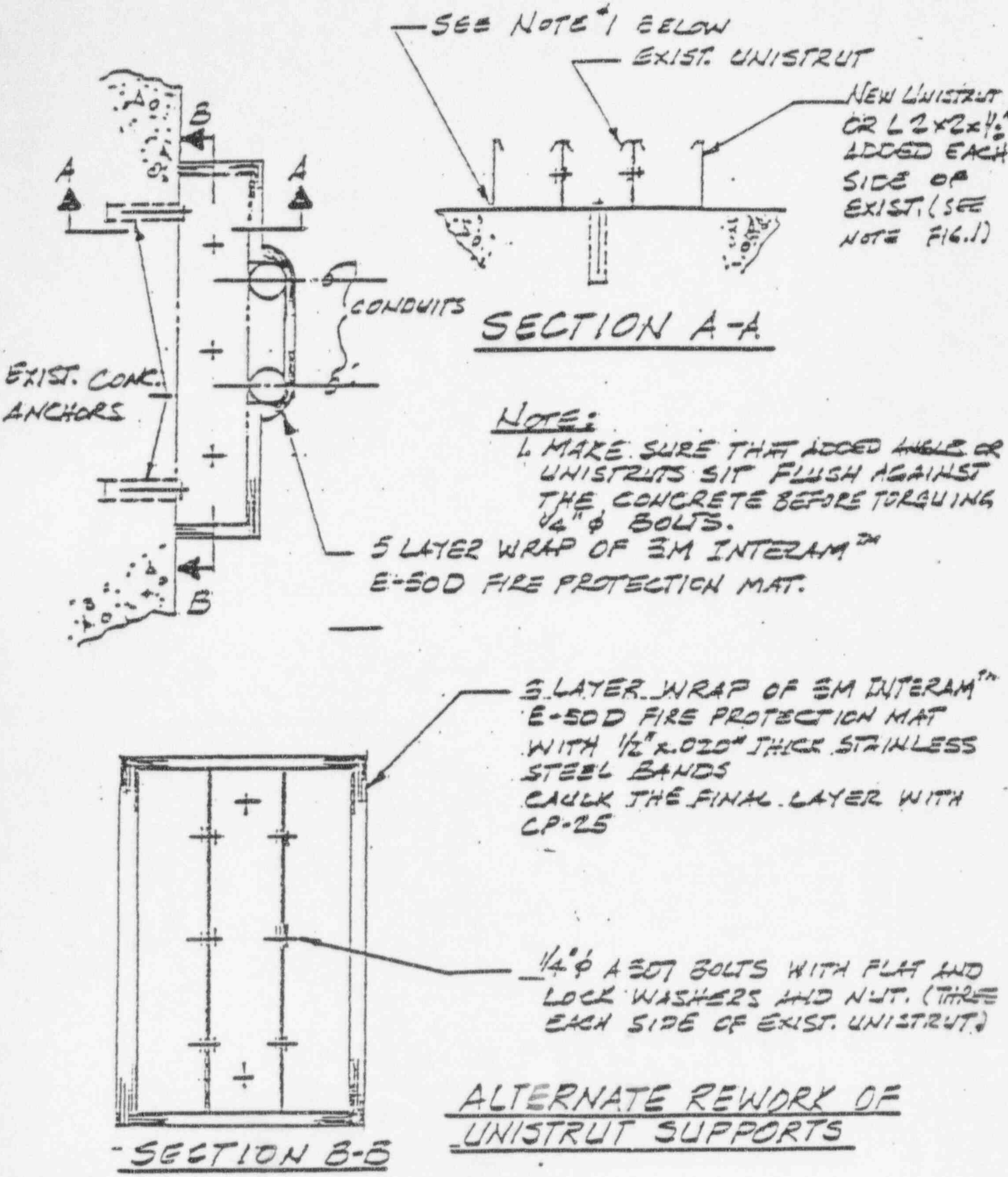
Attachment 9.4
Page 2 of 2



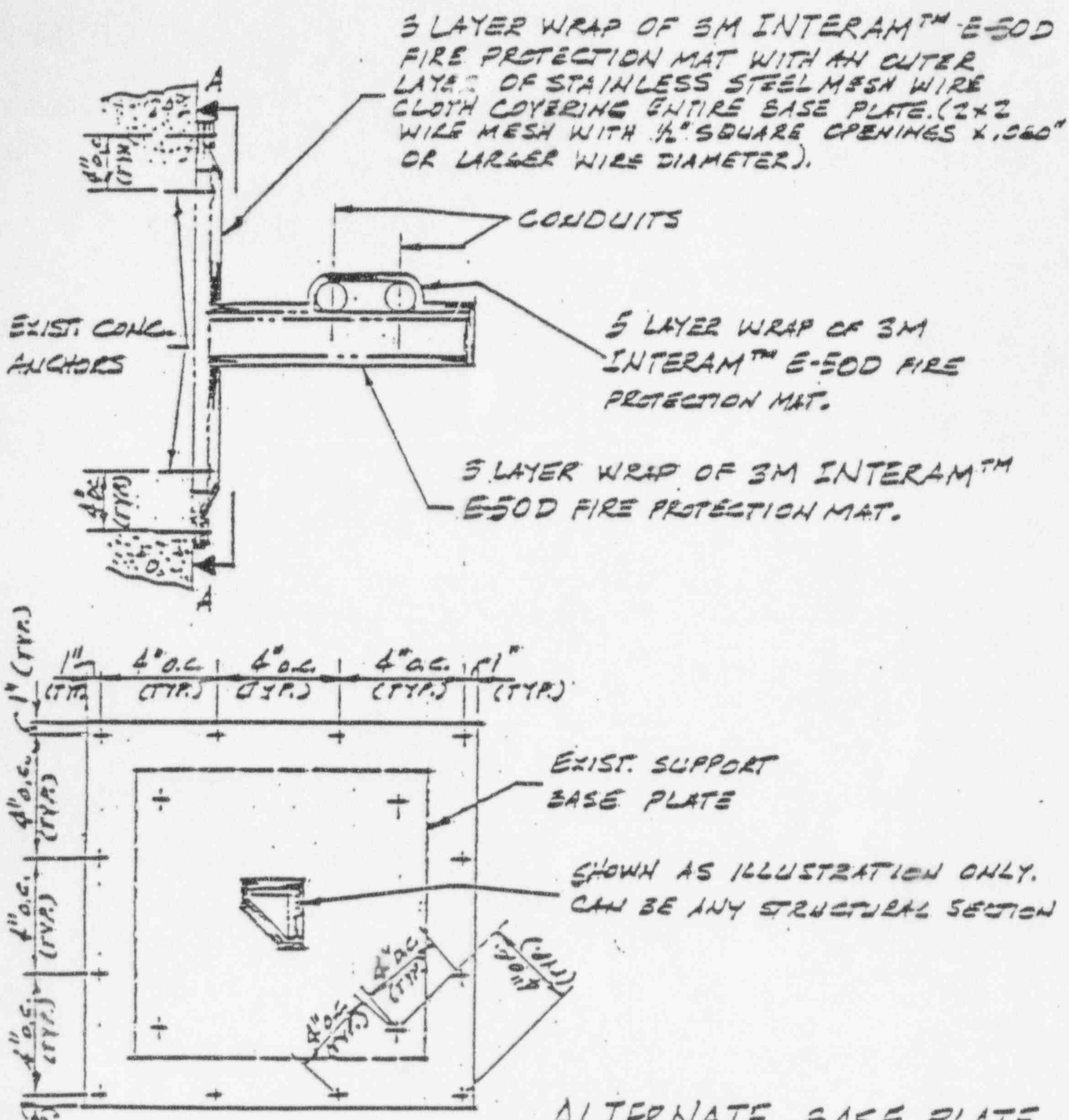

NOTE:
AS AN ALTERNATE REWORK FOR OVERLOADED TYPE SY SUPPORTS, AN ADDED SUPPORT BETWEEN THE OVERLOADED SUPPORTS SHALL BE INSTALLED AT THE MIDSPAN OF THE CONDUIT CONCERNED.

ALTERNATE REWORK OF UNISTRUT SUPPORTS

Attachment 9.5
Page 1 of 14



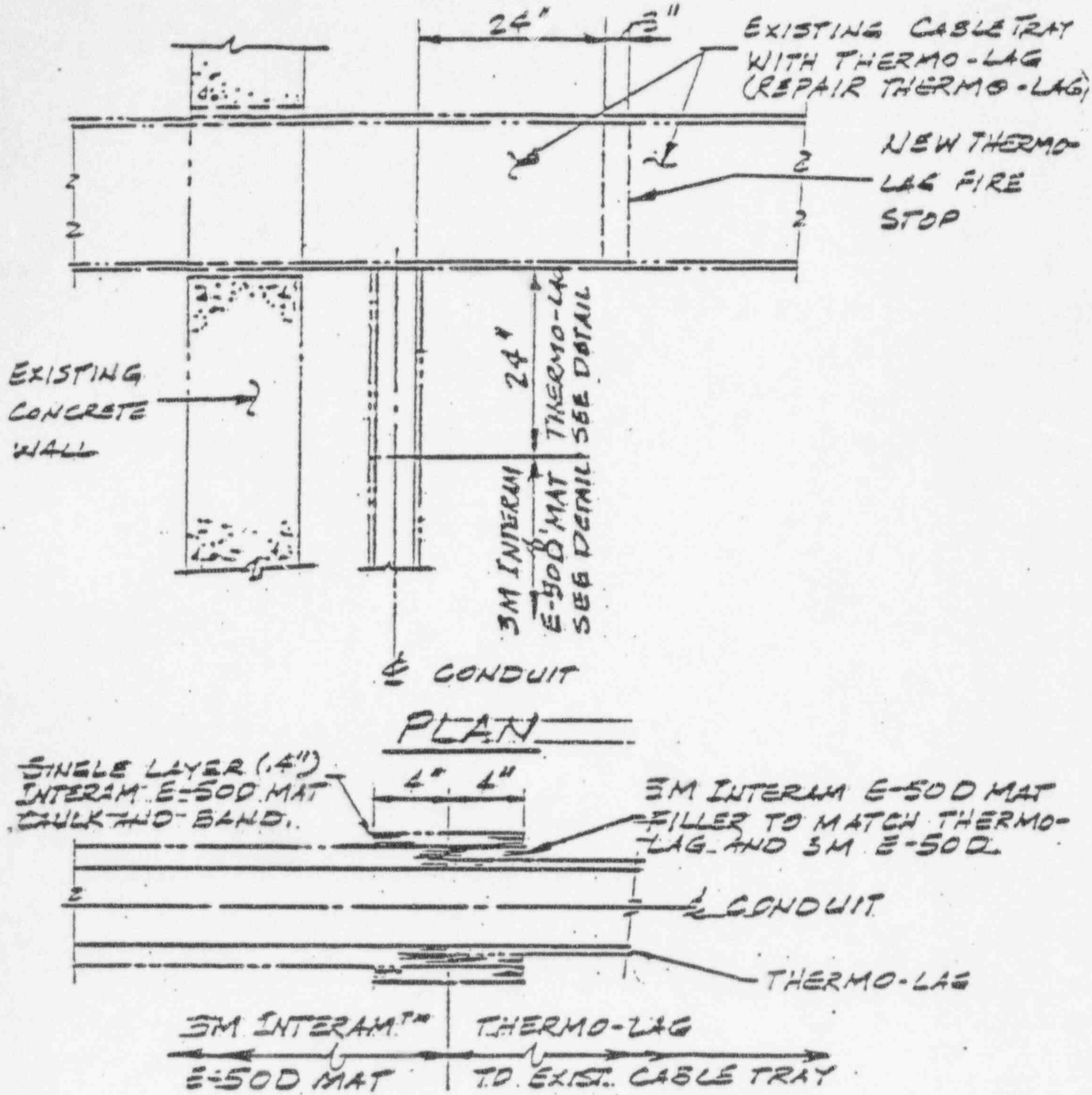

Attachment 9.5
Page 2 of 14



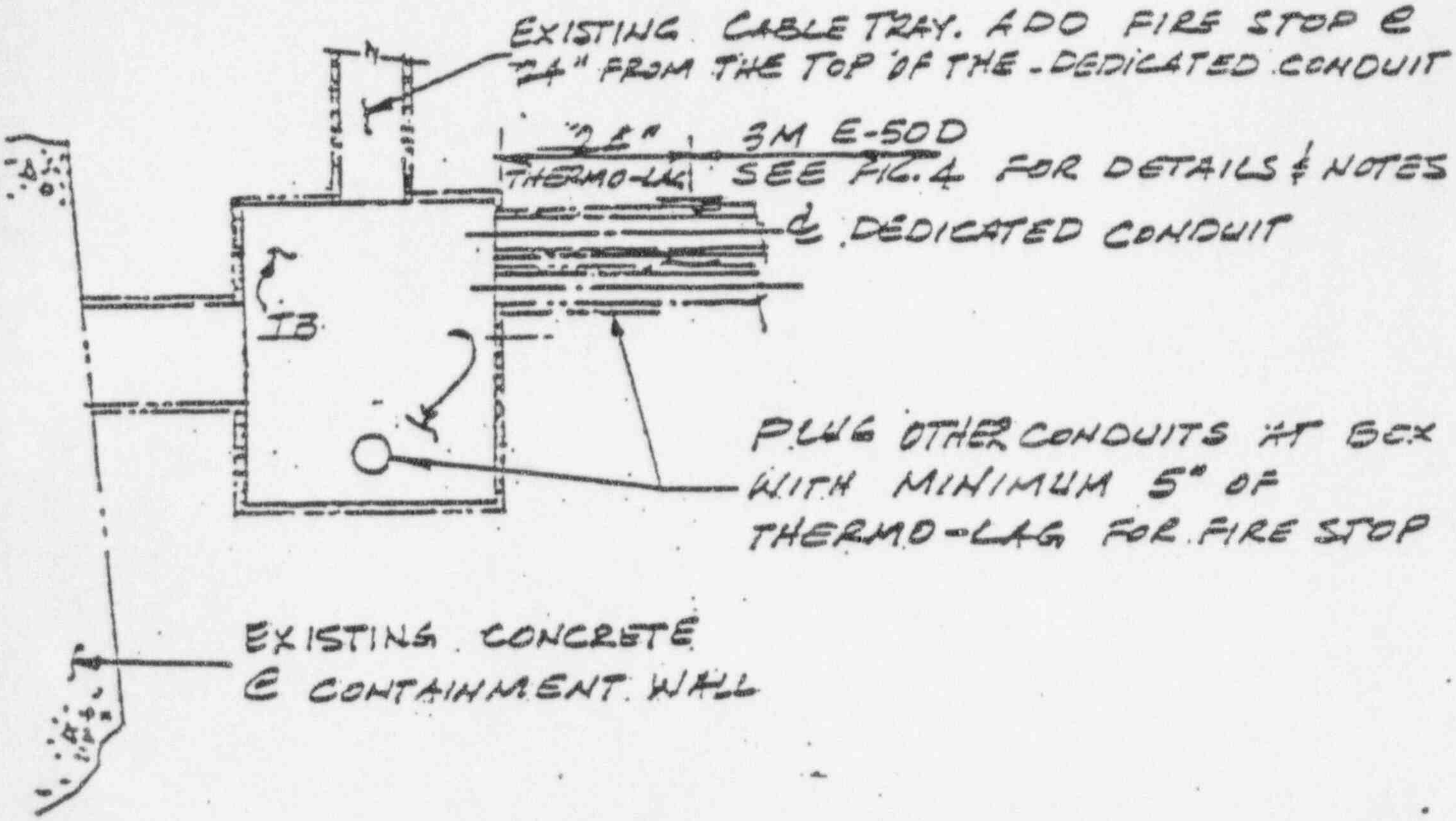

ALTERNATE BASE PLATE DETAIL

SECTION A-A

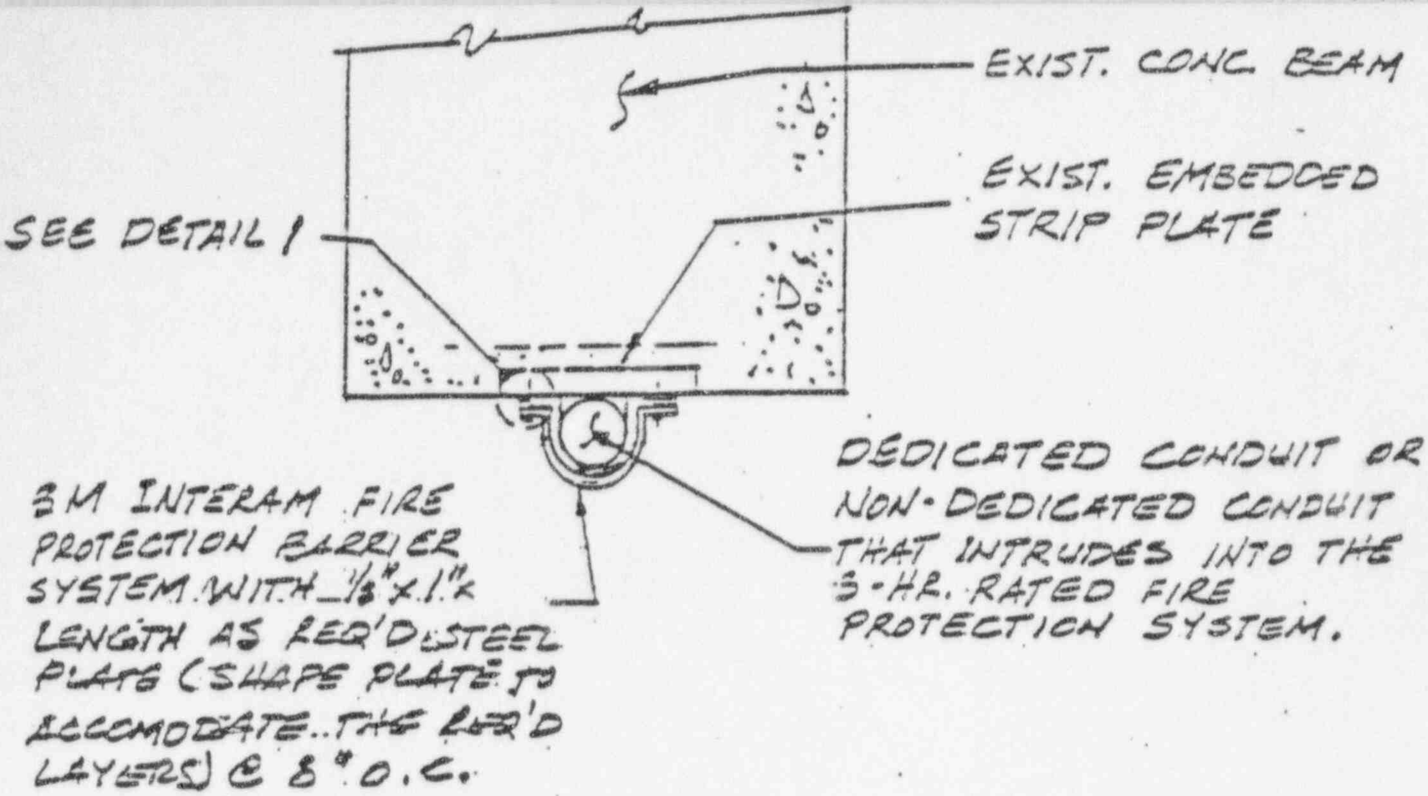
Attachment 9.5
Page 3 of 14



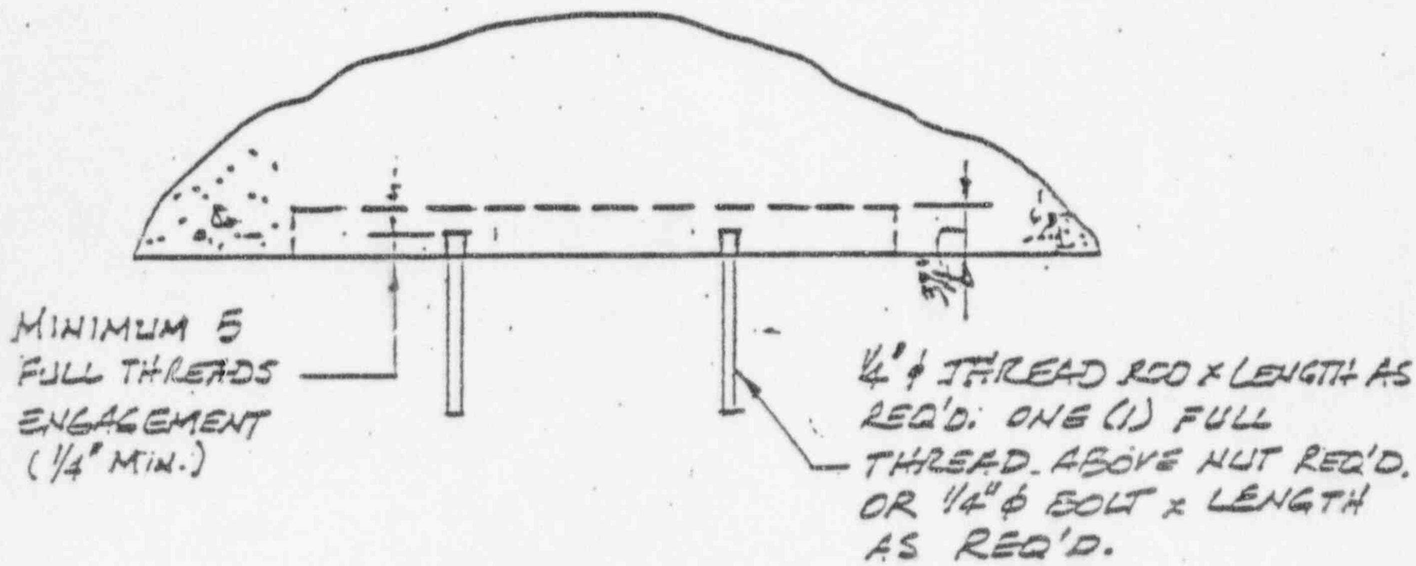

DETAIL FOR CABLE TRAY AND DEDICATED CONDUIT FOR 3-HOUR FIRE RATING (ALTERNATE) (MAY REQUIRE MODIFICATION BASED UPON FIRE TEST RESULTS)




DETAIL FOR JUNCTION BOX AND DEDICATED CONDUIT FOR 3-HOUR FIRE RATING



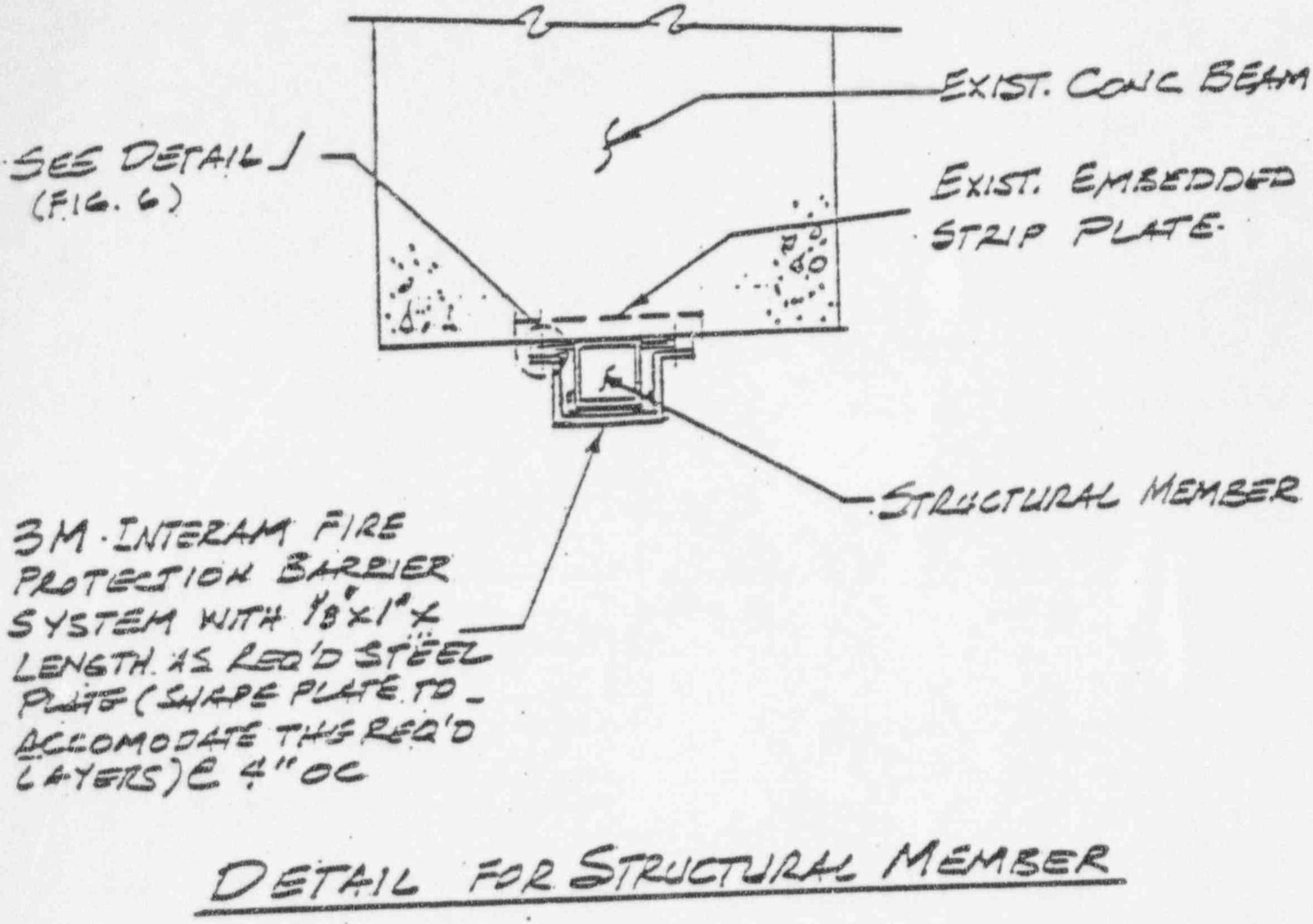

DETAIL FOR CONDUITS



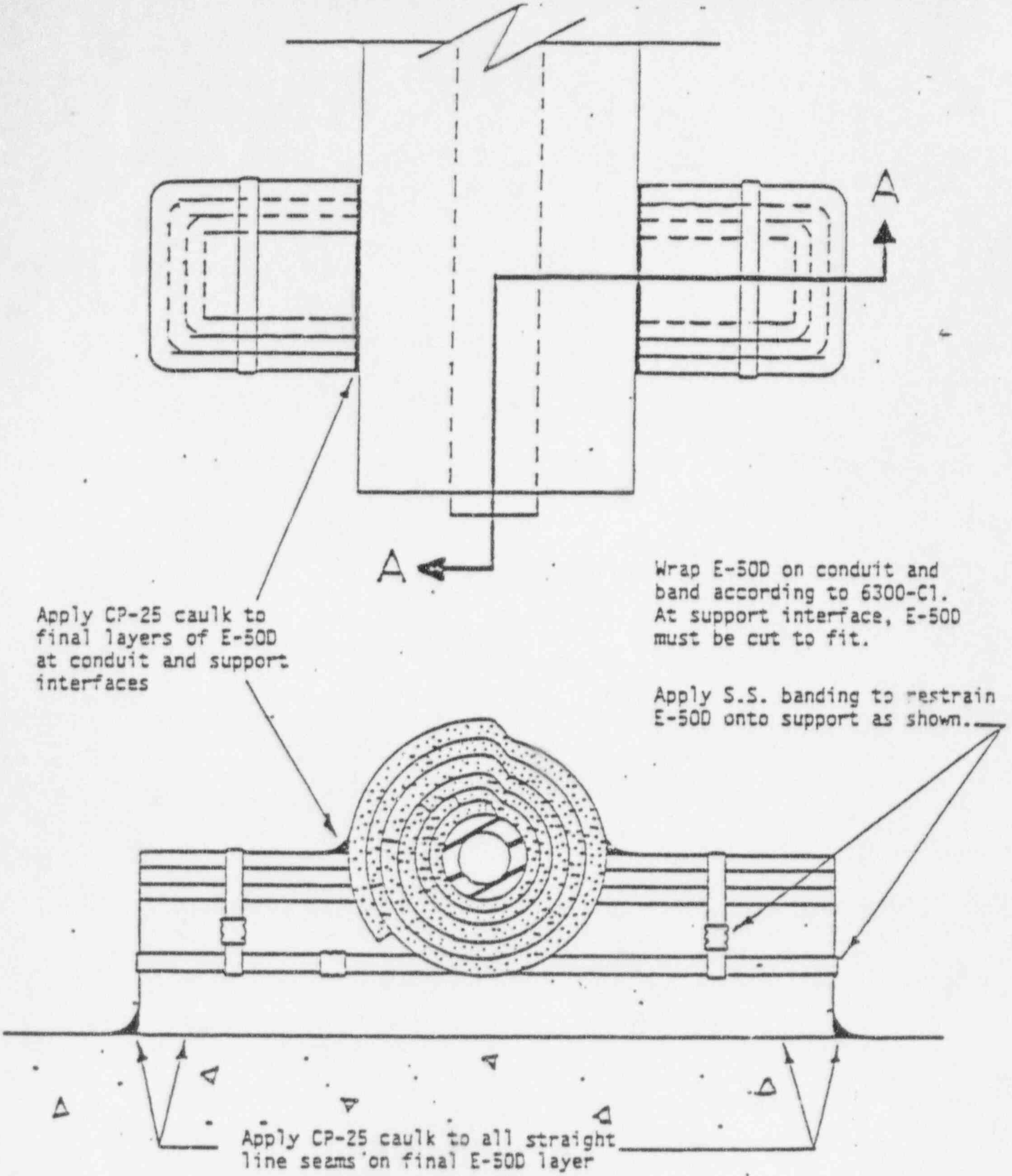

DETAIL 1

Detail for Dedicated and Non-Dedicated Conduits Intruding into the 3-Hour Fire Protection System.

Attachment 9.5
Page 6 of 14

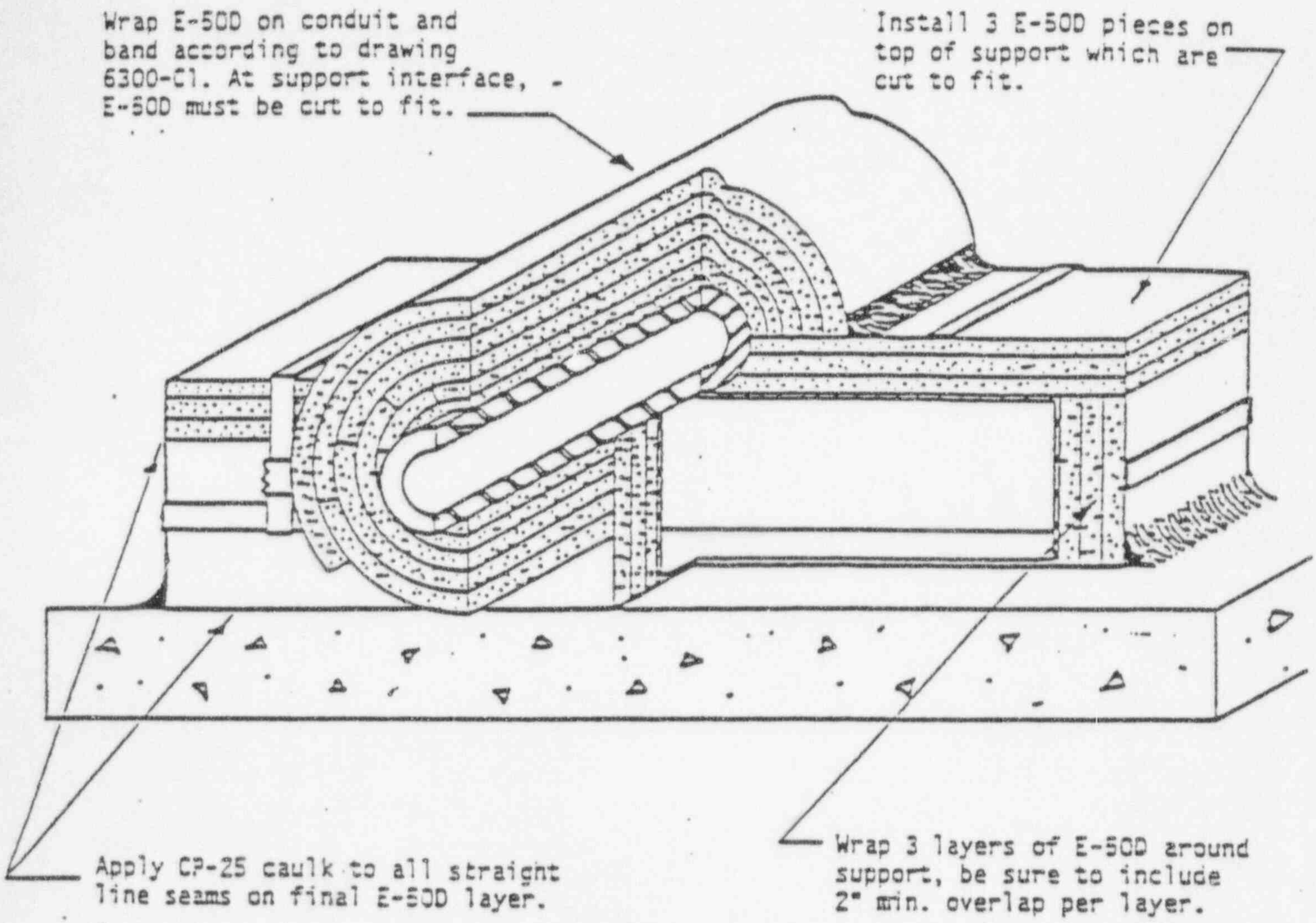



Detail for Structural Member Intruding into the
3-Hour Fire Protection System




Alternate Detail of 3-Hour Fire Protection System of Unistrut Conduit Support Attached to Concrete

Attachment 9.5
Page 8 of 14



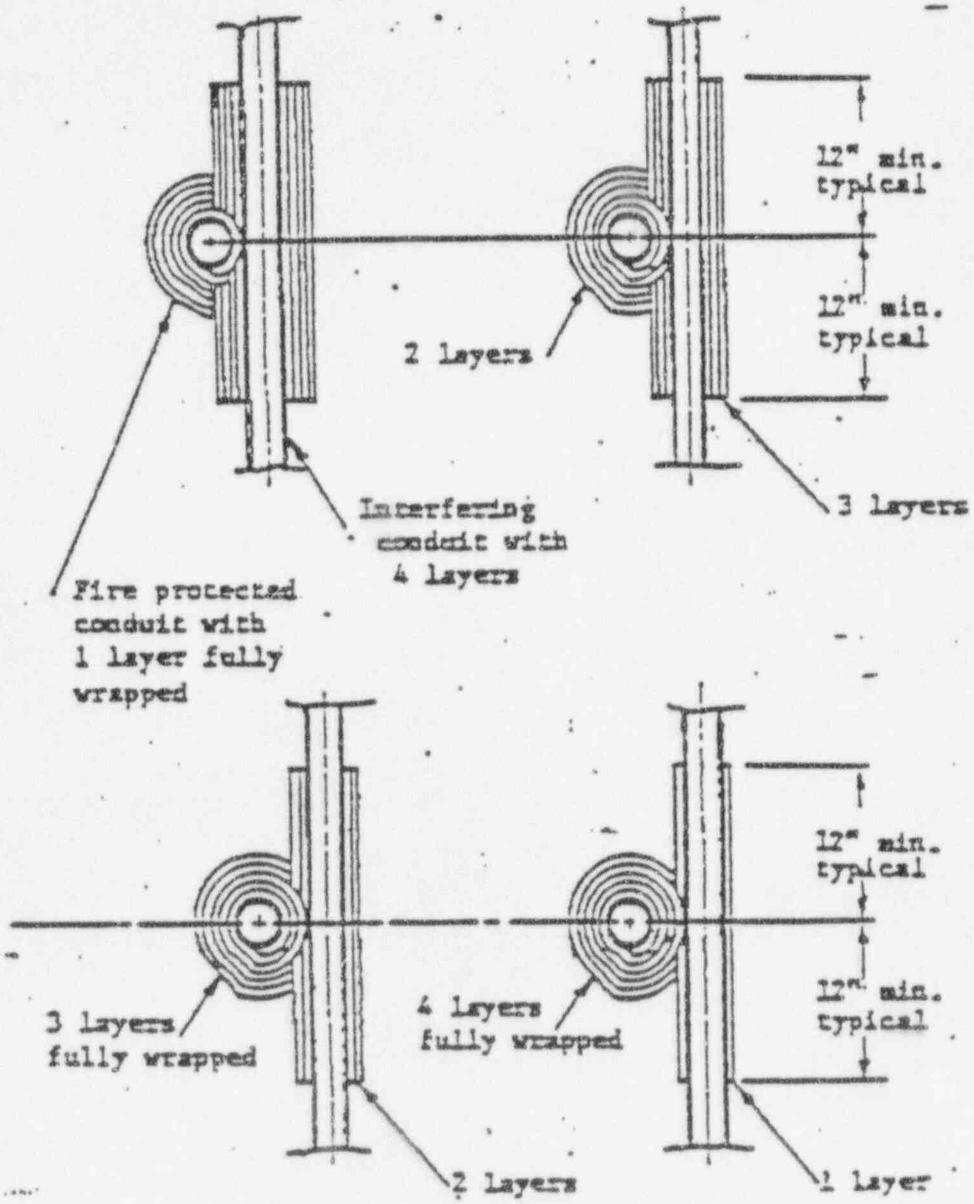

Internal Detail of 3-Hour Fire Protection System of Unistrut Conduit Support Attached to Concrete

Attachment 9.5
Page 9 of 14

For interfering heat transfer items not in contact with a fire protected item, refer to the following:

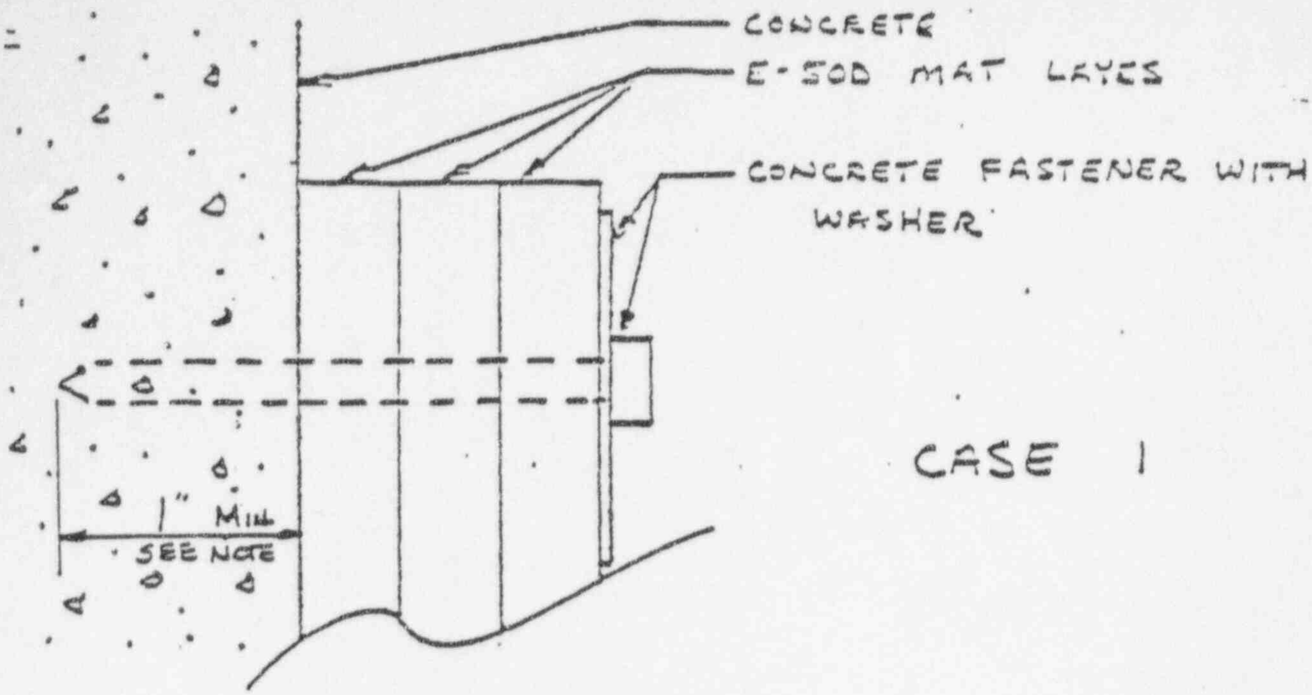
For every layer which can be placed between an interfering heat transfer item and the fire protected item, a layer may be removed from the total number of layers required to wrap the heat transfer item.

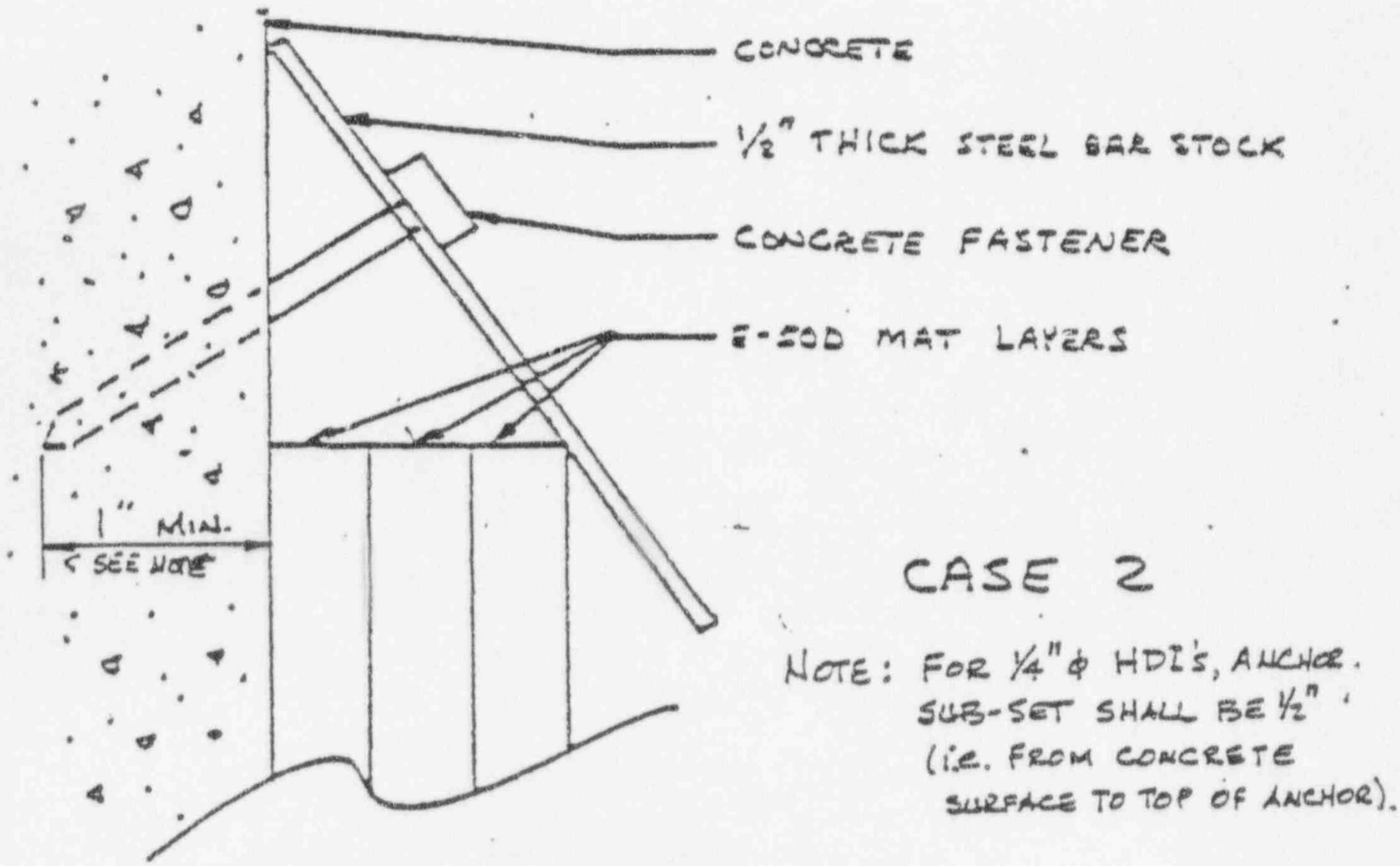
Examples of a fire protected conduit and an interfering conduit in cross-section:



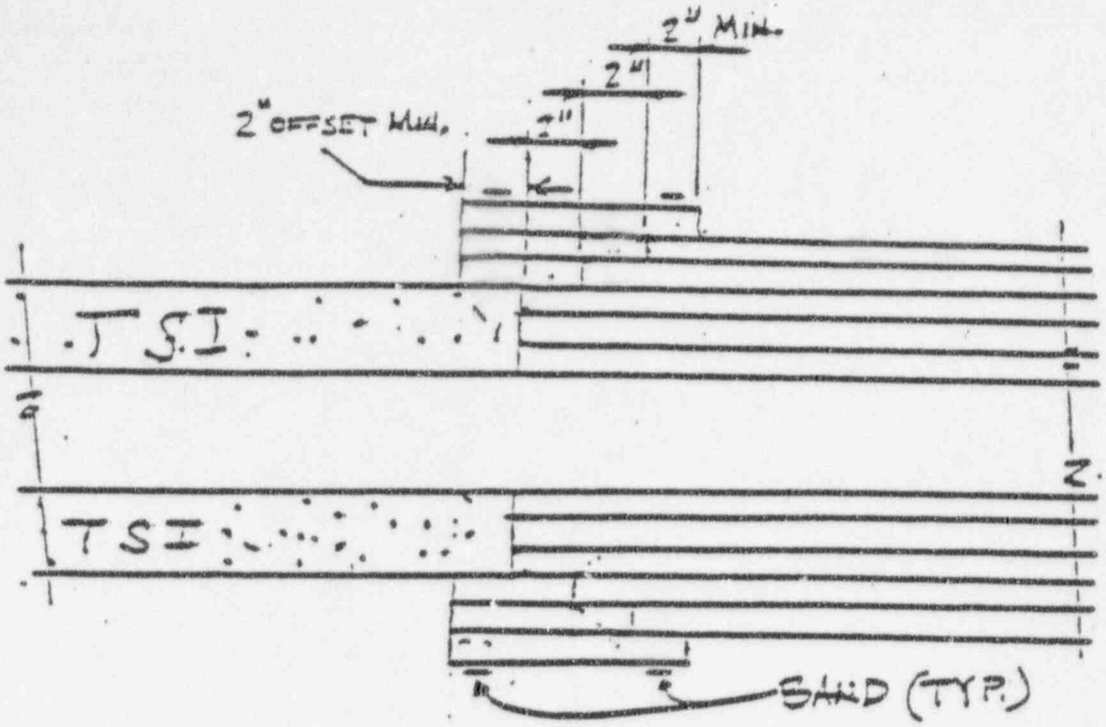

Detail of Required Layers of 3M Mat Material for Intruding Elements Intruding in the 3-Hour Fire Protection System

Attachment 9.5
Page 10 of 14

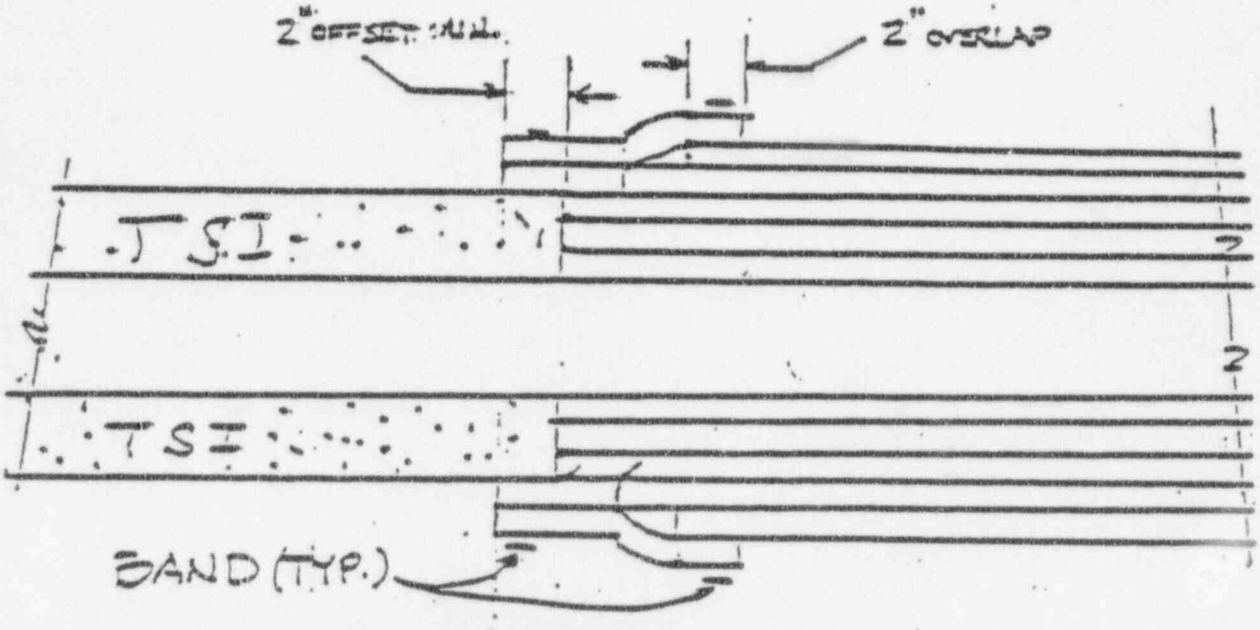



Alternate Methods of Securing 3M Mat Material
for 3-Hour Fire Rating

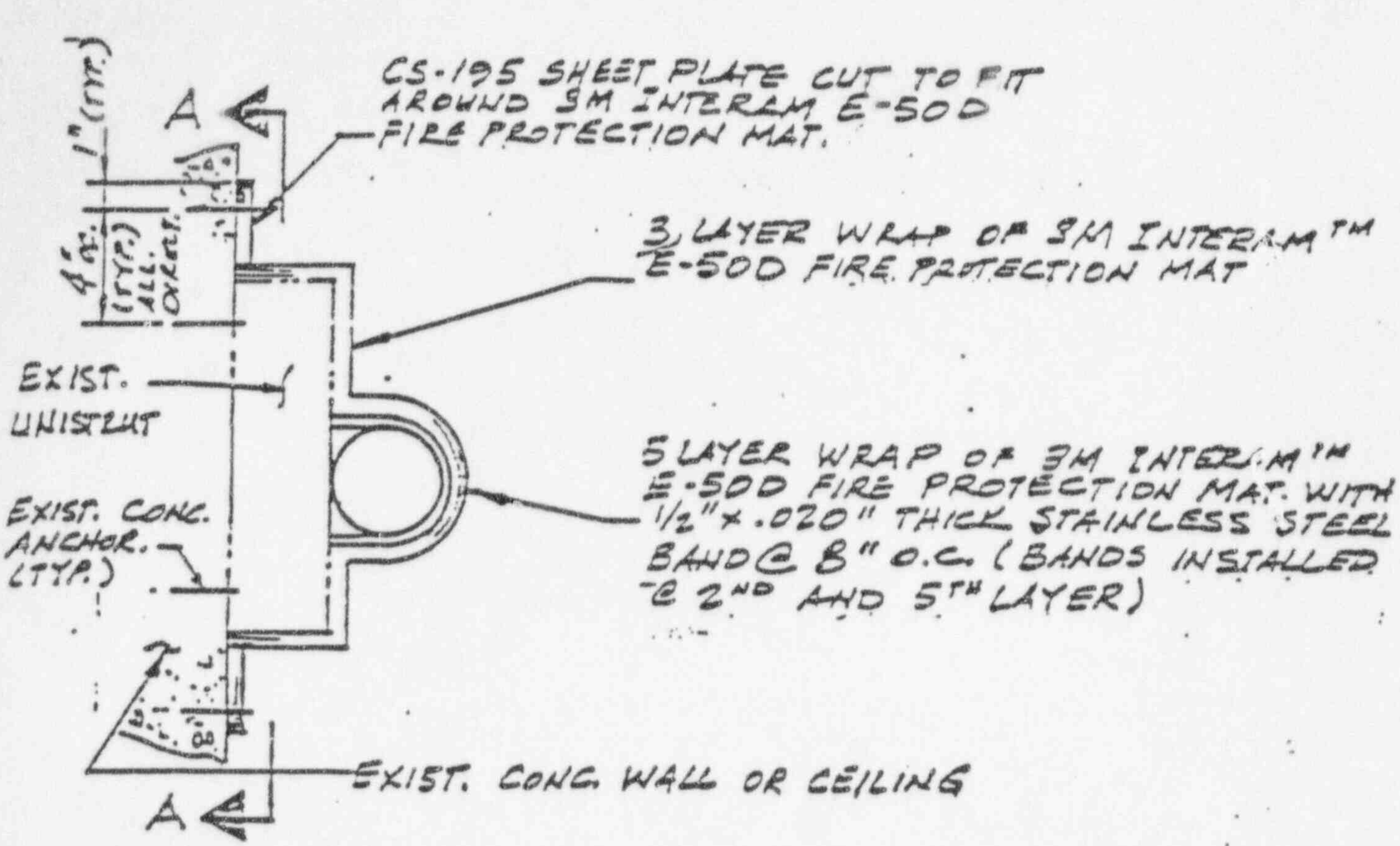



CASE 1

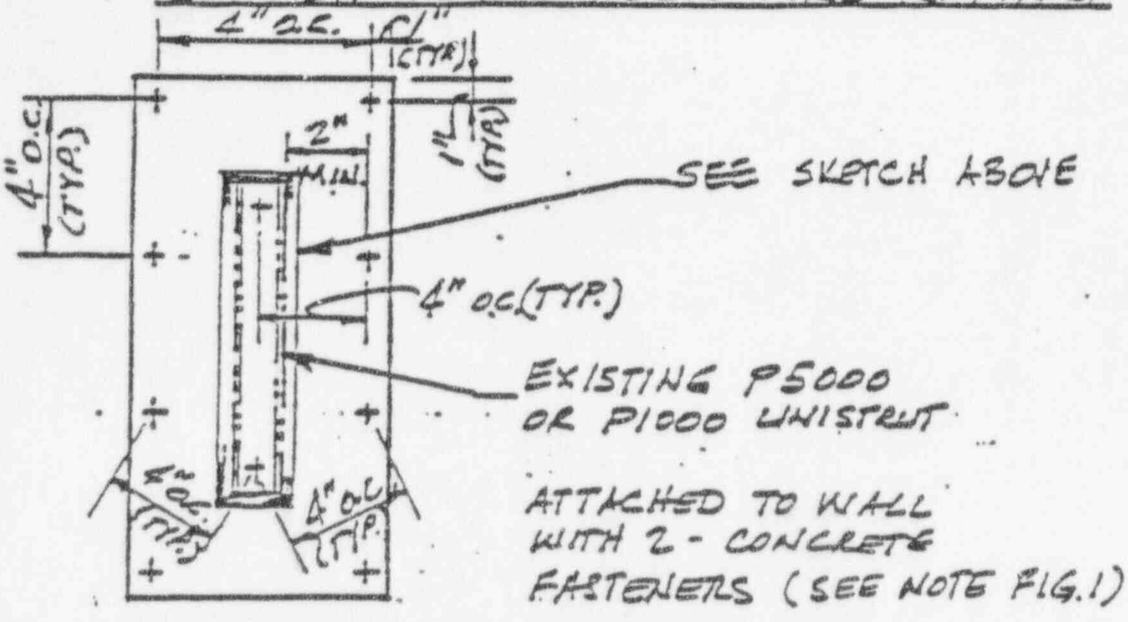



CASE 2

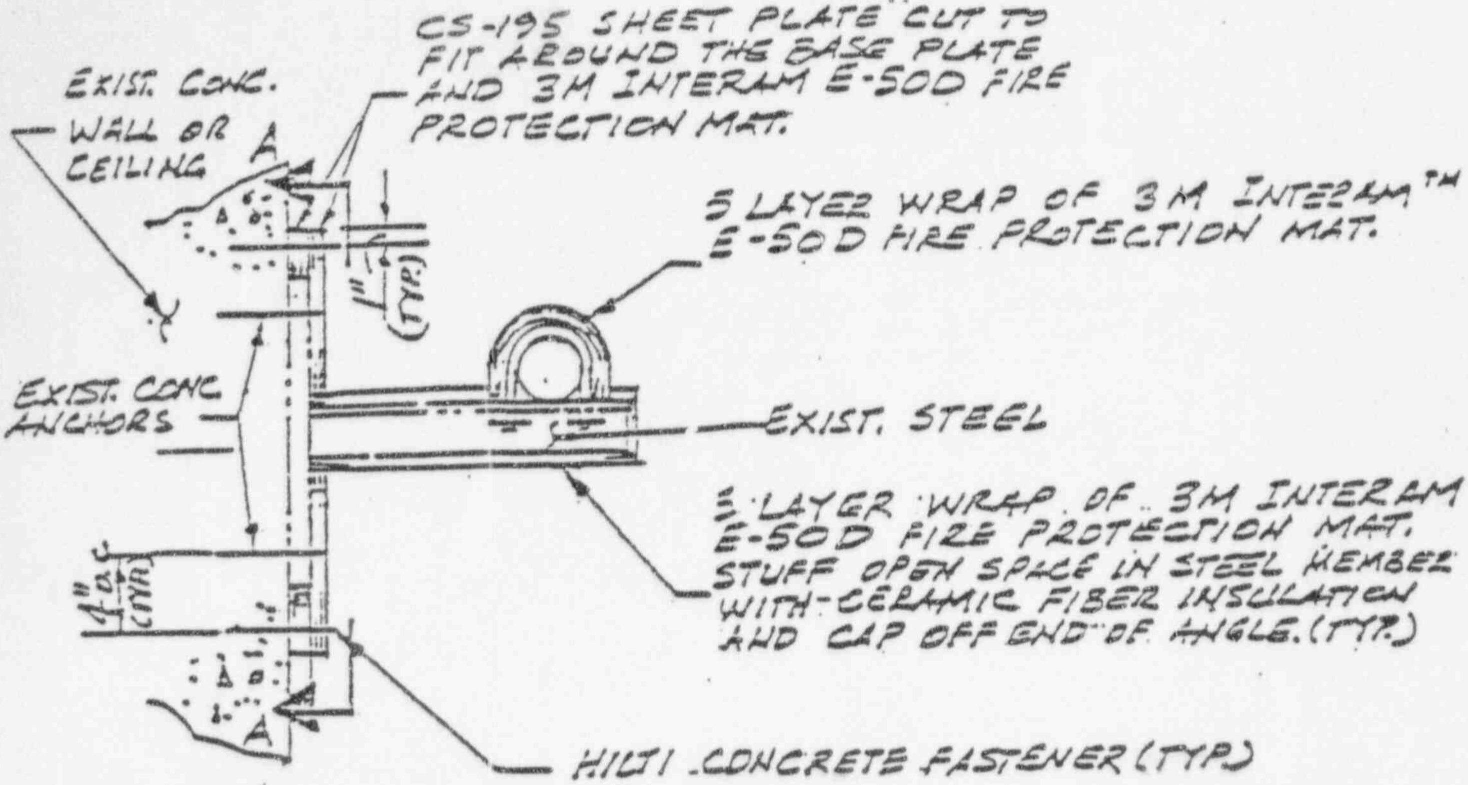
3M / TSI CONDUIT INTERFACE DETAILS



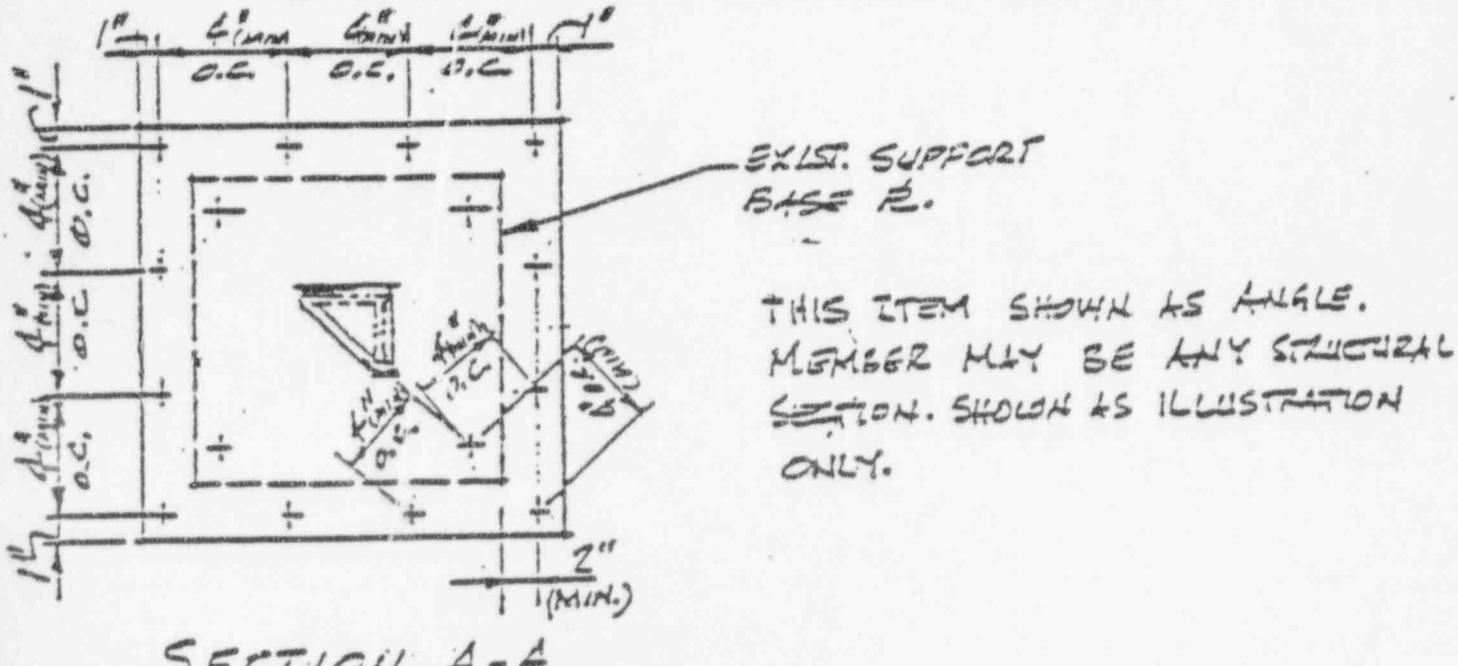

DETAIL OF CONDUIT SUPPORT OF DEDICATED CONDUIT FOR 3-HOUR FIRE RATING




SECTION A-A




DETAIL OF CONDUIT SUPPORT OF DEDICATED CONDUIT FOR 3-HOUR FIRE RATING




SECTION A-A

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Gaithersburg, MD 20899

**REPORT OF TEST**
**FR 3987**

April 29, 1992

# TOXICOLOGICAL EVALUATION OF THE COMBUSTION PRODUCTS FROM A THERMAL BARRIER MATERIAL DECOMPOSED UNDER FLAMING AND NONFLAMING CONDITIONS

Barbara C. Levin, Richard H. Harris, Jr. and Magdalena Navarro

*Submitted to:*

Office of the Inspector General
United States Nuclear Regulatory Commission
Washington, DC 20555

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L/18

# TOXICOLOGICAL EVALUATION OF THE COMBUSTION PRODUCTS FROM A THERMAL BARRIER MATERIAL DECOMPOSED UNDER FLAMING AND NONFLAMING CONDITIONS[1]

B. C. Levin, R. H. Harris, Jr., and M. Navarro

## ABSTRACT

The toxicity of a sample of the material used in nuclear power plants as a fire protection barrier for cable trays, was examined under both flaming and non-flaming conditions in the radiant heat smoke toxicity apparatus. The procedure was modified slightly to account for the long burning and decomposition time of this material. Carbon monoxide, $CO_2$, HCN, and $O_2$ concentrations were monitored in each test. Hydrogen chloride, HBr, HF, and $NO_x$ were measured initially and determined to be produced in insufficient quantities to warrant further monitoring. A total of eight $LC_{50}$ values (based on animal tests) and their equivalent N-Gas values were determined for the various combinations of flaming or non-flaming conditions, for loaded or consumed masses, and for the deaths that occurred during the 30 minute exposures or for those that occurred during the 30 minute exposures plus the 14 day post-exposure observation periods. A comparison of the $LC_{50}$ values based on consumed mass and within plus post-exposure deaths for the flaming or non-flaming modes showed the material sample to be about as toxic as Douglas fir or flexible polyurethane foam which were tested previously in the same apparatus. In the flaming mode, the N-Gas values indicate that the toxic gases monitored were probably responsible for the deaths that occurred. In the non-flaming mode, it appears that one or more additional gases or other factors are contributing to the toxicity. The intumescent char layer that remains following the 30 minute exposures was removed from the non-flaming test residues and heated at 50 $kW/m^2$ in a separate non-flaming test. Compared to the gas yields from the other non-flaming tests, the intumescent char generated more CO and $CO_2$ and an amount of HCN which fell within the mean and one standard deviation of the HCN generated from the complete samples.

Keywords: combustion products; flaming; inhalation; $LC_{50}$; N-Gas model; non-flaming; radiant heat; toxicology.

[1] This report is a contribution of the National Institute of Standards and Technology and is not subject to copyright.

## 1.0 INTRODUCTION

A sample of a material used in nuclear plants as a fire protection barrier for cable trays was provided to the National Institute of Standards and Technology (NIST) by the Office of the Inspector General of the United States Nuclear Regulatory Commission (NRC) to determine the toxicity of the fumes emitted during thermal decomposition. The Fire Hazard Analysis group at NIST evaluated the toxicity of the material under both flaming and nonflaming laboratory conditions using a bench-scale radiant heat smoke toxicity procedure [1].[2]

## 2.0 MATERIALS AND METHODS

### 2.1 Materials

The material was designated by NRC as Exhibit #3, prefabricated subliming material approximately 25 mm (1 inch) thick and identified by invoice #3-91-006.

### 2.2. Gases

In all tests, chemical analyses were conducted to determine the concentrations of carbon monoxide (CO), carbon dioxide ($CO_2$), hydrogen cyanide (HCN), and oxygen ($O_2$). In some tests, hydrogen chloride (HCl), hydrogen fluoride (HF), hydrogen bromide (HBr) and total nitrogen oxides ($NO_x$) were also measured to determine if sufficient quantities would be generated to warrant further monitoring. Calibration gases (CO, $CO_2$, HCN) were commercially supplied in various concentrations in nitrogen. The concentrations of HCN in the commercially supplied cylinders were routinely checked by silver nitrate titration [2], since it is known that the concentration of HCN stored under these conditions will decrease with time. Nitric oxide (NO) in nitrogen, a standard reference material, was obtained from the Gas and Particulate Science Division, NIST.

Carbon monoxide and $CO_2$ were measured continuously during each test by non-dispersive infrared analyzers. Oxygen concentrations were measured continuously with a paramagnetic analyzer. Syringe samples (100 μL) of the chamber atmosphere were analyzed for HCN approximately every three minutes with a gas chromatograph equipped with a thermionic detector [3]. The concentration of $NO_x$ was measured continuously by a chemiluminescent $NO_x$ analyzer equipped with a molybdenum converter (set at 375°C) and a sampling rate of 25 mL/min. The change from a stainless steel converter to a molybdenum converter prevented interference from HCN. All combustion products and gases (except HCN, $NO_x$, and the halogen gases) that were removed for chemical analysis were returned to the chamber. The CO, $CO_2$, $O_2$ and $NO_x$ data were recorded by an on-line computer every 15 seconds.

The halogen gases, HF, HCl, and HBr, were analyzed by ion chromatography. The combustion products were bubbled into 30 mL impingers containing 25 mL of 5 mM KOH at a rate of approximately 30 mL/min for the 30 minute tests. The flow was monitored every five minutes and averaged over the 30 minute run to determine the amount of gases collected. The resulting solution was analyzed for $F^-$, $Cl^-$, and $Br^-$ by the modified method A-106 as described in reference [4]. In this modified method, the eluent was changed from a 2.5 mM lithium hydroxide solution to a 5 mM KOH

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[2] Numbers in brackets refer to references listed at the end of this report.

solution, a manual injector was used instead of an automatic injector, and a 590 programmable pump was employed instead of the 510 solvent delivery module.

For each test, the reported gas concentrations are the time-integrated average exposure values which were calculated by integrating the area under the instrument response curve and dividing by the exposure time [i.e., (ppm x min)/min or, in the case of $O_2$, (% x min)/min]. The calculated CO and $CO_2$ concentrations are accurate to within 100 ppm and 500 ppm, respectively. The calculated HCN concentrations are accurate to 10% of the HCN concentration. The calculated $NO_x$ concentrations are accurate to 10% of the $NO_x$ concentration.

### 2.3. Animals

Fischer 344 male rats, weighing 200-300 grams, obtained from Taconic Farms (Germantown, NY),[3] were used in these tests. They were allowed to acclimate to our laboratory conditions for at least 7 days prior to testing. Animal care and maintenance were performed in accordance with the procedures outlined in the National Institutes of Health's "Guide for the Care and Use of Laboratory Animals." Each rat was housed individually in suspended stainless steel cages and provided with food (Ralston Purina Rat Chow 5012) and water *ad libitum*. Twelve hours of fluorescent lighting per day were provided using an automatic timer. All animals (including the controls) were weighed daily from the day of arrival until the end of the 14 day post-exposure observation period.

### 2.4. Radiant Heat Smoke Toxicity Procedure

All exposures were conducted using the combustion system, the chemical analysis system, and the animal exposure system that were designed for the radiant heat smoke toxicity method [1]. Figures 1 and 2 are a diagram and schematic drawing of the experimental arrangement, respectively. To prepare the test samples, the sheet was cut into pieces of predetermined weight to obtain the desired test concentrations (defined as grams of material loaded or consumed in the furnace divided by the exposure chamber volume in cubic meters, i.e., $g/m^3$).

Tests were conducted in both flaming and non-flaming modes. The flaming mode tests were conducted at a flux of 50 $kW/m^2$ with a spark ignitor kept on until the flaming ceased. Tests to determine a non-flaming flux showed that this material would not flame even at 50 $kW/m^2$ as long as the spark ignitor was off. Therefore, the only difference between the flaming and non-flaming tests is that the spark ignitor was only used in the flaming mode.

The radiant heat smoke toxicity method is a closed design in which all the gases and smoke are kept in a 200 liter rectangular chamber for the duration of the test. The samples are decomposed in the furnace located directly below the animal exposure chamber such that all the combustion products from the test sample evolve directly into the chamber. Six rats are exposed in each test. Each animal

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[3] Certain commercial equipment, instruments, materials or companies are identified in this paper to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

is placed in a restrainer and inserted into one of six portholes located along the front of the exposure chamber such that only the heads of the animals are exposed. In the tests conducted to determine $LC_{50}$ values, the weighed sample was placed onto a load cell in the combustion chamber and animal exposures started when the radiant lamps were turned on. Animal exposures continued for 30 minutes. In the first flaming test, it was noted that the material was still vigorously flaming at 15 minutes, the time at which the lamps would usually be turned off, since the thermal decomposition of most previously tested materials was complete by 15 minutes. Since the material was obviously still being decomposed, the decision was made to leave the radiant heat on until the end of the animal exposures to assure that the underlying layers would also be exposed. In addition to the continuous mass loss data from the load cell, the test specimens were weighed before and after the exposure to determine the total mass of material consumed.

The toxicological endpoint was the $LC_{50}$ values, which were calculated based on the deaths that occurred either during the 30 minute exposures or the 30 minute exposure plus 14 day post-exposure observation period. The percentage of animals dying at each fire effluent concentration was plotted to produce a concentration-response curve from which the $LC_{50}$ values were calculated. The $LC_{50}$ in these cases is defined as the mass of material loaded in the furnace or consumed by the exposure divided by the animal exposure chamber volume ($g/m^3$) which caused 50% of the animals to die during the exposure only or during the exposure plus the 14-day post-exposure observation period. It is important to note that the lower the $LC_{50}$ value, the greater the toxicity. The $LC_{50}$ values and their 95% confidence limits were calculated by the statistical method of Litchfield and Wilcoxon [5].

For this study, eight $LC_{50}$ values were determined for the conditions shown in Table 1. The N-Gas values (determined as shown in Section 2.5) that were equivalent to these $LC_{50}$ values were also calculated.

Table 1. Test Conditions for $LC_{50}$ Determinations

| $LC_{50}$ number | Conditions | | | | | |
|---|---|---|---|---|---|---|
| | Flaming | Non-Flaming | Mass Loaded | Mass Consumed | WE | WE & PE |
| 1 | X | | X | | X | |
| 2 | X | | X | | | X |
| 3 | X | | | X | X | |
| 4 | X | | | X | | X |
| 5 | | X | X | | X | |
| 6 | | X | X | | | X |
| 7 | | X | | X | X | |
| 8 | | X | | X | | X |

WE. Deaths occurring within the 30 min exposure.
WE & PE. Deaths occurring during the 30 min exposure and the 14 day post-exposure period.

2.5. Determination of Unusual Toxicity

In previous studies, NIST has examined the toxicological interactions of six gases, CO, $CO_2$, HCN, reduced $O_2$, HCl and HBr, to provide enough data to predict the toxic potency (based on mass) and determine whether that toxicity is usual (i.e., the toxicity can be explained by the measured gases) or is unusual (i.e., additional gases are needed to explain the toxicity). These studies have resulted in the empirically derived N-Gas Model [6-9] shown in equation (1).

$$N\text{-}Gas\ Value = \frac{m[CO]}{[CO_2]-b} + \frac{[HCN]}{LC_{50}\ HCN} + \frac{21-[O_2]}{21-LC_{50}\ O_2} + \frac{[HCl]}{LC_{50}\ HCl} + \frac{[HBr]}{LC_{50}\ HBr} \quad (1)$$

where the numbers in brackets are the time-integrated average atmospheric concentrations during a 30 minute exposure period [(ppm x min)/min or for $O_2$ (% x min)/min]. If the N-Gas value equivalent to the $LC_{50}$ value is approximately 1 $\pm$ 0.2 (95% Confidence interval), then the gases monitored are probably responsible for the deaths that occurred. If the N-Gas value equivalent to the $LC_{50}$ value is below 0.8, then additional gases or toxicological factors are probably contributing to the toxicity and the combustion products from the material would be considered unusually toxic.

The N-Gas approach has been shown to work well in different combustion systems (radiant as well as convective heat sources; bench-scale as well as full-scale room tests) [11-14].

## 3.0 RESULTS AND DISCUSSION

### 3.1 Flaming Tests

#### 3.1.1 Determination of Best Test Conditions

The one inch thick material was exposed to a radiant flux of 50 $kW/m^2$ with the spark ignitor on. In the first test (Table 2, Expt. A-1), the material began emitting smoke at 35 seconds, started flaming intermittently about 1.25 minutes, began burning intensely and consistently about 7 minutes, and continued burning until the radiant heat was turned off and the shutter between the combustion chamber and animal chamber was closed at 15 minutes. Analytical sampling continued for another 15 minutes. Examination of the sample at the end of the 30 minute exposure showed that the material had intumesced approximately 0.75 inches above the original height.

Since the material was still burning vigorously at 15 minutes and only 30% of the sample had decomposed by this time, a decision was made to allow the radiant heat to continue beyond the 15 minutes in future tests to permit as much of the material to decompose as possible during the 30 minute exposure. In this way, lower layers of the material would also be exposed to the heat. We considered the test sample fully decomposed when the CO concentrations had reached equilibrium. Table 2 indicates the times at which the samples experienced the various stages of smoke and flaming. Comparison of test A-1 with test A-3 in which the same amount of material was loaded into the furnace shows that in the first case (where the sample was exposed to 15 minutes of heat), only 30% of the sample was consumed; whereas, in the second case (where the sample was exposed to 30 minutes of heat), 53% was consumed. In all the other tests, between 53 and 56% of the sample was consumed. As would be expected from the increased mass consumed, the time-integrated concentrations of CO, $CO_2$, and HCN all increased and $O_2$ decreased. In most cases, the rate of CO generation was rapid during the flaming stage, slowed significantly after the flaming stopped and reached equilibrium shortly thereafter. The CO generation in the test in which the radiant heat was turned off and the shutter was closed at 15 minutes (Expt. A-1) and in an test where the radiant heat was kept on and the shutter was kept open for the full 30 minutes (Expt. R-3) is illustrated in Figure 3. Table 3 provides the time-integrated average concentrations. In these two tests, approximately the same amount of material was consumed, although almost twice as much of the material was loaded into the furnace in the 15 minute heat exposure. The results show that the CO generation was significantly greater when the radiant heat was kept on for the full 30 minutes. Comparison of the HCN generation in Expt. A-1 (radiant heat off and shutter closed at 15 minutes) and other tests (radiant heat on and shutter open for 30 minutes) shows that Expt. A-1 generated the lowest concentration of HCN even though the amount of mass consumed was similar to that of many of the other tests (Fig. 4 and Table 3).

To confirm that we were exposing the complete sample to the radiant heat, we also compared a thinner sample with a larger surface area (the thinner sample was prepared in our laboratory by shaving the thick sample) and a thicker sample with a smaller surface area (Fig. 5). The same amount was loaded in the furnace and exposed to the radiant heat for the full 30 minutes; about the same amount was consumed. The time-integrated average gas concentrations were about equal

(Table 4). Examination of the production of the gases over time indicated that the thinner sample started to generate the gases earlier ($O_2$ concentrations dropped earlier), but, eventually, they reached the same equilibrium levels; the one exception was the HCN concentration where the thicker sample seemed to generate a higher maximum level of HCN (Fig. 5).

Since we decided to leave the radiant heat on for the full 30 minutes, a control test without any material was conducted to examine the effects of just the heat from the radiant lamps and any stress that the animals may have experienced from undergoing the test conditions (Table 3, Expt. RC-1) The animals were exposed to the same conditions as the other flaming tests (except A-1), i.e., a radiant flux of 50 $kW/m^2$ with the shutter open for the full 30 minutes and the ignitor on for 20 minutes. In this control exposure, the average 30 minute temperature measured at animal positions 1, 3, and 6 was 26.5°C and the highest temperature was 28.8°C. These temperatures were slightly lower than those observed in some of the flaming material tests in which the average animal exposure temperatures ranged from 24.5 to 33°C and the highest temperatures ranged from 26.2 to 42.9°C. This heat control test appeared to have little or no effect on the animals. Their appearance and activity levels were fine following the exposure and their post-exposure weight gain was similar to the control animals which were kept in their cages and weighed daily (Fig. 6). The analytical chemical results from this control heat exposure show the increased $CO_2$ which comes from the animals' respiration and a small amount of $NO_x$ which comes from the spark ignitor. These results indicate that keeping the heat on for the full 30 minutes did not add any undue stress on the animals.

These results supported our decision that leaving the radiant heat on for the full 30 minutes would provide a more realistic toxicological profile of the material's behavior in an actual fire. It would also allow us to use smaller sample sizes to produce a toxic atmosphere and prevent the possibility of overloading the system.

### 3.1.2 Determination of $LC_{50}$ Values and Equivalent N-Gas Values

Table 3 presents the chemical and toxicological data for all the flaming tests except the thin shaved sample. Three tests were conducted for chemical analytical data only and five tests were conducted to determine the toxicological as well as the chemical data. Hydrogen chloride, HBr, HF, and $NO_x$ were not routinely measured, since their concentrations were relatively low or not detectable.

Table 2. Smoke and Flaming Data from Flaming Tests

| Mass loaded ($g/m^3$) | Mass consumed ($g/m^3$) | Test Type - number | Smoke noted (min:sec) | Flame intermittent (min:sec) | Flame steady (min:sec) | Flame out (min:sec) | Ignitor off (min:sec) | CO equilbrium (min) |
|---|---|---|---|---|---|---|---|---|
| 225[a] | 68 | A-1 | 0:35 | 1:15 | 7:00 | 15:00 | 15:00 | SGU @ 15 min |
| 129 | 70 | A-2 | 0:13 | 1:20 | 1:30 | 17:30 | 18:00 | 22 |
| 223 | 118 | A-3 | immediately | 1:20 | NR | 16:40 | 17:05 | SGU @ 30 min |
| 94 | 53 | R-2 | NR | NR | 1:45 | 17:10 | 17:40 | SGU @ 30 min |
| 114 | 63 | R-3 | NR | 1:50 | 2:15 | 14:55 | 21:35 | 21 |
| 129[b] | 69 | R-4 | 0:13 | 0:40 | 1:30 | 7:25 | 9:20 | 23 |
| 129 | 71 | R-5 | 0:15 | 0:58 | 1:55 | 21:20 | 20:50 | 22 |

a. In this test, the radiant lamps were shut off at 15 minutes. In all other tests, the radiant lamps were left on for the full 30 minutes.
b. Some of gases leaked out of chamber during test.
A. Analytical chemical test; no animals exposed.
NR. Not recorded.
R. Rat test; animals exposed and chemical analyses conducted.
SGU. Carbon monoxide concentrations were still increasing at time noted.

Table 3

Chemical and Toxicological Data from Material Sample Decomposed in the Flaming Mode at 50 kW/m$^2$ in Radiant Heat Smoke Toxicity System

| Test type-number | Mass | | Chemical Analytical Data[a] | | | | | | | | Toxicological Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | loaded (g/m$^3$) | consumed (g/m$^3$) | CO (ppm) | $CO_2$ (ppm) | HCN (ppm) | $O_2$ (%) | $NO_x$ (ppm) | HCl (ppm) | HBr (ppm) | HF (ppm) | # died / # tested | | N-Gas Value | | Day of death |
| | | | | | | | | | | | WE | WE & PE | WE | WE & PE | |
| A-1[b] | 225 | 68 | 770 | 17900 | 60 | 18.3 | NM | 10 | ND | 30 | NA | NA | 0.63 | 0.74 | - |
| A-2 | 129 | 70 | 1530 | 22300 | 130 | 17.8 | NM | 10 | ND | 16 | NA | NA | 1.14 | 1.36 | - |
| A-3 | 223 | 118 | 1790 | 26700 | 120 | 16.9 | NM | trace | ND | 30 | NA | NA | 1.23 | 1.43 | - |
| RC-1 | 0 | 0 | 0 | 5000 | 6 | 20.4 | 30 | NM | NM | NM | 0/6 | 0/6 | 0.07 | 0.08 | - |
| R-2 | 94 | 53 | 1100 | 20400 | 90 | 18.1 | NM | NM | NM | NM | 3/6 | 3/6 | 0.83 | 0.98 | - |
| R-3 | 114 | 63 | 1230 | 19400 | 120 | 18.3 | 5 | NM | NM | NM | 5/6 | 6/6 | 0.98 | 1.17 | 1 |
| R-4[d] | 129 | 69 | 490 | 8700 | 80 | 19.9 | NM | NM | NM | NM | 4/6 | 6/6 | 0.56 | 0.69 | 2,11 |
| R-5 | 129 | 71 | 1110 | 23400 | 100 | 17.7 | 10 | NM | NM | NM | 5/6 | 5/6 | 0.92 | 1.08 | - |

a. Time-integrated average concentrations.
A. Analytical chemical test, no animals exposed.
b. Shutter on combustion system, radiant heat and ignitor were turned off at 15 minutes even though material was still flaming vigorously.
R. Test in which both analytical chemical and animal exposure data were collected.
C. Control Test with animals to determine effect of heat; no sample was decomposed.
d. Gases leaked from exposure chamber; sample flamed only until 7:25 min:sec; whereas, in all other tests, the shortest time at which the material stopped flaming was 14:55 min:sec.
NA. Not applicable.
ND. Not detected.
NM. Not measured.
WE. Within exposure
WE&PE Within exposure plus post-exposure.

Table 4

Comparison of Chemical and Toxicological Data from the Material Sample Cut into Thick, Smaller Surface Areas and Thin, Larger Surface Areas and Decomposed in the Flaming Mode

| Test type number | Mass | | Size | | Chemical Analytical Data[a] | | | | | | | | N-Gas Value | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | loaded ($g/m^3$) | consumed ($g/m^3$) | thickness (cm) | surface area ($cm^2$) | CO (ppm) | $CO_2$ (ppm) | HCN (ppm) | $O_2$ (%) | $NO_x$ (ppm) | HCl (ppm) | HBr (ppm) | HF (ppm) | WE | WE & PE |
| Thin Sample | 130 | 72 | 0.6 | 34 | 1700 | 28600 | 120 | 16.8 | NM | NM | NM | NM | 1.19 | 1.38 |
| A-2 | 129 | 70 | 3.0-3.2 | 8.6 | 1530 | 22300 | 130 | 17.8 | NM | 10 | ND | 16 | 1.14 | 1.36 |

a. Time-integrated average concentrations.

Table 5 gives the $LC_{50}$ values and their equivalent N-Gas values based on tests in Table 3. Animals that survived the exposures experienced difficulty breathing, were gasping loudly, and had extensive mucus discharges from their noses and mouths. Some exhibited tremors. Since there were few post-exposure deaths, the $LC_{50}$ values were essentially the same for the deaths that occurred during the 30 minutes and those that included both within and post-exposure deaths. One death occurred as late as 11 days post-exposure. The $LC_{50}$ value based on the mass loaded in the furnace was 94 $g/m^3$ for the within and within plus post-exposure and the $LC_{50}$ value based on mass consumed was 53 $g/m^3$. At this mass (either loaded or consumed), the N-Gas values were 0.90 for the within exposure deaths and 1.07 for the within plus post-exposure deaths. Both of these values are in the range where one would expect some deaths to occur; an indication that the gases monitored are probably the gases responsible for the deaths. The slightly lower N-Gas value for the within exposure deaths may be due to the high levels of HCN which occur during the latter half of the exposures (Fig. 4) and which are not obvious from the time-integrated average concentrations. Table 6 lists both the time-integrated average and the maximum HCN concentrations.

The N-Gas values equivalent to the $LC_{50}$ values were calculated a second time excluding Expt. A-3 which looked as though this large sample loading could have overloaded the system (compare HCN generation of Expt. A-3 with A-2 in Table 6). The results of the N-Gas calculations without this point are shown in Table 5 and indicate that the N-Gas values are about the same as when the calculation included Expt. A-3.

Table 5

$LC_{50}$ Values, Confidence Limits and Equivalent N-Gas Values for the Material Sample Decomposed in the Flaming Mode

| Conditions | $LC_{50}$ ($g/m^3$) | 95% Confidence Limits ($g/m^3$) | N-Gas Value[a] | N-Gas Value[b] |
|---|---|---|---|---|
| Mass loaded WE | 94 | 77 - 114 | 0.90 | 0.84 |
| Mass loaded WE & PE | 94 | 78 - 113 | 1.07 | 1.00 |
| Mass consumed WE | 53 | 45 - 63 | 0.90 | 0.85 |
| Mass consumed WE & PE | 53 | 45 - 63 | 1.07 | 1.00 |

a. N-Gas value at the $LC_{50}$ based on a least squares linear regression analysis of mass (loaded or consumed) vs. N-Gas value for tests A-2, A-3, R-2, R-3, and R-5 in Table 3. Other tests not used for reasons listed in legend of Table 3.

b. N-Gas value at the $LC_{50}$ based on a least squares linear regression analysis of the mass (loaded or consumed) vs. the N-Gas value for all tests used in a. except A-3 which was eliminated from the calculation due to a possible overload condition.

WE: Values based on animals that died during the 30 minute exposures.

WE & PE: Values based on animals that died during the 30 minute exposures plus the 14 day post-exposure observation period.

Table 6. Hydrogen Cyanide Concentrations in Flaming Tests

| Test type-Number | Mass | | HCN | |
|---|---|---|---|---|
| | loaded ($g/m^3$) | consumed ($g/m^3$) | time-integrated average (ppm) | maximum (ppm) |
| A-1 | 225 | 68 | 60 | 90 |
| A-2 | 129 | 70 | 130 | 300 |
| A-3 | 223 | 118 | 120 | 300 |
| RC-1 | 0 | 0 | 6 | 7 |
| R-2 | 94 | 53 | 90 | 150 |
| R-3 | 114 | 63 | 120 | 290 |
| R-4 | 129 | 69 | 80 | 160 |
| R-5 | 129 | 71 | 100 | 190 |

### 3.2 Non-Flaming Tests

#### 3.2.1 Determination of the Non-Flaming Flux

To determine the flux at which the non-flaming tests should be conducted, we started by examining a flux of 25 $kW/m^2$ without the spark ignitor (Table 7, Expt. A-1). No flaming occurred and only 26% of the mass loaded (151 $g/m^3$) was consumed in the 30 minute exposure. As in the flaming mode, the material also intumesced. The concentrations of the gases were low providing N-Gas values of 0.09 (within exposure) or 0.11 (within exposure plus post-exposure). These extremely low N-Gas values indicated that we were not close to a fire effluent concentration that would be lethal to the rats.

The next flux tested was 35 $kW/m^2$ (Table 7, Expt. A-2). No flaming was observed, 45% of the mass loaded (154 $g/m^3$) was decomposed, and the N-Gas values were 0.27 (within exposure) and 0.35 (within exposure plus post-exposure). Again, these values indicated that these fire atmospheres would not be very toxic.

We then tested a flux of 50 $kW/m^2$, which is the same as that used for the flaming combustion mode, except without the spark ignitor (Table 7, Expt. A-3). No flaming occurred, 52% of the mass loaded (159 $g/m^3$) decomposed, and the N-Gas values were 0.56 and 0.72 for the within exposure and the within exposure plus post-exposure, respectively. As expected, the highest flux (50 $kW/m^2$) generated the greatest concentrations of gases. The effect of flux on the evolution of HCN over time is illustrated in Fig. 7.

Two more analytical tests at higher mass loadings were conducted to try to achieve higher N-Gas values. However, even though the amount loaded into the furnace was doubled, the concentrations of the gases did not change very much and the final N-Gas values were about the same or lower (Table 7, compare Expt. A-4 and A-5 with A-3). In these tests, it appeared that mass loadings above 200 $g/m^3$ or consumed masses above 100 $g/m^3$ overload the system.

#### 3.2.2 Determination of $LC_{50}$ Values and Equivalent N-Gas Values

The first animal exposure (Table 7, Expt. R-9) was conducted with a mass loading of 607 $g/m^3$ in an effort to achieve higher N-Gas values. At this loading, about 30% of the material was consumed and we obtained N-Gas values of 0.77 (within exposure) and 0.96 (within plus post-exposure). At these N-Gas values, we would expect no deaths within exposure and only some deaths post-exposure. However, all of the animals died during the 30 minute exposure at times ranging from 16.5 to 27 min; an indication that the material is probably generating a toxic gas that we are not taking into account with our N-Gas equation.

The non-flaming $LC_{50}$ values, their 95% confidence limits and their equivalent N-Gas values are given in Table 8. The N-Gas values equivalent to the $LC_{50}$ values are calculated from a least squares linear regression analyses of individual test N-Gas values vs. mass (loaded or consumed) from Expts. R-1 through R-9. To determine if there was any difference due to a possible overload of the system from sample sizes above 200 $g/m^3$, these values were also calculated from a least squares linear regression analyses of individual test N-Gas values vs. mass (loaded or consumed) from Expts. R-1 through R-6 in Table 7. These results show that in the non-flaming mode, the N-Gas values which are equivalent to the $LC_{50}$ values (regardless of whether the possible overload was considered) are lower than those expected if the gases in the model were the only gases contributing to the toxicity.

Many of the animals that survived the 30 minute exposures had difficulty breathing (were gasping for breath) and had brownish, watery discharges from their mouths. Some exhibited convulsions or tremors. Eight animals died beyond 24 hours following the exposures and three died as late as 8 days post-exposure (Figs. 8 and 9). These post-exposure deaths beyond 24 hours also indicate that gases other than those considered in the N-Gas Model or additional factors are probably contributing to the toxicity.

As in the flaming tests, the HCN continued to increase during the last 15 minutes of exposure (Fig. 10). The time-integrated average HCN concentrations do not reflect the high maximum levels reached towards the end of the exposures (Table 9). Although not specifically examined, the possibility exists that the animal deaths are resulting from the high levels achieved during the latter half of the exposures. The N-Gas model is based on steady-state pure and mixed gas exposures. Additional research may be needed to examine the effects of continuously increasing concentrations.

Table 7. Chemical and Toxicological Data from the Material Sample Decomposed in the Non-Flaming Mode in Radiant Heat Smoke Toxicity System

| Test type - number | Flux ($kW/m^2$) | Mass | | Chemical Analytical Data[a] | | | | | Toxicological Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Loaded ($g/m^3$) | Consumed ($g/m^3$) | CO (ppm) | $CO_2$ (ppm) | HCN (ppm) | $O_2$ (%) | $NO_x$ (ppm) | # died / # tested | | N-Gas Value | | Day of death |
| | | | | | | | | | WE | WE & PE | WE | WE & PE | |
| A-1 | 25 | 151 | 39 | 45 | 1350 | 15 | 21.1 | 4 | NA | NA | 0.09 | 0.11 | NA |
| A-2 | 35 | 154 | 69 | 130 | 2050 | 45 | 20.7 | 2 | NA | NA | 0.27 | 0.35 | NA |
| A-3 | 50 | 159 | 83 | 490 | 4210 | 90 | 20.5 | 3 | NA | NA | 0.56 | 0.72 | NA |
| A-4 | 50 | 299 | 120 | 660 | 3400 | 80 | 20.4 | NM | NA | NA | 0.55 | 0.68 | NA |
| A-5 | 50 | 313 | 130 | 480 | 3090 | 55 | 20.5 | 3 | NA | NA | 0.38 | 0.47 | NA |
| R-1 | 50 | 52 | 30 | 370 | 4940 | 70 | 20.4 | NM | 1/6 | 3/6 | 0.44 | 0.55 | 8,8 |
| R-2 | 50 | 55 | 31 | 290 | 5100 | 55 | 20.3 | NM | 0/6 | 1/6 | 0.36 | 0.44 | 8 |
| R-3 | 50 | 56 | 33 | 280 | 5110 | 60 | 20.4 | NM | 0/6 | 2/6 | 0.37 | 0.46 | 1,2 |
| R-4 | 50 | 76 | 43 | 410 | 5530 | 60 | 20.2 | NM | 0/6 | 6/6 | 0.42 | 0.52 | 1,1,1,2,2,3 |
| R-5 | 50 | 102 | 56 | 410 | 5340 | 100 | 20.5 | NM | 2/6 | 6/6 | 0.60 | 0.77 | 1,1,1,6 |
| R-6 | 50 | 152 | 81 | 520 | 6840 | 125 | 20.1 | NM | 2/6 | 6/6 | 0.76 | 0.96 | 1,1,1,1 |
| R-7 | 50 | 203 | 107 | 580 | 7420 | 120 | 20.2 | NM | 5/6 | 6/6 | 0.75 | 0.96 | 0 |
| R-8 | 50 | 229 | 110 | 470 | 6850 | 60 | 20.2 | NM | 4/6 | 6/6 | 0.41 | 0.51 | 1,1 |
| R-9 | 50 | 607 | 178 | 880 | 6930 | 115 | 20.0 | NM | 6/6 | 6/6 | 0.77 | 0.96 | - |

a. Time-integrated average concentrations; HCl, HBr, and HF were not measured in these tests.
A. Analytical chemical test, no animals exposed.
R. Test in which both analytical chemical and animal exposure data were collected.
NA. Not applicable.
NM. Not measured.
WE. Within exposure.
WE&PE. Within exposure plus post-exposure.

Table 8

$LC_{50}$ Values, Confidence Limits and Equivalent N-Gas Values for the Material Sample Decomposed in the Non-Flaming Mode

| Conditions | $LC_{50}$ (g/m$^3$) | 95% Confidence Limits (g/m$^3$) | N-Gas Value[a] | N-Gas Value[b] |
|---|---|---|---|---|
| Mass loaded WE | 138 | 99 - 193 | 0.52 | 0.71 |
| Mass loaded WE & PE | 69 | 55 - 87 | 0.60 | 0.55 |
| Mass consumed WE | 72 | 54 - 96 | 0.54 | 0.68 |
| Mass consumed WE & PE | 42 | 32 - 55 | 0.58 | 0.58 |

a. N-Gas value at the $LC_{50}$ based on a least squares linear regression analysis of mass (loaded or consumed) vs. N-Gas value for tests R-1 through R-9 in Table 7.

b. N-Gas value at the $LC_{50}$ based on a least squares linear regression analysis of the mass (loaded or consumed) vs. the N-Gas value for tests R-1 through R-6 in Table 7. Tests R-7, R-8, and R-9 were eliminated from calculation due to possible overload condition.

WE: Values based on animals that died during the 30 minute exposures.

WE & PE: Values based on animals that died during the 30 minute exposures plus the 14 day post-exposure observation period.

Table 9. Hydrogen Cyanide Concentrations in Non-Flaming Tests

| Test type - number | Mass | | HCN | |
|---|---|---|---|---|
| | loaded ($g/m^3$) | consumed ($g/m^3$) | time-integrated average (ppm) | maximum (ppm) |
| A-1[a] | 151 | 39 | 15 | 28 |
| A-2[b] | 154 | 69 | 45 | 86 |
| A-3 | 159 | 83 | 90 | 175 |
| A-4 | 299 | 120 | 80 | 196 |
| A-5 | 313 | 130 | 55 | 227 |
| R-1 | 52 | 30 | 70 | 126 |
| R-2 | 55 | 31 | 55 | 88 |
| R-3 | 56 | 33 | 60 | 109 |
| R-4 | 76 | 43 | 60 | 124 |
| R-5 | 102 | 56 | 100 | 206 |
| R-6 | 152 | 81 | 125 | 254 |
| R-7 | 203 | 107 | 120 | 337 |
| R-8 | 229 | 110 | 60 | 186 |
| R-9 | 607 | 178 | 115 | 277 |

Flux level was 50 $kW/m^2$ except where noted. Flaming tests had the spark ignitor on; whereas, non-flaming tests were conducted without the spark ignitor.

a. Flux level was 25 $kW/m^2$

b. Flux level was 35 $kW/m^2$

### 3.2.3 Examination of the Intumescent Material

In 1985, we found that heating the charred residues from a flexible polyurethane foam that had been thermally decomposed in the non-flaming mode generated significant quantities of HCN [15]. Since the intumescent char layer from the NRC material sample increased as the HCN was generated, the question arose as to whether the HCN was produced by the intumescent char layer. A test was conducted in which 194 $g/m^3$ of the intumescent char layers (including the imbedded mesh) that remained following a number of 30 minute non-flaming tests were combined and exposed to the non-flaming conditions (radiant heat of 50 $kW/m^2$ for 30 minutes, no ignitor). The amount consumed was 29 $g/m^3$. Fig. 11 shows the generation of CO, $CO_2$, HCN, and the reduction in $O_2$ over time (two of the HCN points appear to be the result of the obstruction of the sampling syringe and are, therefore, not connected to the main curve). The yields of the gases from this test of the intumescent material and from the other tests on the complete material are given in Table 10. These results show that the intumescent char layer produces yields of CO and $CO_2$ which are greater than those produced by the whole material. Yields of HCN are within one standard deviation of the mean ($x = 0.0029 \pm 0.0010$ g/g) of the yields from the whole material.

Table 10
Comparison of Gas Yields from the Intumescent Char Layer and the Whole Sample Decomposed in the Non-Flaming Mode.

| Test | Gas Yields (g/g) | | |
|---|---|---|---|
| | CO | $CO_2$ | HCN |
| Intumescent Char | 0.088 | 0.868 | 0.0023 |
| A-3 | 0.017 | 0.174 | 0.0022 |
| A-4 | 0.018 | 0.121 | 0.0017 |
| A-5 | 0.011 | 0.094 | 0.0019 |
| R-1 | 0.028 | 0.548 | 0.0046 |
| R-2 | 0.021 | 0.510 | 0.0030 |
| R-3 | 0.021 | 0.500 | 0.0036 |
| R-4 | 0.021 | 0.399 | 0.0031 |
| R-5 | 0.018 | 0.307 | 0.0039 |
| R-6 | 0.019 | 0.288 | 0.0033 |
| R-7 | 0.019 | 0.240 | 0.0034 |
| R-8 | 0.014 | 0.221 | 0.0018 |
| R-9 | 0.014 | 0.146 | 0.0017 |

3.3 Comparison of Toxicity of NRC Material Sample and Other Materials

A number of materials have been examined by the radiant heat smoke toxicity methodology [1]. These materials (other than the material tested for this report) have been examined in the flaming mode in which they were exposed to a radiant heat flux of 50 $kW/m^2$ for 15 minutes. For most of these materials, 15 minutes was sufficient to decompose the sample and heating the material any longer would not have generated any additional gases. For the NRC sample material to be toxic in the 15 minute exposure time, we would have had to increase the sample size and we ran the risk of overloading the system. A larger sample size and a shorter exposure time would have generated a larger $LC_{50}$ value and make the material appear less toxic than with a smaller sample size and longer exposure time as used in these tests. The lower the $LC_{50}$ value, the more toxic the material. Comparison of the values in Table 11 indicates that the sample material is one of the least toxic of the materials examined.

Table 11. Comparison of $LC_{50}$ Values for Various Materials

| Material | $LC_{50}$[a] ($g/m^3$) | |
|---|---|---|
| | Value | 95% Confidence Limits |
| NRC Sample | 53 | 45 - 63 |
| NRC Sample - (Non-flaming) | 42 | 32 - 55 |
| Douglas fir | 56 | 54 - 57 |
| Rigid Polyurethane Foam | 22 | 21.6 - 22.2 |
| PVC | 26 | 21 - 31 |
| Flexible Polyurethane Foam | 52 | 46 - 59 |
| Melamine Polyurethane Foam | 13 | 10 - 16 |
| Vinyl Fabric | 32 | 28 - 37 |
| Vinyl Fabric over Melamine Polyurethane Foam | 26 | 24 - 28 |

a. $LC_{50}$ values in this table are based on the mass of consumed material (radiant heat flux was 50 $kW/m^2$ and the mode was flaming except where noted) that caused 50% of the rats to die during the exposures and the 14 day post-exposure observation period (WE & PE).

## 4.0 CONCLUSIONS

1. The $LC_{50}$ value of the sample material decomposed in the flaming mode was compared to the $LC_{50}$ values of other materials tested in the radiant heat smoke toxicity apparatus and appears to be among the least toxic.

2. The $LC_{50}$ value of the sample material decomposed in the non-flaming mode also indicates a relatively low toxicity compared to materials decomposed in the flaming mode.

3. The monitored gases (CO, $CO_2$, HCN, and reduced $O_2$) generated in the flaming mode appear to account for the toxicity produced.

4. The monitored gases (CO, $CO_2$, HCN, and reduced $O_2$) generated in the non-flaming mode appear to account for only 55 to 70% of the toxicity. Therefore, one or more additional gases or other factors may need to be considered when determining the gases or factors responsible for the toxicity.

5. The animal deaths occurring beyond 24 hours following the non-flaming exposures also indicate an additional toxic factor which acts during the post-exposure period.

6. When heated in the non-flaming mode, the intumescent char layer generates higher yields of CO and $CO_2$ and about the same amount of HCN as the whole material.

## 5.0 ACKNOWLEDGEMENTS

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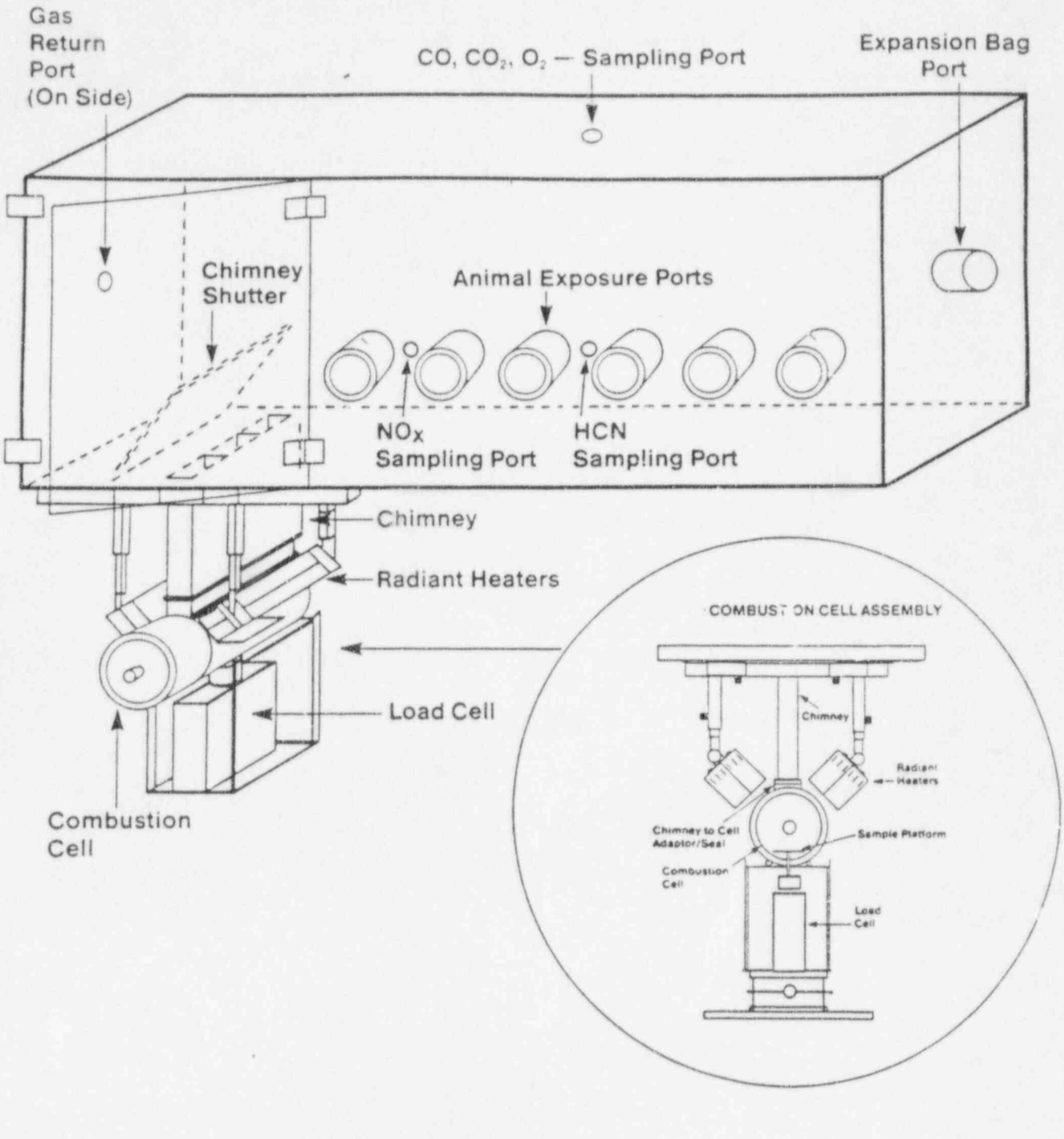


Figure 1. Radiant Smoke Toxicity Apparatus with insert showing radiant furnace.

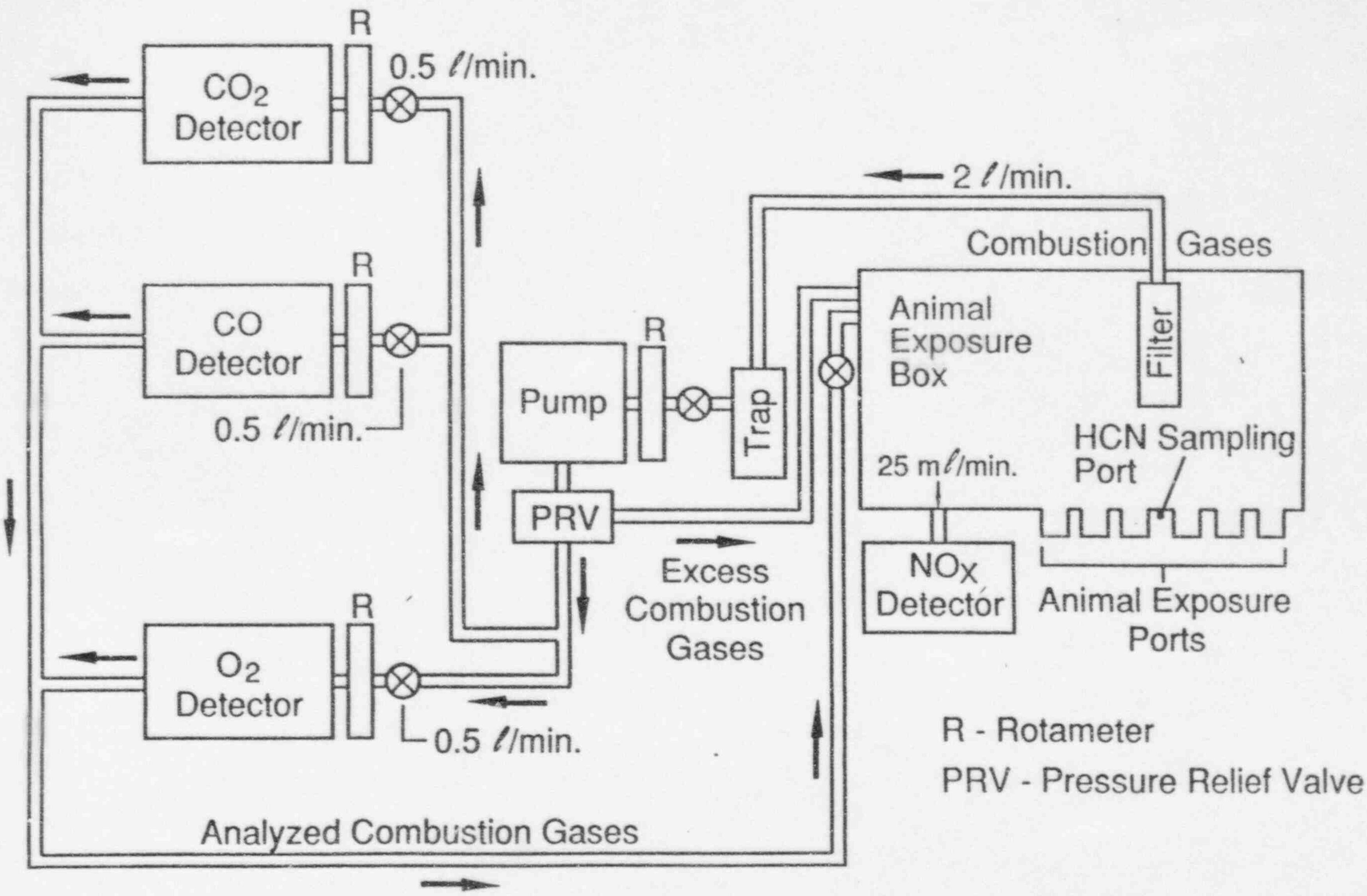


Figure 2. Schematic of Radiant Smoke Toxicity Apparatus showing chemical analytical instrumentation.

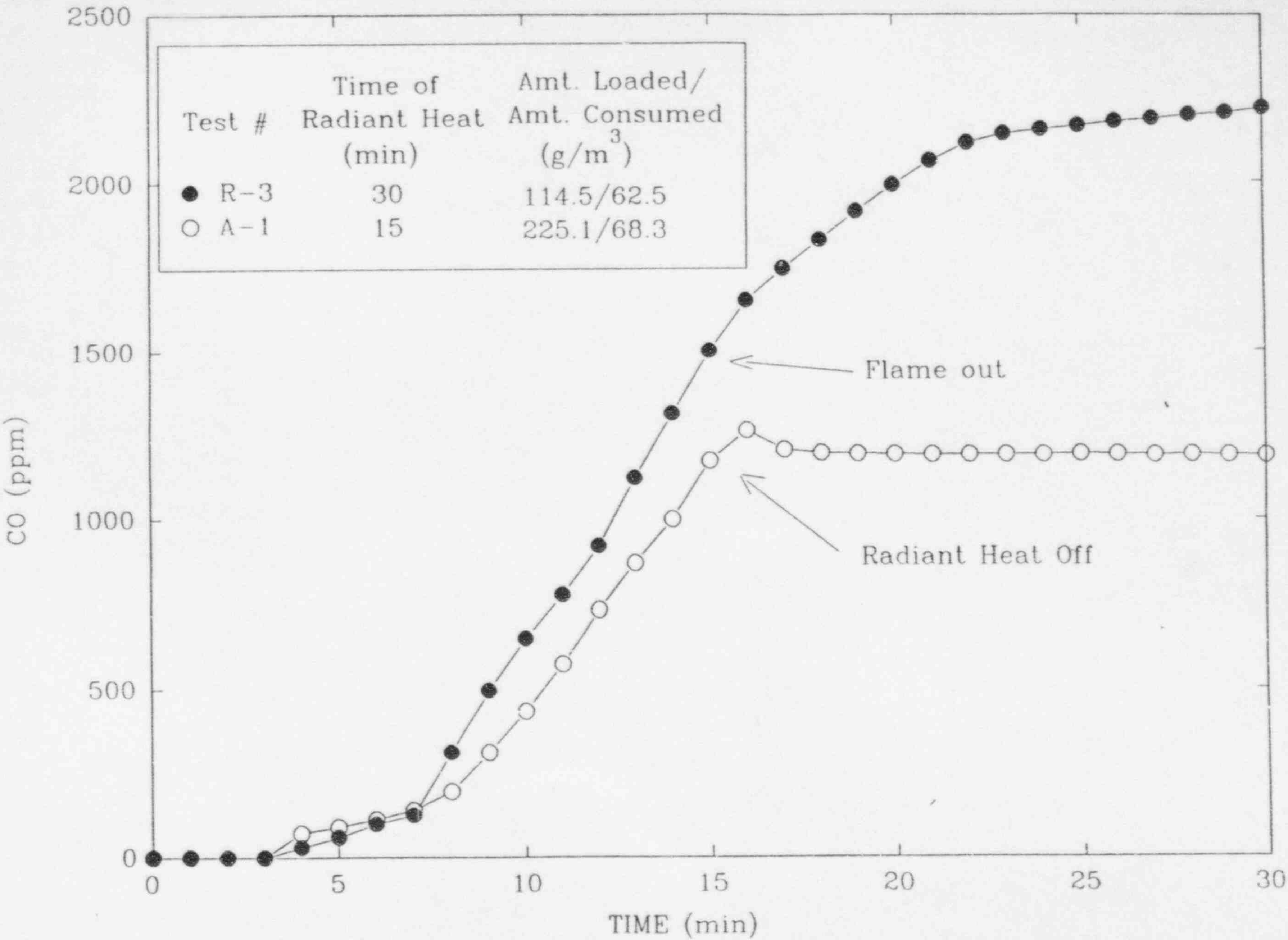


Figure 3. Effect of increased heating time on monoxide generation from sample decomposed in flaming mode.

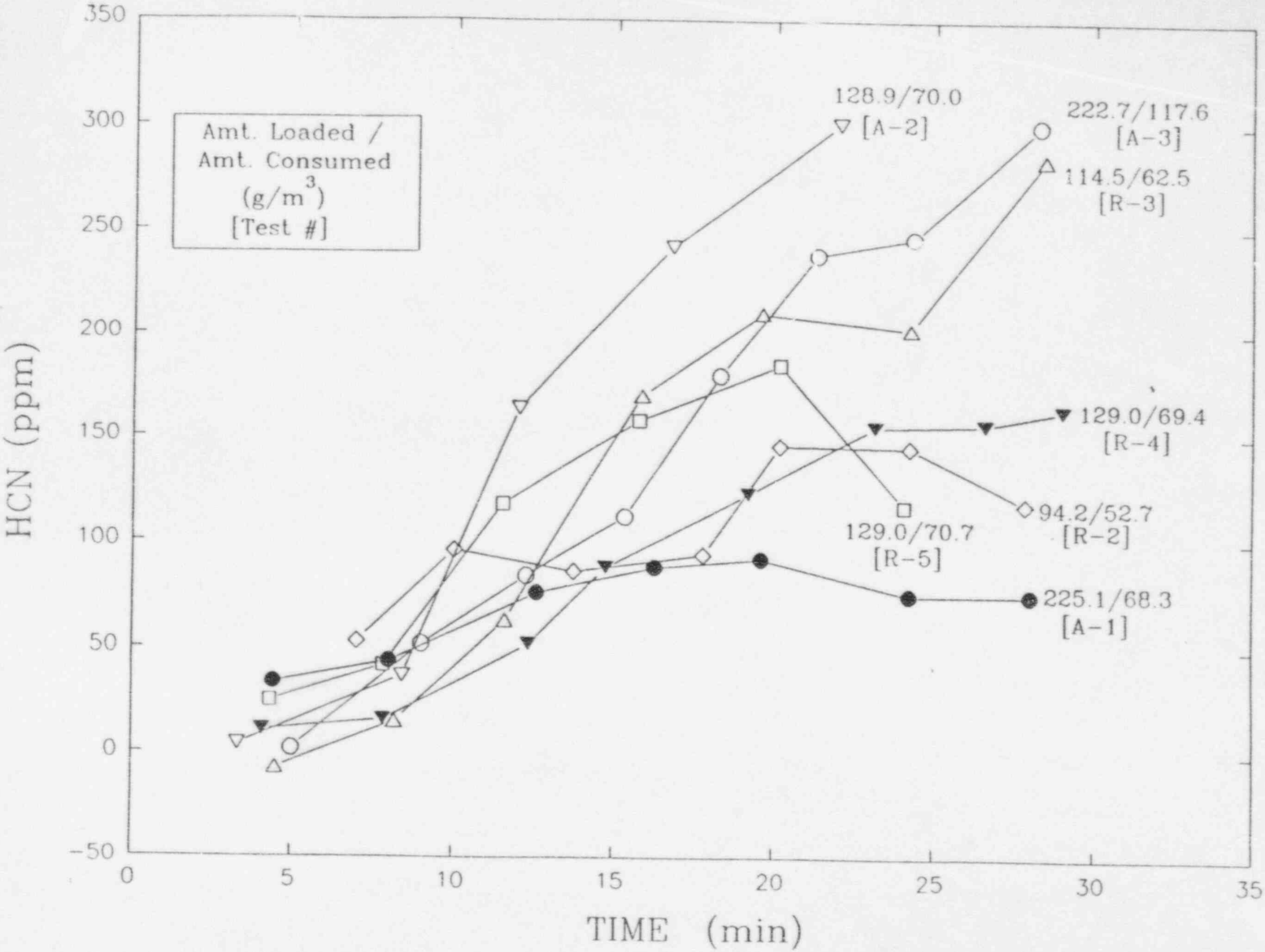


Figure 4. Hydrogen cyanide generation from samples decomposed in flaming mode.

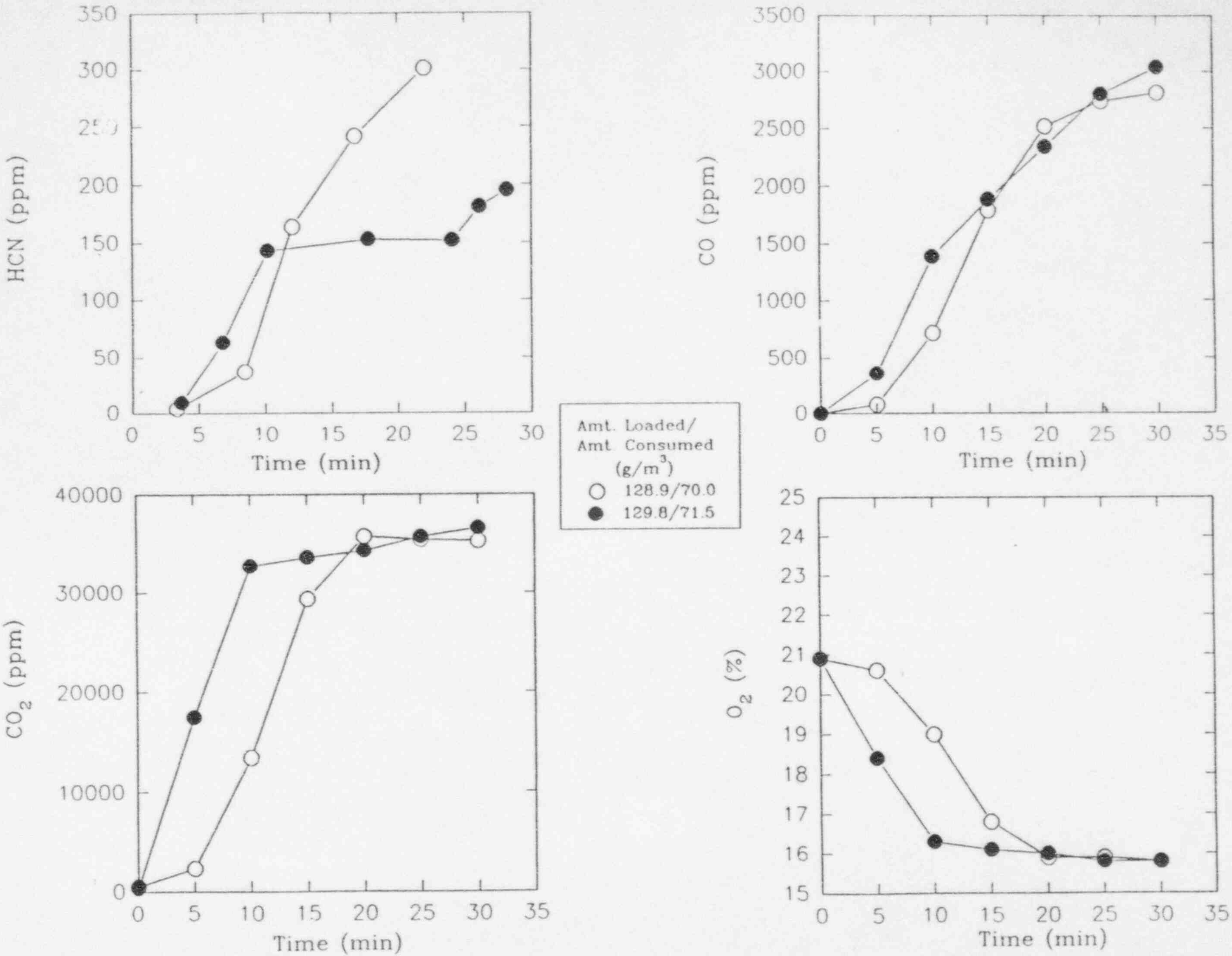


Figure 5. Comparison of gas generation from a thick, smaller surface area and a thin, larger surface area sample decomposed in the flaming mode.

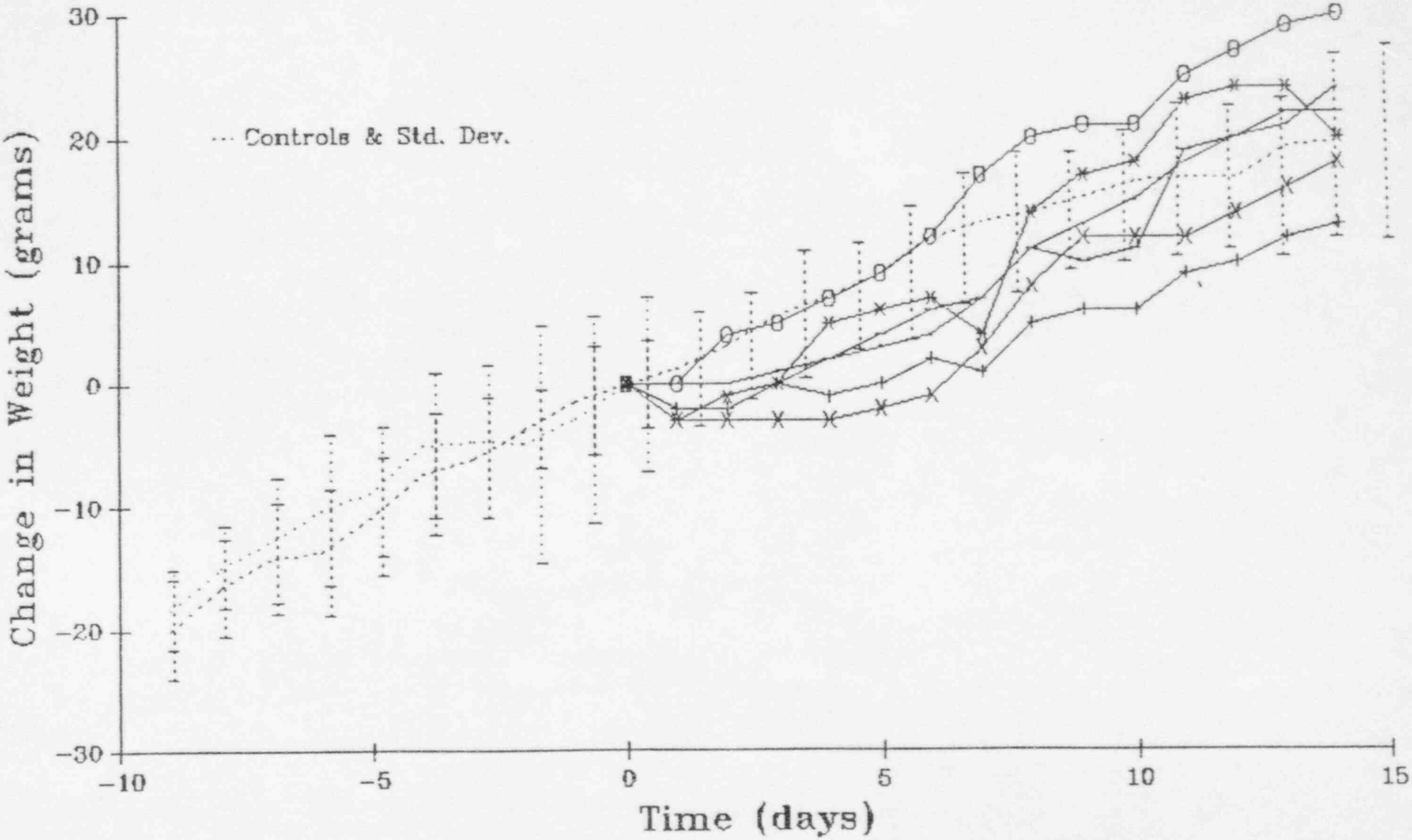


Figure 6. Control test indicating effect of radiant heat and experimental stress on weight gain of the rats. Day 0 is the day of exposure. The lines prior to Day 0 show the mean and standard deviation of the weight gain of animals who have not been exposed and the six animals who were used in this test. The rats were exposed in the head-only mode for 30 minutes while the furnace was heated by the radiant lamps set at a flux level of 50 $kW/m^2$. All the animals lived 14 days and gained weight normally.

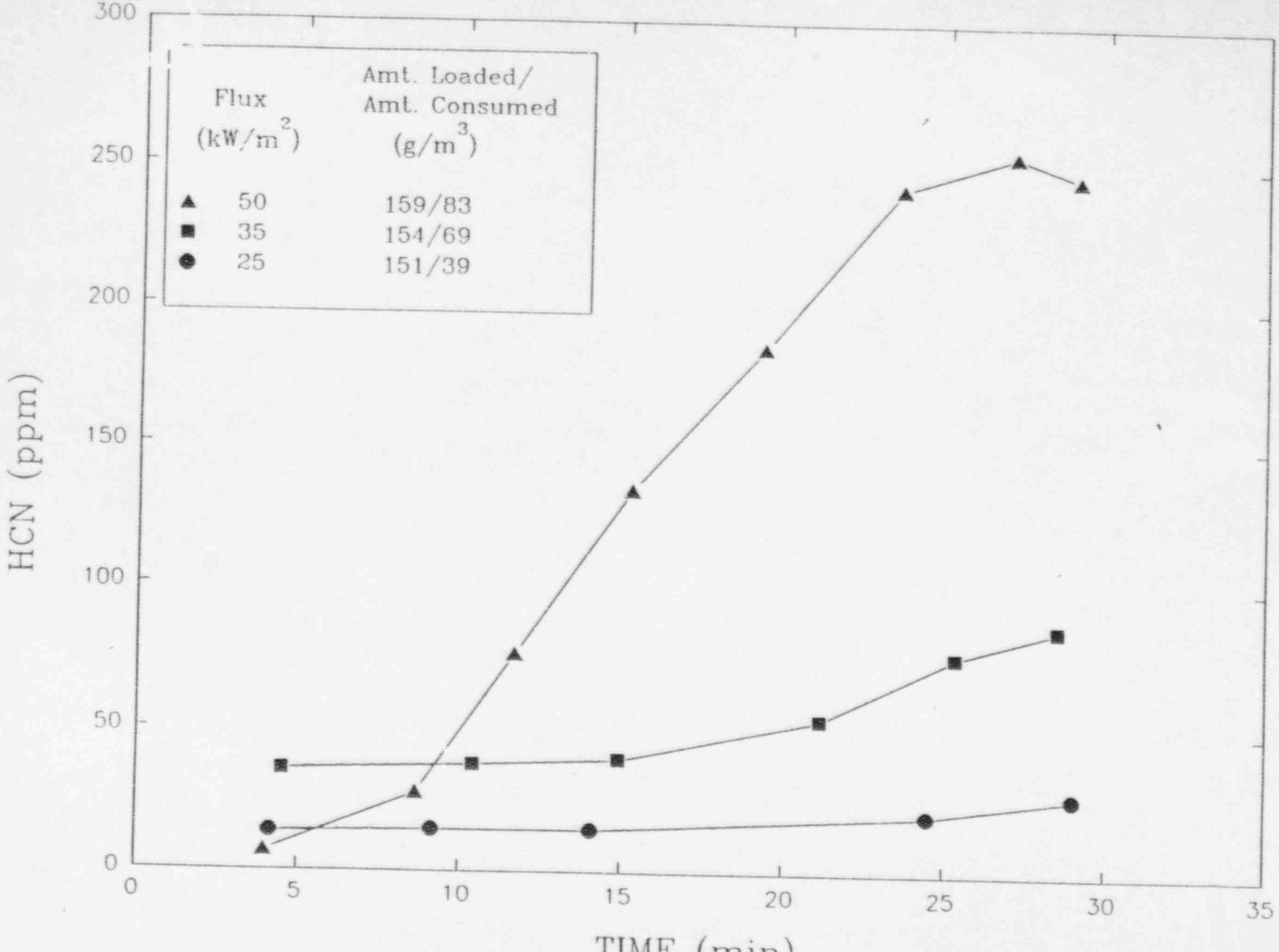


Figure 7. Effect of changing the radiant heat flux on the generation of hydrogen cyanide from samples decomposed in the non-flaming mode.

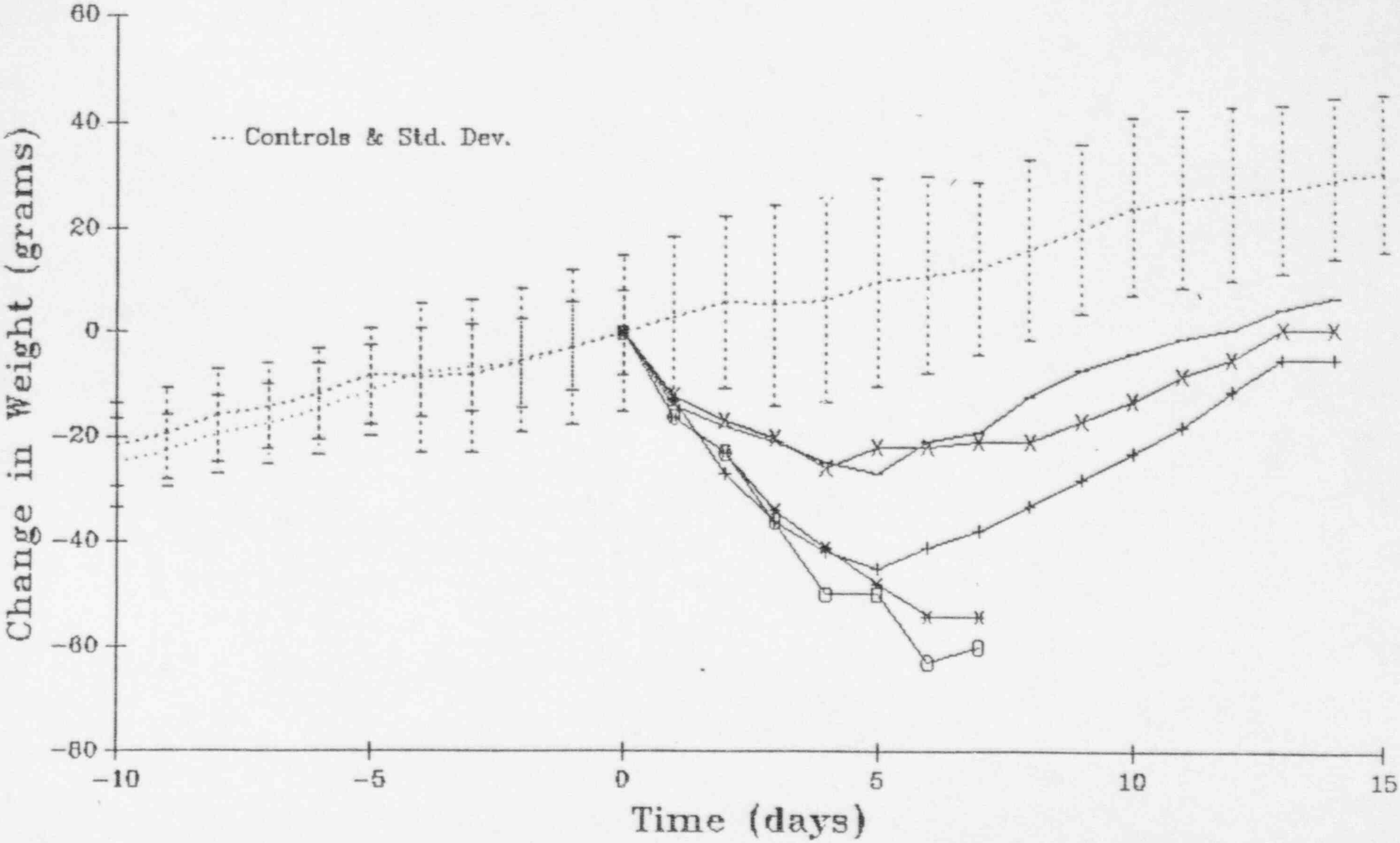


Figure 8. Change in weight of test animals following exposure to a sample decomposed in the non-flaming mode. The amount loaded in the furnace was 52 g/m$^3$ and the amount consumed was 30 g/m$^3$. Day 0 is the day of exposure. The lines prior to Day 0 indicate the mean and standard deviation of the weight gain of animals who have not been exposed and the six animals who were used in this test. In this test, one animal died at the end of the 30 minute exposure and two animals died on day 8.

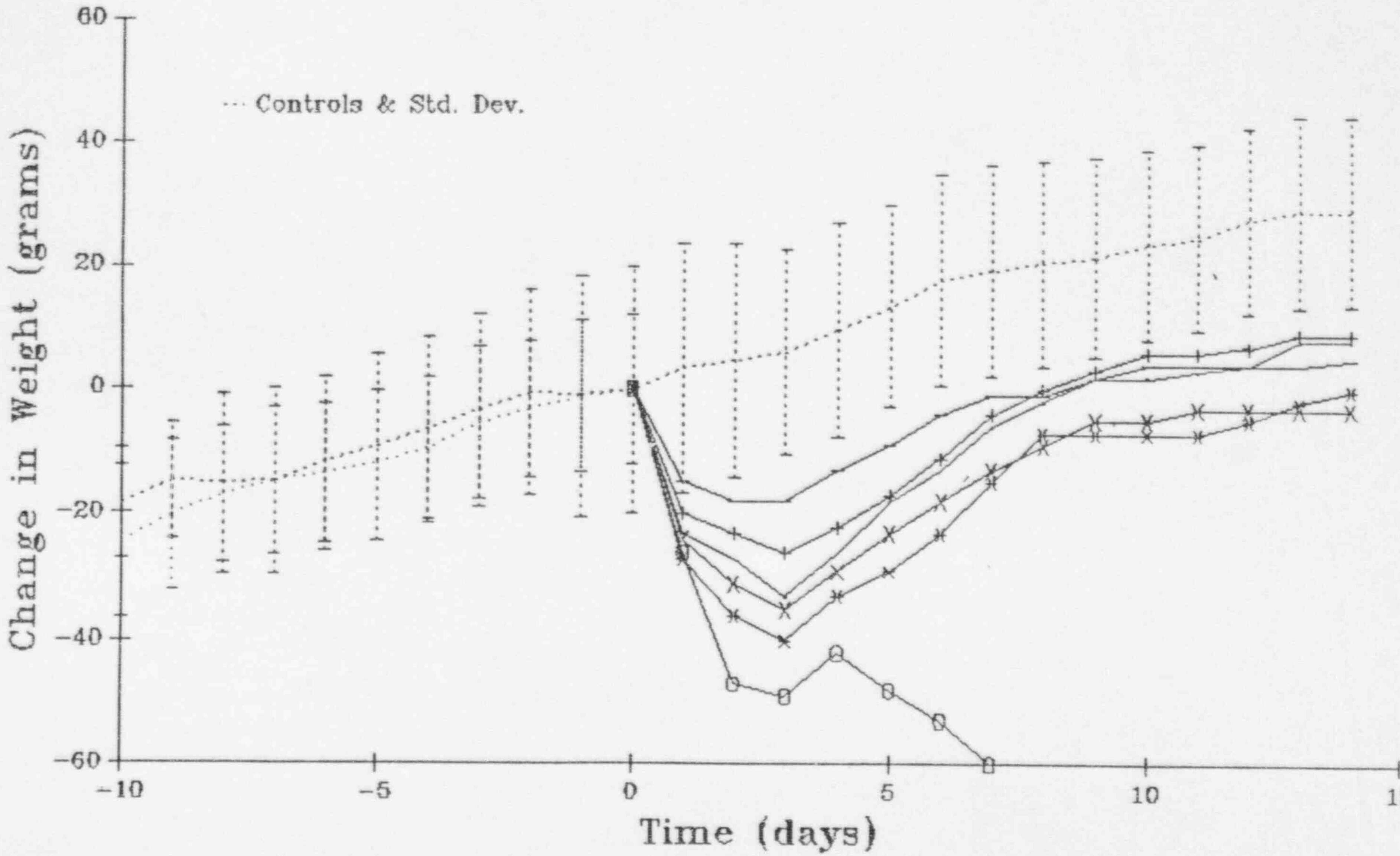


Figure 9. Change in weight of test animals following exposure to a sample decomposed in the non-flaming mode. The amount loaded in the furnace was 55 g/m$^3$ and the amount consumed was 31 g/m$^3$. Day 0 is the day of exposure. The lines prior to Day 0 indicate the mean and standard deviation of the weight gain of animals who have not been exposed and the six animals who were used in this test. In this test, one animal died on day 8.

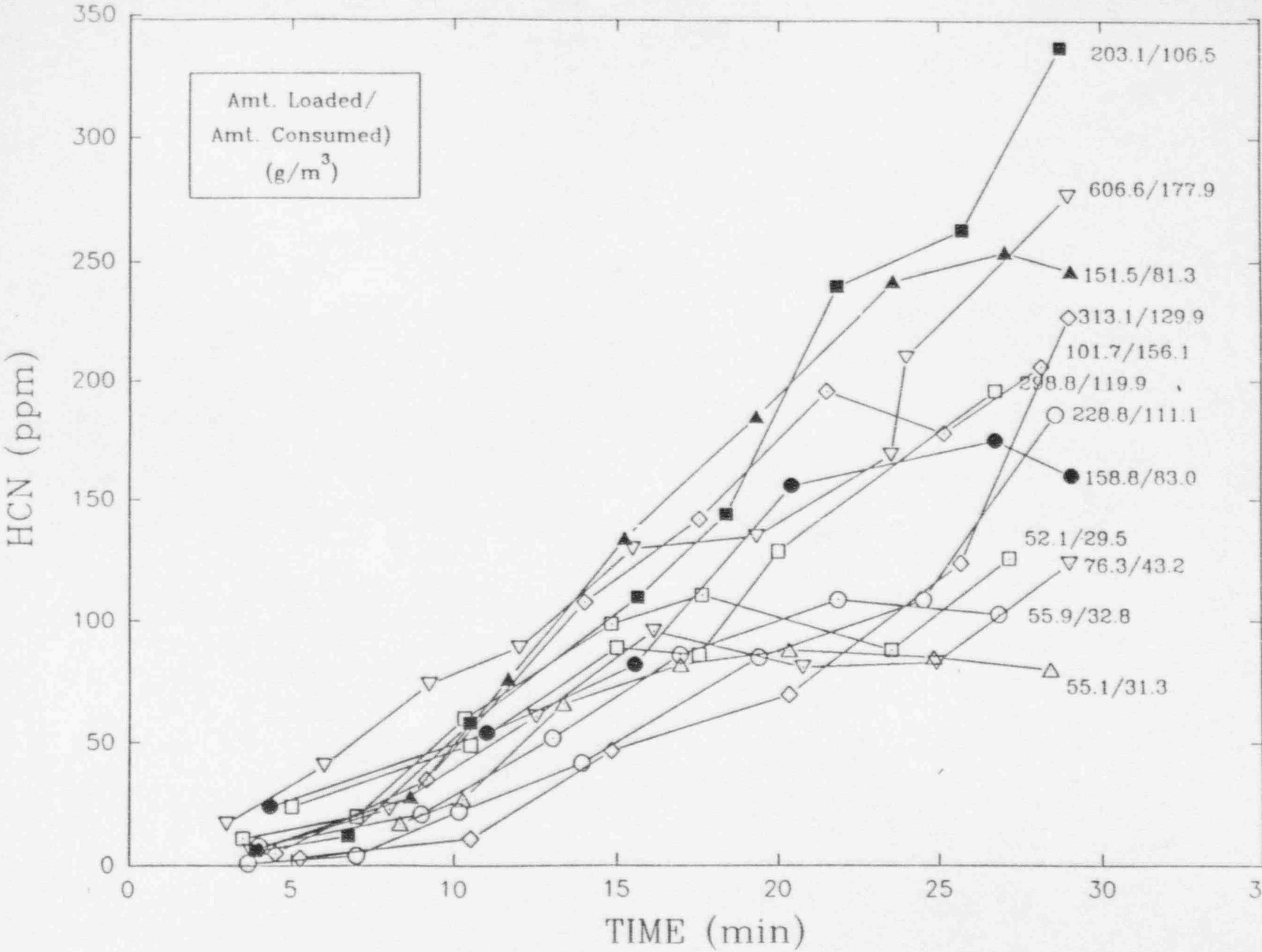

Figure 10. Hydrogen cyanide generation from samples decomposed in non-flaming mode.

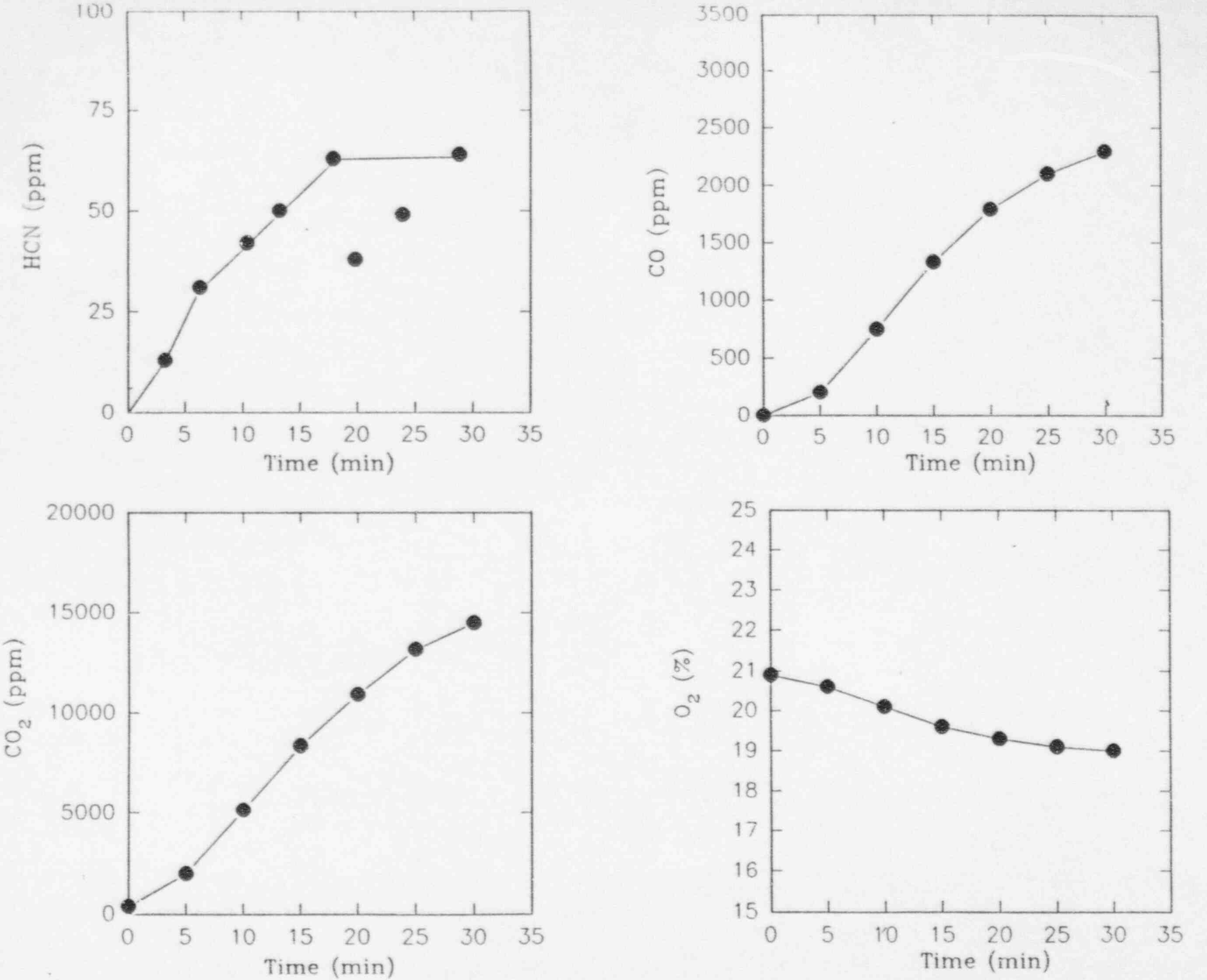


Figure 11. Gas generation from the intumescent char layer formed during the non-flaming tests. The amount of material loaded in the furnace was 194 $g/m^3$ and the amount consumed was 29 $g/m^3$.

TU ELECTRIC

Log # TXX-92219
File # 10010
# 909.5

May 1, 1992

**William J. Cahill, Jr.**
*Group Vice President*

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

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
CONFIRMATORY TESTING OF THERMO-LAG
FIRE BARRIER SYSTEM

Gentlemen:

Recent industry wide issues, relating to the Thermo-Lag fire barriers, has prompted TU Electric to initiate a comprehensive confirmatory test program to envelope the full range of protected conduit and cable tray configurations. The test program was implemented to provide further assurance of the overall adequacy of Thermo-Lag barriers at CPSES.

Thermo-Lag testing is currently scheduled for the second week in June, 1992 (June 8-12) at the following address:

OMEGA POINT LABORATORIES, INC.
6868 Alamo Downs Parkway
San Antonio, Texas 78238

TU Electric extends an invitation to your representatives to witness the confirmatory tests at Omega Point Labs.

L1/83
D039 1/0

Please contact Obaid Bhatty at (817)897-5839 to confirm your arrival or if additional information is required.

Sincerely,

William J. Cahill, Jr.

William J. Cahill, Jr.

By: Roger D. Walker

R. D. Walker
Manager of Nuclear Licensing

OB/tg

c - Mr. R. D. Martin, Region IV
Mr. B. E. Holian, NRR
Mr. T. A. Bergman, NRR
Resident Inspectors, CPSES (2)

TU ELECTRIC

Log # TXX-92228
File # 10010
# 909.5

May 6, 1992

William J. Cahill, Jr.
*Group Vice President*

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NO. 50-445 AND 50-446
EVALUATION OF THERMO-LAG 330-1 FIRE BARRIER SYSTEM

REF: 1) TU Electric letter from W. J. Cahill, Jr. to the NRC logged TXX-92219 dated May 1, 1992.

Gentlemen:

At a meeting in Rockville, Maryland on February 12, 1992, the Nuclear Regulatory Commission (NRC) expressed concerns regarding Thermo-Lag 330-1 materials. Our understanding of the current NRC staff concerns relative to Thermo-Lag 330-1 fire barrier systems are summarized as follows:

1. Adequacy of fire endurance testing and applicability of test results to as-installed configurations.

2. Adequacy of ampacity derating design bases.

3. Less than adequate installation and inspection processes and procedures as recommended by Thermal Science Inc. (TSI)

Subsequent to the Rockville presentation and other recent NRC concerns. TU Electric conducted an assessment of test results and documentation, ampacity derating design basis, and installation/inspection specifications and procedures applicable to Thermo-Lag configurations at CPSES. This review concluded that Thermo-Lag fire barrier systems at CPSES are adequately designed and installed. Accordingly, we are proceeding with application of Thermo-Lag in Unit 2 as contemplated by our completion plan and schedule. This review has been documented via an Engineering Report and includes a Design Matrix of the Thermo-Lag configurations at CPSES with associated supporting test documentation. The aforementioned Engineering Report is available at the site for your review. Specific results of TU Electric's review and related actions to the above concerns are as follows.



P. O. Box 1002 Glen Rose, Texas 76043-1002

1. Nine fire endurance tests were reviewed to support the one-hour fire rating qualification basis for Thermo-Lag configurations installed. These tests demonstrate that the vast majority of configurations are adequately substantiated by test and the commodities tested are representative of as-installed conditions. Specific instances (small diameter conduits and large cable trays) where available test documentation could be improved or detail enhanced have been identified and further evaluation is in process. Nevertheless, to provide further assurance of the overall adequacy of the Thermo-Lag program, TU Electric has initiated a comprehensive confirmatory test program to envelope the full range of protected conduit and cable tray configurations used. TU Electric has contracted directly with Omega Point Laboratories in San Antonio, Texas to conduct this program. To fabricate the test assembly, CPSES stock Thermo-Lag products will be installed by site craft personnel in accordance with our installation procedures and inspected by CPSES Quality Control (QC) inspectors. Per reference 1, TU Electric has submitted an invitation to your staff representatives to witness these confirmatory tests.

2. The TU Electric review of the CPSES design basis for applying ampacity derating factors has concluded that conservative values have been incorporated into cable sizing criteria for raceways protected with Thermo-Lag. No change to the current CPSES program is required.

3. The TU Electric review has concluded that the installation and inspection controls as implemented by the Thermo-Lag specifications and applicable procedures satisfactorily address concerns identified during the February 12, 1992, meeting. The installation drawings are significantly more detailed than corresponding TSI installation guidance. In some instances, the CPSES requirements are more conservative than TSI's recommended practices. The Thermo-Lag products are installed by CPSES site craft personnel in accordance with our installation procedures and inspected by CPSES QC inspectors. No change to the current CPSES program is required.

Upon completion of confirmatory testing activities as described above, the Thermo-Lag Engineering Report and Design Matrix will be revised to include applicable test results. The test report to be issued by Omega Point Laboratories will also be made available for review by NRC Staff personnel.

As discussed above in item 1 and reference 1, TU Electric had submitted an invitation to your staff representatives to witness these confirmatory tests during the second week of June 1992. Subsequent discussions with your staff regarding the cure time of the trowelable grade Thermo-lag, TU electric has rescheduled the confirmatory test for June 15 through June 19, 1992. However, this is a tentative schedule. We will verbally inform your representatives in ample time if there is a change in this schedule.

Should you require additional information regarding this issue or details related to the testing activities, please contact Obaid Bhatty at (817) 897-5839.

Sincerely,

William J. Cahill, Jr.

OB/ds
Enclosures

c - Mr. R. D. Martin, Region IV
Mr. B. E. Holian, NRR
Mr. T. A. Bergman, NRR
Resident Inspectors, CPSES (2)

GULF STATES UTILITIES COMPANY

RIVER BEND STATION POST OFFICE BOX 220 ST FRANCISVILLE LOUISIANA 70775

AREA CODE 504 635 6094 346 8651

May 6 , 1992
RBG-36802
File Nos. G9.5, G9.25.1.3

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Gentlemen:

River Bend Station - Unit 1
Docket No. 50-458

Please find enclosed Supplement 2 to Licensee Event Report No. 91-008 for River Bend Station - Unit 1. This report is submitted to document corrective actions for three fire areas for which Appendix R separation concerns had been identified. This supplement is submitted at this time as discussed with Mr. Elmo Collins of the NRC.

Sincerely,

W.H. Odell
Manager - Oversight
River Bend Nuclear Group

LAE/PDG/JRH/DCH/MRC/kvm

cc: U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

NRC Resident Inspector
P.O. Box 1051
St. Francisville, LA 70775

INPO Records Center
1100 Circle Parkway
Atlanta, GA 30339-3064

Mr. C.R. Oberg
Public Utility Commission of Texas
7800 Shoal Creek Blvd., Suite 400 North
Austin, TX 78757

# LICENSEE EVENT REPORT (LER)

APPROVED OMB NO. 3150-0104
EXPIRES 4/30/92
ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

| FACILITY NAME (1) | DOCKET NUMBER (2) | PAGE (3) |
|---|---|---|
| RIVER BEND STATION | 0 5 0 0 0 4 5 8 | 1 OF 0 9 |

TITLE (4) FIRE HAZARDS ANALYSIS DEFICIENCIES INCLUDING LACK OF FIRE WRAP/INADEQUATE FIRE BARRIER

| EVENT DATE (5) | | | LER NUMBER (6) | | | REPORT DATE (7) | | | OTHER FACILITIES INVOLVED (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | MONTH | DAY | YEAR | FACILITY NAMES | DOCKET NUMBER(S) |
| 0 4 | 1 5 | 9 1 | 9 1 | 0 0 8 | 0 2 | 0 5 | 0 6 | 9 2 | | 0 5 0 0 0 |
| | | | | | | | | | | 0 5 0 0 0 |

OPERATING MODE (9): 1
POWER LEVEL (10): 1 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

| | | | |
|---|---|---|---|
| 20.402(b) | 20.405(c) | 50.73(a)(2)(iv) | 73.71(b) |
| 20.405(a)(1)(i) | 50.36(c)(1) | 50.73(a)(2)(v) | 73.71(c) |
| 20.405(a)(1)(ii) | 50.36(c)(2) | 50.73(a)(2)(vii) | OTHER (Specify in Abstract below and in Text, NRC Form 366A) |
| 20.405(a)(1)(iii) | X 50.73(a)(2)(i) | 50.73(a)(2)(viii)(A) | |
| 20.405(a)(1)(iv) | 50.73(a)(2)(ii) | 50.73(a)(2)(viii)(B) | |
| 20.405(a)(1)(v) | 50.73(a)(2)(iii) | 50.73(a)(2)(x) | |

LICENSEE CONTACT FOR THIS LER (12)

| NAME | TELEPHONE NUMBER |
|---|---|
| L.A. ENGLAND, DIRECTOR - NUCLEAR LICENSING | AREA CODE 5 0 4 3 8 1 - 4 1 4 5 |

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

| CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NPRDS | CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NPRDS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |

SUPPLEMENTAL REPORT EXPECTED (14)

YES (If yes, complete EXPECTED SUBMISSION DATE) X NO

EXPECTED SUBMISSION DATE (15): MONTH DAY YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

At 1345 hours on 4/15/91, with the reactor at full power in Operational Condition 1, it was discovered that electrical cables located in fire area ET-2, which may cause spurious operation of valves 1E51*MOVF063 (RCIC inboard steam isolation valve) and 1E51*MOVF078 (RCIC vacuum breaker valve), did not have fire wrap contrary to Fire Hazards Analysis (FHA) requirements. At 1300 on 4/23/91, additional cables, which could cause the same problem were found in fire areas AB-2, C-2 and C-6. RCIC is required by the FHA for safe shutdown in these fire areas. Since these valves are required not to change position for operation of RCIC and fire damage to these cables may cause loss of RCIC, the cables would require wrapping in these fire areas.

Upon discovery of this condition, the affected cables were treated as having missing fire barriers and the action statement prescribed in Technical Specification 3/4.7.7, "Fire Rated Assemblies", was implemented for areas containing these cables. Errors made during the original development of the FHA were the cause for the identified cables not being wrapped in the identified fire areas. Additional deficiencies have been discovered during the FHA review. These recently discovered deficiencies concern Appendix R separation and a fire area that was not previously identified. GSU has implemented corrective actions to address each of these conditions.

| FACILITY NAME (1) | DOCKET NUMBER (2) | LER NUMBER (6) YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | PAGE (3) |
|---|---|---|---|---|---|
| RIVER BEND STATION | 0 5 0 0 0 4 5 8 | 9 1 | — 0 0 8 | — 0 2 | 0 2 OF 0 9 |

TEXT (If more space is required, use additional NRC Form 366A's) (17)

**REPORTED CONDITION**

At 1345 hours on 4/15/91, with the reactor at full power in Operational Condition 1, it was reported to the shift supervisor that certain electrical cables associated with valves 1E51*MOVF063 (*ISV*) (RCIC inboard steam isolation valve) and 1E51*MOVF078 (*VTV*) (RCIC vacuum breaker valve) located in fire area ET-2 (Electrical Tunnel "B" West), did not have fire wrap. This discovered condition is contrary to requirements contained in the FHA. While working on resolution of this issue, additional cables which could cause the same problem were found in fire areas AB-2, C-2 and C-6. At 1300 hours on 4/23/91, these additional areas of concern were reported to the shift supervisor. The FHA lists Method 1 as the analyzed method of shutdown for fire areas AB-2, C-2, C-6 and ET-2. Method 1 shutdown is identified as using 3 safety relief valves (SRVs) (*RV*) for reactor pressure vessel (RPV) (*JE*) pressure control, RCIC for RPV level control, and RHR-A for suppression pool cooling and shutdown cooling. The FHA lists these valves as "Passive Valves" required for Method 1 shutdown which means the valves must not change position due to fire damage on their cables. The FHA states the identified cables for these valves should be wrapped in these fire areas.

The affected cables did not have the required fire wrap (fire barrier) since plant startup; therefore, the fire barrier is considered inoperable per Technical Specification 3/4.7.7 and this report is submitted pursuant to 10CFR50.73(a)(2)(i)(B) as operation prohibited by the Technical Specification.

Additional reportable conditions have been discovered as a result of the FHA review. These conditions concern Appendix R separation and the discovery of a previously unidentified fire area. These conditions are described in the Investigation section below.

**INVESTIGATION**

The River Bend Station - Unit 1 Appendix R Data Management System lists equipment, raceways, and cables by fire area. A review of this data base found inconsistencies between the data base and the FHA for the identified cables which may cause spurious operation of valves 1E51*MOVF063 and 1E51*MOVF078. The FHA indicates the cables should be wrapped in these fire areas but the data base indicates the cables do not require wrap.

FHA Section V "Fire Hazards Evaluation Conclusions" states that for fire areas AB-2, C-2, C-6 and ET-2 shutdown can be achieved by Method 1. FHA Section I and Tables 1, 2 and 6 identify Method 1 shutdown equipment. Reactor core isolation cooling (RCIC) (*BN*) is used for reactor pressure vessel (RPV) level control in Method 1 shutdown. The RCIC inboard steam isolation valve 1E51*MOVF063 and the RCIC vacuum breaker valve 1E51*MOVF078 are passive valves for Method 1 shutdown which means they must not change position due to fire damage. FHA Table 2 states that cables for these two valves, which may result in spurious signals, are wrapped in these fire areas. Circuit analysis on cables 1ICSABC001 and 1ICSABC004 (*CBL2*) found that fire damage can cause spurious closure of valve 1E51*MOVF063 which would prevent steam from reaching the RCIC turbine (*TBR*). Circuit analysis on cables 1ICSEBC001 and 1ICSEBC003 found that fire damage can cause spurious opening of valve 1E51*MOVF078 which would adversely affect RCIC vacuum breaker capabilities.

Since these valves are required not to change position for operation of RCIC and RCIC is required for safe shutdown in the affected fire areas, the valves are correctly classified in the FHA as "Passive - Method 1 Components". Therefore, to comply with the USAR, FHA, and 10CFR50 Appendix R Section III.G, the cables would require wrapping in fire areas AB-2, C-2, C-6 and ET-2. With the exception of FHA Table 8 with regards to fire area AB-2, the FHA correctly indicates these cables require wrapping in these fire areas. The Appendix R data base is incorrect as it indicates the cables are not required to be wrapped.

Additional reportable conditions have been discovered as a result of the FHA review. These conditions concerned Appendix R separation and the discovery of a previously unidentified fire area. The Appendix R separation concerns involve fire area C-25 (main control room), FB-1 (fuel building), and RC-5/Z-13 (containment building). The previously unidentified fire area is a small electrical cable chase room located in the Northeast corner of D Tunnel on elevation 70' in the auxiliary building. These additional concerns are discussed individually below.

Fire Area C-25 (main control room):

The FHA identifies fire area C-25 as an area where alternate shutdown capability is provided. FHA Table 3 (method 1E - main control room fire required items) lists specific spent fuel pool cooling & cleanup (SFC) system and fuel building ventilation (HVF) system equipment as being required and therefore, independent of the fire in the control room. Review of circuits for this equipment determined the circuits are not electrically independent from the control room and potential fire damage could cause loss of the equipment which may result in loss of spent fuel pool cooling.

Fire Area FB-1 (fuel building):

Fuel building ventilation dampers 1HVF*AOD037A, 102 and 122 are identified in the FHA as equipment required for spent fuel pool cooling. Potential fire damage to electrical cables, located in fire area FB-1, for these dampers may cause spurious operation of the dampers which could potentially cause loss of the spent fuel pool cooling pump and thus loss of spent fuel pool cooling. Pre-fire strategies for this area stated these dampers must be verified to be in their proper position and if not, remove power so they fail to the correct position. Removing power to these dampers may not cause the dampers to go to the correct position since a potential hot short could cause the damper to remain in the incorrect position.

Fire Area RC-5/Z-13 (containment building):

USAR Section 9A.2.2.1 states "Safe shutdown Method 1 and 2 equipment, instrumentation and electrical cables are well separated in the Containment. The east (Division II - blue) side of containment is separated from the west (Division I - red) side by the main steam tunnel on the south and by an area free of combustibles on the north. Safe shutdown by either Method 1 or 2 can be used, depending on the actual location of the fire in the containment." With a fire in the west side (Division I), safe shutdown could be achieved using Method 2 equipment (Division II).

The FHA identifies the fact that containment unit cooler 1HVR*UC1B and related valves 1SWP*MOV502B & 503B (Method 2 equipment) are located on the west side of containment on elevation 162'-3" in Fire Area RC-5/Z-13. Valves 1SWP*MOV502B & 503B are inlet and outlet valves controlling cooling water to the unit cooler heat exchanger. The FHA states that this equipment is separated from its alternate counterpart by 24 ft. In addition, a 10 ft. missile barrier serves as a radiant energy shield and intervening combustibles are wrapped with a 3-hour rated product.

Unit coolers 1HVR*UC1A & 1B are separated from each other by a minimum distance of approximately 11'-2" (not 24' as reported in the FHA). A 10' high, 18" thick reinforced concrete missile barrier, which acts as a radiant energy shield, is located between the redundant unit coolers and related SWP valves. However, electrical cables for the redundant unit coolers and valves are routed such that the missile barrier is not located between redundant cables. Electrical cables for 1HVR*UC1B are in conduit # 1CL540BB and are routed along the containment liner. One portion of this conduit that is located within 20' of the redundant conduit # 1CL540RC (electric cables for 1HVR*UC1A) is wrapped with a three hour rated Thermo-lag conduit fire wrap material. The 20' dimension used was taken along the direct line between the two conduits, not horizontal distance as required by Appendix R. Since both conduits are routed along the containment liner but at different elevations, this application o the 20' rule allowed one of these redundant cables to be located directly over the other (separated by a minimum distance of 20' vertical but 0' horizontal) and not provided with the fire wrap material. Cables associated with the SWP valves also do not meet the 20 ft. horizontal separation criteria as identified in 10CFR50 Appendix R, Section III.G.

Valve 1SWP*MOV5A is listed as a component required for Method 2 safe shutdown in the FHA. This valve isolates Division II from Division 1 standby service water and is also located on the west side of the containment. This valve is located on elevation 153'-9" and is separated from its counterpart by a horizontal distance of 20'-2", however; this distance is not free of intervening combustibles. The intervening combustibles consist of electrical cables located in two 18" wide cable trays. A review of the cable routing for the 5A valve found that the cables do not meet the 20 ft. horizontal separation criteria as identified in 10CFR50 Appendix R, Section III.G.

Fire Area AB-18 (previously unidentified)

During the final FHA review, all fire areas except one were found to have a fire hazards analysis and 58 of 62 fire areas were found to have administrative controls identified in the FHA included in their pre-fire strategies. A fire hazards analysis for the new fire area, not previously identified in the FHA, was performed to determine potential impact on safe shutdown capability. The analysis determined that safe shutdown for this new fire area is provided utilizing Method 1 shutdown equipment and by initiating high pressure core spray (HPCS) in lieu of reactor core isolation cooling (RCIC) for level control during a fire. Also, administrative controls to align valve 1SFC*MOV120 to supply cooling to the upper fuel pools were necessary. Modification request (MR) 92-0013 was initiated on January 27, 1992, to make necessary document changes to the FHA and USAR for the new fire area. A new pre-fire strategy was prepared to identify this information to reactor operators and the fire brigade. Pre-fire strategies for the four fire areas were revised to include the omitted administrative controls identified in the FHA.

## CORRECTIVE ACTIONS

A detailed review and verification of the FHA by ~~an~~ independent contractor was initiated as a result of NRC Inspection Report No. 50-458/90-02. The conditions as described in this report were identified by the independent contractor during resolution of questions identified in the review and verification process. Evaluations of all questions arising from the final review of the FHA by the independent contractor were completed in January 1992.

Upon discovery of the condition identified on 4/15/91, the affected cables were treated as having missing fire barriers and the action statement prescribed in Technical Specification 3/4.7.7, "Fire Rated Assemblies", was implemented for areas containing these cables. With the exception of the Division II electrical room located in the northeast corner of "D" tunnel on elevation 70', fire watches had been previously in place for the affected areas due to operability questions associated with penetration seals. However, there is no assurance that fire watches had been in place for the entire time period since startup.

For the affected fire areas, an analysis has been performed to determine what alternate system for RCIC is available (free of fire damage). The analysis determined that low pressure core spray (LPCS) (*BM*) is free of fire damage in Fire Areas AB-2, C-2, & C-6 and high pressure core spray (HPCS) (*BJ*) is free of fire damage in Fire Area ET-2.

Errors made during the original development of the FHA were the cause of inconsistencies found within the FHA and between the FHA and the Appendix R data base. These inconsistencies resulted in the identified circuits not being protected in accordance with 10CFR50, Appendix R, Section III.G. A contributing factor involving these errors appears to be the fact that the affected components are Division II and are required for Method 1 shutdown, which primarily uses Division I and III components. Review of this condition has determined there are also Division I cables/equipment which are required for Method 2 shutdown, which primarily uses Division II components. The cables for this type of equipment are considered "Appendix R Crossover Cables". Analysis has determined that there are approximately 80 of these crossover cables. A review of these crossover cables was performed and with one exception no similar deficiencies exist. The exception is the Division II cable chase area located in the northeast corner of D-Tunnel. In this area, RCIC may be lost due to fire damage on crossover cables. As previously stated in the investigation, it was found that this area had not been previously identified or evaluated in the FHA. Analysis for this new fire area (AB-18) demonstrates safe shutdown capability is provided. Since the area contains only Division II cabling, safe shutdown can be achieved utilizing Method 1 shutdown methodology and substituting HPCS for RCIC for RPV level control. The corrective actions to address the new fire area included the identification of the proper safe shutdown method, implementation of administrative controls to align valve 1SFC*MOV120 to provide cooling to the upper fuel pools, documentation changes to the FHA and USAR, and the preparation of a pre-fire strategy for this area.

Fire Area C-25 (Main Control Room):

Immediate actions were taken and administrative controls implemented to address the concerns with spent fuel pool cooling until permanent corrective actions could be identified and implemented. Engineering analysis determined that the time required for the spent fuel pool temperature to reach the cooling system design limit of 155.6 degrees F with the existing fuel load conditions prior to RF-4 was approximately 5.3 days. Administrative controls were implemented and AOP-0031 ("Shutdown From Outside Main Control Room") was revised to provide the necessary manual actions to restore spent fuel pool cooling with a fire in the main control room. The entire reactor core was offloaded to the fuel building spent fuel pool for RF-4. With the increased heat load in the fuel pool, the minimum time required to reach the cooling system design limit of 155.6 degrees F was approximately 4 hours. This is sufficient time to take the manual actions identified in AOP-0031.

The corrective action for addressing the concerns with spent fuel pool cooling is to complete an analysis which demonstrates a design which allows a higher spent fuel pool temperature and still allows sufficient time to restore spent fuel pool cooling. With this revised design bases, the spent fuel pool cooling equipment presently identified as required by the FHA would not be immediately required. This analysis is scheduled to be completed by July 10, 1992. Any modifications found necessary will be scheduled during Fuel Cycle 5. MR 92-0038 has been approved to complete analysis of long term corrective actions. The administrative controls and manual actions discussed above will be maintained until long term corrective actions are implemented.

Fire Area FB-1 (Fuel Building):

The immediate action taken was to treat the electrical cables as having missing fire barriers and initiate a continuous fire watch per RBS Technical Specification. After actions identified above for the main control room was implemented and pre-fire strategies for Fire Area FB-1 were revised to identify the manual actions required to place the dampers in the correct position, the continuous fire watch was removed. The permanent corrective action for this condition will be addressed with completion of the analysis and modifications, if required, as discussed above for the main control room.

Fire Area RC-5/Z-13 (Containment Building):

The immediate action taken was to treat the cables as having missing fire barriers and initiate an hourly fire watch per RBS Technical Specification.

The permanent corrective action for this condition will be to provide an analysis which demonstrates the unit coolers are not required or install noncombustible radiant energy shields to provided separation in accordance with Appendix R, Section III.G.2.f. Modification request (MR) 92-0037 has been approved to install the required radiant energy shields if needed. The analysis to demonstrate the unit coolers are not required and the preparation of MR 92-0037 will proceed concurrently. This approach will allow the analysis and/or installation of the radiant energy shields to be completed prior to startup from RF-4.

Similar events have been reported in LERs 87-005, 89-009, 89-036, and 90-003. LERs 87-005, 89-009 and 90-003 reported installation-related deficiencies in Thermo-Lag fire barriers. LER 89-036 reported an event in which the fire hazards analysis specified that certain motor-operated valves (MOVs) should be normally de-energized. The actual condition of the valves was that they were energized. New issues identified during the FHA review have revealed FHA deficiencies concerning spent fuel pool cooling and a previously unidentified fire area.

## SAFETY ASSESSMENT

The FHA states safe shutdown can be achieved in fire areas AB-2, C-2, C-6 and ET-2 using Method 1 shutdown. Method 1 is identified as using 3 SRVs for RPV pressure control, RCIC for RPV level control, and RHR-A for suppression pool cooling and shutdown cooling. Since the affected cables were not wrapped in these fire areas, fire damage could cause loss of RCIC. With the loss of RCIC, a review was made to determine what alternate method of RPV level control was available in these fire areas. Analysis has demonstrated that for Fire Areas AB-2, C-2 & C-6, LPCS is free of fire damage and for ET-2 & the new fire area (AB-18), HPCS is free of fire damage. This demonstrates that with a fire in any of these fire areas, at least one method of safe shutdown is unaffected.

Fire Areas C-25 (main control room) and FB-1 (fuel bldg.) were identified as areas where potential fire damage could cause a loss of spent fuel pool cooling. Calculation No. G13.18.14.0*46-0 was developed which demonstrates the time required for the spent fuel pool temperature to reach the design limit of 155.6 degrees F with the present fuel load is approximately 5.3 days. Abnormal Operating Procedure (AOP)-0031 "Shutdown From Outside Main Control Room" and pre-fire strategies for fire area FB-1 have been revised to address manual actions which may be required to restore spent fuel pool cooling with a fire in these areas. These corrective actions and administrative controls have been implemented to address these concerns under present fuel pool load conditions until permanent corrective actions are identified and implemented.

The FHA indicates safe shutdown can be achieved in Fire Area RC-5/Z-13 (reactor containment bldg.) using Method 1 or 2 depending on the location of the fire. The FHA states containment unit cooler 1HVR*UC1B is separated from its alternate counterpart by 24 ft. and a

10 ft. radiant energy shield and is being protected from intervening combustibles by wrapping the intervening combustibles with a 3-hour rated barrier. Since the cables for this unit cooler were not wrapped in accordance with Appendix R, Section III.G requirements, fire damage could cause a loss of containment cooling. The affected cables were treated as having missing fire barriers and fire watch requirements specified in Technical Specification 3/4.7.7, "Fire Rated Assemblies" have been implemented.

NOTE: Energy Industry Identification System Codes are identified in the text as (*XX*).

Log # TXX-92228
File # 10010
# 909.5

**TU**ELECTRIC

May 6, 1992

**William J. Cahill, Jr.**
*Group Vice President*

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NO. 50-445 AND 50-446
EVALUATION OF THERMO-LAG 330-1 FIRE BARRIER SYSTEM

REF: 1) TU Electric letter from W. J. Cahill, Jr. to the NRC logged TXX-92219 dated May 1, 1992.

Gentlemen:

At a meeting in Rockville, Maryland on February 12, 1992, the Nuclear Regulatory Commission (NRC) expressed concerns regarding Thermo-Lag 330-1 materials. Our understanding of the current NRC staff concerns relative to Thermo-Lag 330-1 fire barrier systems are summarized as follows:

1. Adequacy of fire endurance testing and applicability of test results to as-installed configurations.

2. Adequacy of ampacity derating design bases.

3. Less than adequate installation and inspection processes and procedures as recommended by Thermal Science Inc. (TSI).

Subsequent to the Rockville presentation and other recent NRC concerns. TU Electric conducted an assessment of test results and documentation, ampacity derating design basis, and installation/inspection specifications and procedures applicable to Thermo-Lag configurations at CPSES. This review concluded that Thermo-Lag fire barrier systems at CPSES are adequately designed and installed. Accordingly, we are proceeding with application of Thermo-Lag in Unit 2 as contemplated by our completion plan and schedule. This review has been documented via an Engineering Report and includes a Design Matrix of the Thermo-Lag configurations at CPSES with associated supporting ~~test~~ documentation. The aforementioned Engineering Report is available at the site for your review. Specific results of TU Electric's review and related actions to the above concerns are as follows.

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P. O. Box 1002 Glen Rose, Texas 76043-1002

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1. Nine fire endurance tests were reviewed to support the one-hour fire rating qualification basis for Thermo-Lag configurations installed. These tests demonstrate that the vast majority of configurations are adequately substantiated by test and the commodities tested are representative of as-installed conditions. Specific instances (small diameter conduits and large cable trays) where available test documentation could be improved or detail enhanced have been identified and further evaluation is in process. Nevertheless, to provide further assurance of the overall adequacy of the Thermo-Lag program, TU Electric has initiated a comprehensive confirmatory test program to envelope the full range of protected conduit and cable tray configurations used. TU Electric has contracted directly with Omega Point Laboratories in San Antonio, Texas to conduct this program. To fabricate the test assembly, CPSES stock Thermo-Lag products will be installed by site craft personnel in accordance with our installation procedures and inspected by CPSES Quality Control (QC) inspectors. Per reference 1, TU Electric has submitted an invitation to your staff representatives to witness these confirmatory tests.

2. The TU Electric review of the CPSES design basis for applying ampacity derating factors has concluded that conservative values have been incorporated into cable sizing criteria for raceways protected with Thermo-Lag. No change to the current CPSES program is required.

3. The TU Electric review has concluded that the installation and inspection controls as implemented by the Thermo-Lag specifications and applicable procedures satisfactorily address concerns identified during the February 12, 1992, meeting. The installation drawings are significantly more detailed than corresponding TSI installation guidance. In some instances, the CPSES requirements are more conservative than TSI's recommended practices. The Thermo-Lag products are installed by CPSES site craft personnel in accordance with our installation procedures and inspected by CPSES QC inspectors. No change to the current CPSES program is required.

Upon completion of confirmatory testing activities as described above, the Thermo-Lag Engineering Report and Design Matrix will be revised to include applicable test results. The test report to be issued by Omega Point Laboratories will also be made available for review by NRC Staff personnel.

As discussed above in item 1 and reference 1, TU Electric had submitted an invitation to your staff representatives to witness these confirmatory tests during the second week of June 1992. Subsequent discussions with your staff regarding the cure time of the trowelable grade Thermo-lag, TU electric has rescheduled the confirmatory test for June 15 through June 19, 1992. However, this is a tentative schedule. We will verbally inform your representatives in ample time if there is a change in this schedule.

Should you require additional information regarding this issue or details related to the testing activities, please contact Obaid Bhatty at (817) 897-5839.

Sincerely,

William J. Cahill, Jr.

OB/ds
Enclosures

c - Mr. R. D. Martin, Region IV
Mr. B. E. Holian, NRR
Mr. T. A. Bergman, NRR
Resident Inspectors, CPSES (2)

GULF STATES UTILITIES COMPANY

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May 6, 1992
RBG- 36803
File Nos. G9.5, G15.4.1

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Gentlemen:

River Bend Station - Unit 1
Docket No. 50-458/Report 92-04

This letter provides Gulf States Utilities Company's (GSU) response to the unresolved items noted in NRC Inspection Report No. 50-458/92-04. This letter describes GSU's corrective actions and provides anticipated completion dates. In addition, other fire protection issues discussed at the April 20 meeting at River Bend Station are addressed in this response.

Should you have any questions, please contact Mr. L.A. England at (504) 381-4145.

Sincerely,

W.H. Odell
Manager - Oversight
River Bend Nuclear Group

LAE/PDG/FRC/JCM/IRH/kvm

cc: U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

NRC Resident Inspector
P.O. Box 1051
St. Francisville, LA 70775

ATTACHMENT 1

Response to Unresolved Item 50-458/9204-01

REFERENCES

Inspection Report - Letter from A.B. Beach to J.C. Deddens, dated March 27, 1992

Licensee Event Report No. 90-003 (Rev 3) - Letter from W.H. Odell to U.S. NRC, dated June 28, 1991

Licensee Event Report No. 90-003 (Rev 2) - Letter from W.H. Odell to U.S. NRC, dated February 4, 1991

Licensee Event Report No. 90-003 (Rev 1) - Letter from W.H. Odell to U.S. NRC, dated July 12, 1990

Licensee Event Report No. 90-003 - Letter from W.H. Odell to U.S. NRC, dated March 8, 1990

Revision to Informational Report - Letter from J.E. Booker to U.S. NRC, dated January 9, 1990

Informational Report - Letter from J.E. Booker to U S. NRC, dated December 20, 1989

Licensee Event Report No. 89-009 - Letter from J.E. Booker to U.S. NRC, dated April 7, 1989

Licensee Event Report No. 87-005 - Letter from to U.S. NRC, dated February , 1987

History of Thermo-lag Issues at River Bend Station

In February of 1987, GSU discovered minor problems with installation of Thermo-lag fire barriers. These were identified in LER 87-005 and a commitment was made to perform a 100% inspection of the surface of Thermo-lag barriers. As a result of this inspection, GSU found a Thermo-lag panel with the stress skin, a wire reinforcing material, removed. This condition appeared to be common for fuel building 3-hour barriers. As a result, fire watches were verified or established for the fuel building. GSU decided to pursue qualification testing of these "in situ" conditions based on discussions with Thermal Science, Inc. (TSI) in which GSU was told that the stress skin was not necessary for a Thermo-lag barrier to meet its design function as a fire barrier.

GSU and TSI developed a test procedure from August 1987 to February 1988, specifically for a 12 inch tray covered with Thermo-lag 330 with no internal stress skin or ribs. The initial test was performed on the test article with no internal stress skin on March 9, 1988; however, beacuse the furnace temperature went beyond limits, test results were invalid. The test was repeated on July 29, 1988 and the fire barrier failed. GSU verified or established fire watches for 3-hour cable tray barriers in all buildings due to the possibility of this situation existing with other 3-hour cable tray barriers.

An evaluation of the installation at RBS showed removal and replacement of the Thermo-lag to be undesirable. GSU attempted fire tests to upgrade cable tray barriers. In the third quarter of 1988, Southwest Research Institute (SWRI) was contracted to perform fire tests on cable tray fire barriers. A test procedure was developed for SWRI to test several upgrades to existing installations as well as the "original design" configuration. The test was placed on hold in the spring of 1989 after discussions with TSI. TSI offered to run "informational" fire tests on 12 inch trays with various upgrades as well as a full qualification test of a 30 inch tray at Construction Technologies Laboratory (CTL) in Chicago, Illinois.

The results of the informational tests run by TSI in the spring of 1989 indicated potential problems with "original design" installations for 30 inch cable trays. Of the potential upgrades developed and tested by TSI, several passed; however, all the upgrades would be difficult to install.

The 30 inch cable tray test article to be tested at CTL was constructed by TSI under their QA program. The completed test article was inspected by GSU and several differences were noted between the construction of the test article and standard construction details allowed in the TSI installation manual. The test article successfully passed the qualification test.

Based on the differences between CTL tests and standard installation practices, GSU decided to pursue testing at SWRI. The SWRI test included two 30 inch tray installations, one using standard Thermo-lag installation practices as allowed by the TSI installation manual and the second using a competitor's product to compare both the installation process and fire resistance. The test also included other miscellaneous penetration seal details. The test article was constructed by GSU technicians trained and certified by TSI. The test at SWRI was completed on October 26, 1989. The Thermo-lag barrier failed approximately 47 minutes into the test. Condition Report (CR) 89-1144 was initiated to document the test failure and ensure that all areas with Thermo-lag had fire watches in effect. Extensive discussions were held with TSI regarding the results of the SWRI tests. TSI regarded the SWRI test as invalid, which is a point of technical disagreement between TSI and GSU. A detailed review by GSU of TSI fire tests identified several areas of concern. These concerns were documented in informational reports to the NRC dated December, 1989 and January, 1990. The three primary areas of concern were: size of test articles, use of aluminum conduit, and joint construction methodology.

To resolve both the disagreement and the GSU concerns, an agreement was reached between TSI and GSU to jointly perform fire tests on the in situ Thermo-lag configurations as well as simplified upgrades. Four configurations were tested for both 1-hour and 3-hour qualification: conduit, cable tray, Unistrut support, and vault enclosure. The test procedure was developed from March to August, 1990. The test articles were constructed in September and October 1990, and testing was performed in November 1990. The test results are summarized in Table 1-1.

## TABLE 1-1
## SUMMARY OF IN-SITU TEST RESULTS

| TEST ARTICLE | TEST TYPE | RESULT |
|---|---|---|
| CONDUIT | 1 HR | FAIL |
| CONDUIT | 3 HR | FAIL |
| CABLE TRAY | 1 HR | FAIL |
| CABLE TRAY | 3 HR | FAIL |
| SUPPORT | 1 HR | PASS |
| SUPPORT | 3 HR | PASS |
| VAULT | 1 HR | PASS |
| VAULT | 3 HR | FAIL |

## TABLE 1-2
## SUMMARY OF UPGRADE TEST RESULTS

| TEST ARTICLE | TEST TYPE | RESULT |
|---|---|---|
| CONDUIT | 1 HR | PASS |
| CONDUIT | 3 HR | PASS |
| CABLE TRAY | 1 HR | PASS |
| CABLE TRAY | 3 HR | FAIL |
| VAULT | 3 HR | PASS |

Configuration upgrade tests were conducted on only those configurations which failed the in-situ tests. An additional upgrade configuration was tested for cable trays with a 3-hour fire rating but was not completely successful in that the barrier failed after 2 hours, 55 minutes. The results are summarized in Table 1-2. An alternate product is being evaluated for 3-hour cable tray fire barriers; however, the preliminary results of an ampacity review indicate that some cables will have to be relocated or resized. Also, a structural review will be required due to the increased weight of the barrier. A study of the cost of implementing Thermo-lag upgrades for the other configurations versus a new product showed that the Thermo-lag upgrade is more economically desirable. However, due to concerns related to the recent NRC investigation of TSI, work has been stopped on implementing any upgrade. GSU's schedule for final resolution is dependent on the results of reviews and actions taken by the NUMARC ad hoc committee on Thermo-lag barriers.

GSU's Response to Section 4.2.1, "Thermo-lag Removal"

As part of the Fire Barrier Task Force investigation, Thermo-lag fire barriers were removed in a number of plant locations around junction boxes, conduit seals, and wall penetrations to permit inspection of internal components. The Thermo-lag removed was not immediately re-installed since GSU had previously declared all Thermo-lag barriers inoperable, and had established fire watches for compensatory measures in accordance with the RBS Technical Specifications. The penetration and conduit seal inspections that required removal of Thermo-lag fire barrier material were documented as part of GSU's maintenance work order system. The documentation was designed to ensure that when the re-installation of Thermo-lag material began, all inspection points would be covered with the fire barrier material. The practice of not immediately re-installing Thermo-lag was ceased in July, 1991 when Engineering informed Maintenance that a safety evaluation in a licensee event report credits existing Thermo-lag as providing some degree of protection even though it is being treated as inoperable.

All removed sections of Thermo-lag have been re-installed and sections of Thermo-lag removed in the future will be re-installed upon completion of the work activities necessitating their initial removal.

GSU's Response to Section 4.2.2, "Structural Integrity of Thermo-lag Installation"

ISSUE: The inadvertent operation of fire protection systems potentially causing damage to the materials.

RESPONSE: The damage to the F tunnel enclosure which was observed during the January 1992 NRC inspection was caused by a leak above the enclosure. Upon further investigation by GSU personnel, it was determined that the leak had caused degradation to the trowel grade material applied to the seams/joints of the enclosure and that no damage to the TSI prefabricated panels used to form the enclosure had occurred. The investigation included examinations to both the inside and outside surfaces of the enclosure. Repair of the trowel grade seam/joint closures will be completed during RF-4. Contrary to the assumption in the NRC Inspection Report, there is no record of actuation, inadvertent or designed, of fire protection systems WS-8L or 8M which protect inside enclosures in F tunnel.

ISSUE: Overall structural integrity of the enclosures, specifically drains provided for the enclosures appeared not to be designed to remove all water within the enclosures during an actuation of the cable tray sprinkler systems.

RESPONSE: The design does not assume all water is removed. Since all enclosures using Thermo-lag material are designed to isolate redundant safety-related cable divisions, these enclosures are seismically designed and supported. The support framework is designed to carry the weight of the TSI prefabricated panel assemblies and the calculated weight of water introduced upon operation of the sprinkler systems. The determination of the amount of water introduced is based on review of the sprinkler contractor's calculations of water discharge by nozzles located within the enclosures. Since operation of the systems is alarmed in the control room, first by an indication of smoke detector actuations and then by a water flow alarm signaling actual flow through the nozzles, appropriate actions to respond to the event are assured. The drainage provided for the enclosures is designed to ensure that the height of water assumed in the design will not be exceeded.

Following these types of events, investigation as to the condition of the enclosures and the ability to remain in full service is required. These actions are considered similar to the actions and investigations which are required in the event of any sprinkler actuation or actual fire at the plant. The worse case scenario is that associated with the degradation of the enclosure floors due to the build-up of fire suppression water. The Thermo-lag material could possibly give way and the retained water would be dumped on the tunnel floor. We believe this would take place sufficiently long enough after the actuation of the sprinkler system for the fire brigade to respond to the alarm in the control room (typically 10-15 minutes). This event is discussed in GSU's response to Section 4.2.3, below.

GSU's Response to Section 4.2.3, "Qualification Testing of Installed Configurations"

ISSUE: For assemblies that had passed previous fire tests, none of the tests had simulated the fire suppression systems being activated both internal and external to the fire barrier enclosures as installed in the F and G tunnels. No documentation of tests or an engineering evaluation could be provided at the time of the inspection.

RESPONSE: The design objective is to provide an enclosure which is structurally sound and fire resisting. The steel Unistrut support frame is designed to seismically support itself and the prefabricated Thermo-lag panels. It is also designed to carry a 15 inch deep pool of water on its floor. The prefabricated panels are rated for the required 1-hour fire resistance.

For cases of external transient fire, the panels protect the Division I cables inside the enclosure. The fire suppression water discharged by the sprinkler system creates a pool of water on the floor of the enclosure and dissipates the heat that may be transferred to the supporting steel through the panel.

Typical results from the 3-hour fire endurance tests conducted by TSI on Thermo-lag 330 Conformable, Three Hour Stress Skin Fire Wall System, (Ref. I.T.L. Report No. 82-3-2) recorded at test conclusion an unexposed side surface temperature ranging from 190 degrees F to 250 degrees F. Based on this test information, and given that the supporting steel of the enclosure is immersed in a pool of water, it can be reasonably projected that for a 1-hour barrier, the cold side temperature including that of the supporting steel will not exceed 150 degrees F.

The steel frame is sufficiently flexible because of the sizes of members and bolted connections to accommodate differential thermal expansions resulting from the above scenario without any appreciable stresses and any adverse impact on the structural integrity.

Therefore, the design of the barriers was judged to satisfy the design objective and special qualification testing was not considered necessary.

<u>ISSUE:</u> An accepted and successful test configuration for an 18 inch cable tray was used to simulate the large floor/ceiling installation (approximately 10 x 12 ft) in the G tunnel, the 4 x 6 x 150 ft cable tray enclosure in the F and G tunnels, and the 4 x 6 x 6 ft instrument rack enclosure on the 98 ft elevation of the control building. No engineering evaluation was readily available that would demonstrate that a small scale design could be effectively extrapolated to the sizes that exist at RBS.

<u>RESPONSE:</u> The design basis for Thermo-lag enclosures described above include the following:

- Configurations provided by TSI in their Technical Note 20684, Revision 3, dated February 1985, are used as shown or adopted to suit the plant conditions. The use of Thermo-lag based on the Technical Note was considered equivalent to the use of gypsum wall board design for a specific fire rating based on U.L. standards. Project specific testing was not considered to be necessary since the Technical Note was reported to be based on actual tests.

- The enclosures isolate either the Division I or Division II cable trays and equipment so that a fire confined to one fire area will not cause a loss of both divisions.

- Transient fires within the enclosures are not credible since the areas within the enclosures are inaccessible. Any entrance into the enclosures for maintenance and inspection of fire protection equipment is by personnel well trained in the RBS fire protection program, including the importance of the enclosures.

All three configurations are considered appropriate applications of TSI Technical Note 20684 requirements as outlined under the design basis above, and were not originally evaluated based on similarities with the 18 inch cable tray design as reported in the NRC Inspection Report. The specific applications in the F and G tunnels and for the instrument rack are spacial enclosures rather than fire wraps around a single cable tray. They are based on the published capability of the panel designs to resist fire for the specific hourly rating required.

In essence, the enclosures are considered one-way fire barriers designed to protect the cable and/or equipment within the enclosures from transient or cable induced fires located outside the enclosures. In areas, such as the F and G tunnels which have automatic fire detection and suppression systems, barrier ratings are 1-hour in conformance with the RBS USAR. Areas without automatic fire suppression systems have fire barriers rated for 3-hour fire resistance (SCENARIO 3).

The RBS enclosure designs use techniques ordinarily used to adapt specific small scale tested configurations to large assemblies. As in the design of gypsum board walls and floor-ceiling assemblies the more critical components of the overall design are the materials used, the spacing and anchoring of supports, the method of attaching the gypsum boards to the support system, and the requirements to finish and close joints and seams. Using the guidance provided in TSI Technical Note 20684, Figure 8, the RBS enclosures use prefabricated panels adequately secured to Unistrut supports at designed spacings generally not to exceed 12 inches. Cases where the 12 inch spacing is exceeded have been reviewed and approved by Engineering. All joints and seams are closed with trowel grade 330-1 subliming material. The TSI documentation does not limit the overall dimensions of the Figure 8 fire wall design. The only reference to a size limitation appears in Section 2.1 which restricts the length of a bottom section of a cable tray enclosure configuration to 6.5 feet "since longer sections are unwieldy and more difficult to install." This statement pertains to an installation difficulty which was overcome by the design details prepared for these enclosures by qualified fire protection engineers.

ISSUE: There is no assurance that the exposed structural steel Unistruts would not fail and jeopardize the integrity of the floor-ceiling assembly.

RESPONSE: As noted above, the barriers in the F and G tunnels are designed as one-way barriers. Effects of fires internal to the enclosures are discussed under SCENARIOS, below.

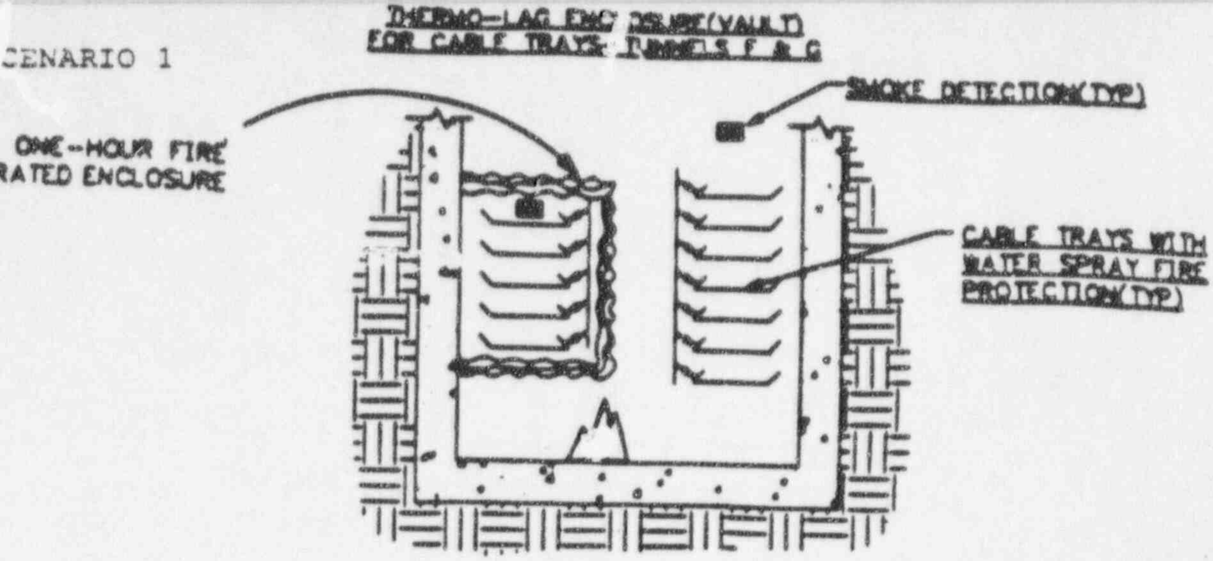
SCENARIOS

The following scenarios are provided to describe the essentials of the fire protection evaluation of the three Thermo-lag fire barrier enclosures highlighted during the NRC inspection.

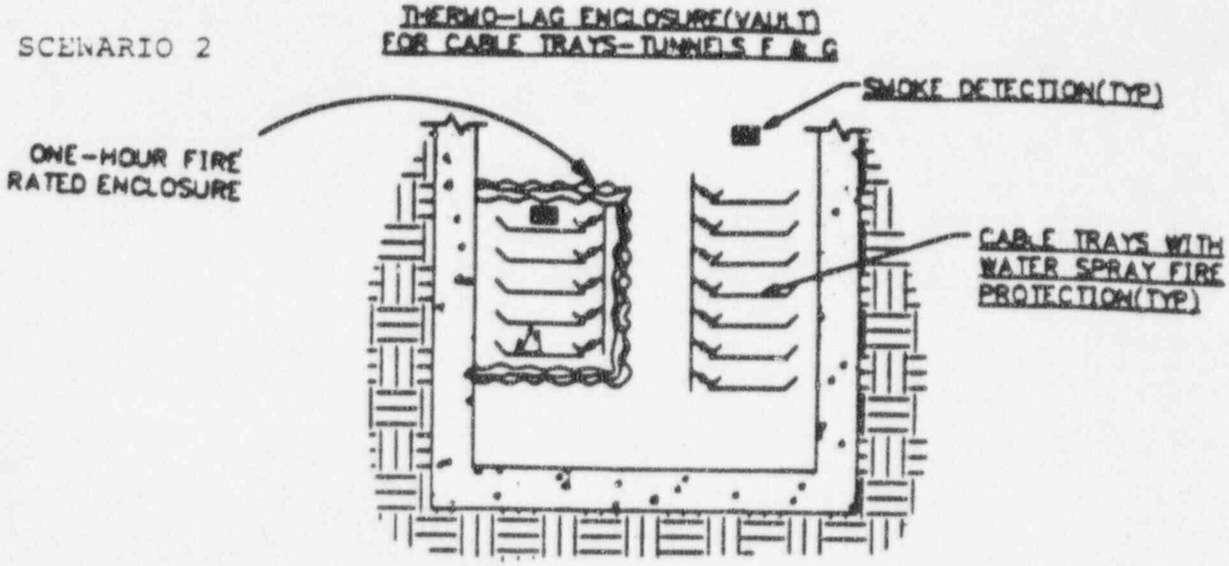
1. Transient Fire, F or G tunnel - As shown in Figure 1-1, Scenario 1, this event provides an immediate challenge to the unenclosed Division II cable trays. The ionization type smoke detectors would respond within a very short time, initiating the flow of water to the cable tray water spray systems for both the Division I and Division II tray stacks. The 1-hour Thermo-lag enclosure prevents simultaneous exposure to the Division I cable trays at this time.

   An effect of water being discharged within the Division I cable tray enclosure is that the potential for water build-up on the floor of the assembly exists. As designed, the support system is sufficient to carry the additional weight. In the unlikely event of catastrophic leakage and potential collapse of the enclosure floor, no impact to the ability to safely shutdown the plant results. This is due to two primary effects of the leakage or collapse. The first effect would be the immediate dumping of the collected water onto the areas in which the transient is burning thereby assisting in extinguishment and/or control. The second effect is that the water being discharged within the enclosure continues to keep the cables thoroughly wet, therefore preventing damage to the Division I cables. In addition, all tray supports (independent from the enclosure supports) are also protected from damage by the water spray deluge occurring on the cable trays within the enclosure. Since Division I cable are maintained free of damage, safe shutdown is assured.

SCENARIO 1




SCENARIO 2




SCENARIO 3

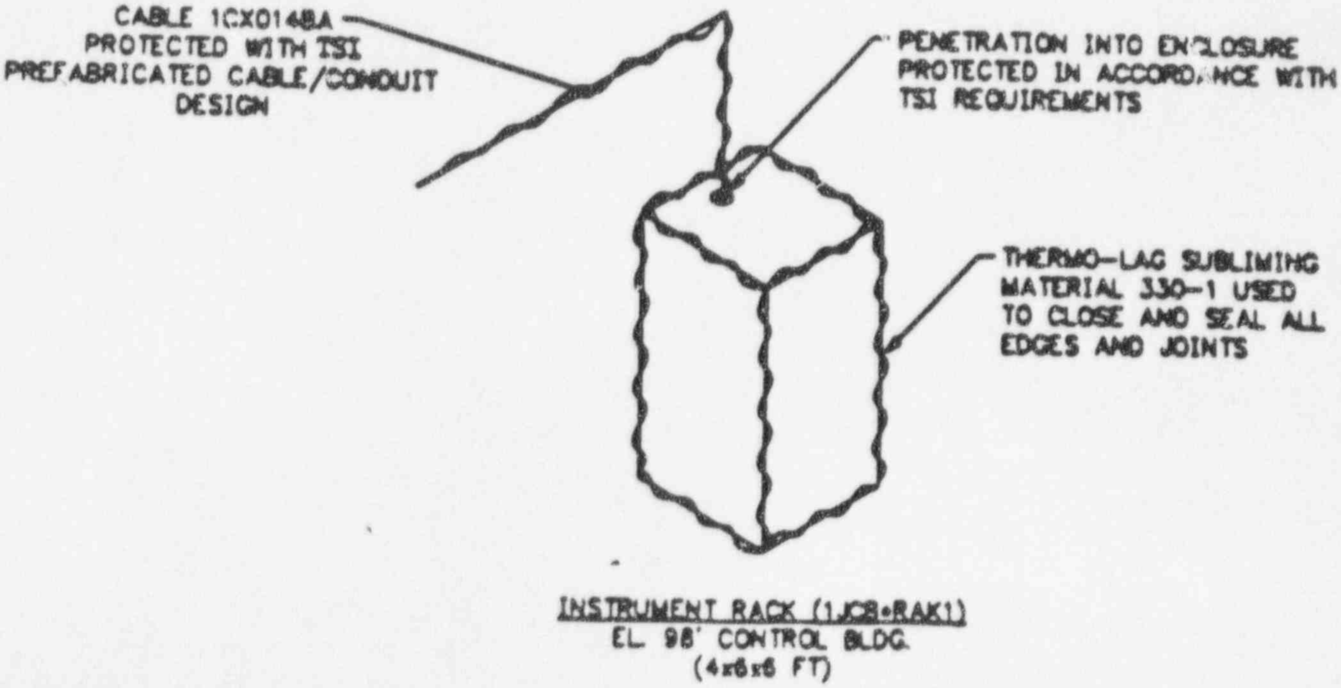



Figure 1-1 Fire Scenarios

2. Cable Fire Within F or G Tunnel Enclosures - Figure 1-1, Scenario 2, shows a fire within a cable tray enclosure as hypothesized in F or G tunnel. The ionization smoke detectors within the enclosures respond and actuate the cable tray water spray sprinkler systems. Sprinkler heads, installed to discharge water on all trays at about 8 to 10 feet intervals along the tray will immediately extinguish the cable tray fire. Exposure to plant shutdown capabilities would not exist since the Division II cable, outside the enclosures, would not be affected and would remain fully functional.

3. Instrument Rack Enclosure - As shown in Figure 1-1, Scenario 3, the 3-hour enclosure design precludes either an interior, cable induced fire, or exterior transient fire from impacting the ability to safely shutdown the plant.

GSU's Response to Section 4.2.4, "Electrical Cable Ampacity Derating"

Engineering Evaluation and Assistance Request (EEAR) 91-C-0115 was initiated on November 22, 1991 to document GSU's review of the Underwriters Laboratories (UL) Report concerning ampacity derating of Thermo-lag fire wrap enclosures. The discussion below provides information regarding the history of Thermo-lag ampacity derating factors and a status of GSU's current evaluation.

Ampacity derating factors presently used in calculation E-218 were provided by TSI to SWEC in a letter dated July 5, 1985. This letter was in response to SWEC comments on various Industrial Test Lab (ITL) reports containing derating factors. TSI concluded the letter by summarizing derating factors that may be used for RBS. This letter along with a telecopy listing SWEC's comments is included as Attachment 13 to Calculation E-218.

A mailgram from TSI dated October 2, 1986 was appropriately sent to Stone and Webster Engineering Corporation (SWEC), GSU's RBS design agent at the time. This mailgram reported preliminary results of the UL test. GSU located copies of several SWEC interoffice memorandums which discuss the potential impact of the UL test on RBS ampacity derating factors. The correspondence indicates that SWEC determined that any impact would be limited to tray installations only and that accounting for actual tray fill, as opposed to the 100% fill assumed in the SWEC derating calculation, should compensate for the higher derating factors.

The mailgram states that, "(TSI) conducted certain 'plant specific' ampacity tests at UL", and that the results are, "preliminary information, subject to verification, reduction, and formal reporting by UL." The mailgram further states that, "as (TSI) receives the reports from UL, (TSI) will transmit copies to you promptly." GSU could find no subsequent correspondence from TSI on this issue.

In response to NRC concerns that non-conservative ampacity derating factors may have been used at RBS, GSU has reviewed all cables addressed in calculation E-218. This review confirms the 1986 SWEC evaluation that these cables will meet acceptance criteria if derating factors reported by UL are used. In the course of this review, GSU noted that approximately 300 additional cables are located in fire barriers that are not addressed in calculation E-218. GSU is currently reviewing these cables for impact due to ampacity derating.

All 480 V cables in this group have been reviewed and there will be no adverse impact if UL ampacity derating factors are applied. Three 120 V cables were found to be impacted by the ampacity derating. These cables supply power to heat tracing on piping for containment monitoring instrumentation inside the reactor building. Condition Report, CR 92-0250 has been initiated to address these cables. Approximately 200 of the 120 V cables remain to be evaluated. This evaluation will be completed and all corrective action scheduled by the end of refueling outage (RF) 4.

GSU has performed a comparison between test articles described in the UL Report and installed raceways at RBS. Several differences between test articles and typical RBS fire barrier configurations have been noted below:

1. UL installed the side panels first. Additional banding was used to hold the top and bottom pieces in place.

2. For the one inch thick configuration, the side panels of the UL test article were installed in the opposite direction (ribbed surface exposed) than the RBS installation. At RBS all of the cable tray enclosures were built with the flat surface exposed.

3. The spacing of the stainless steel bands was greater in the UL test than what is used at RBS (18 to 24 inches at UL versus 12 inches at RBS).

4. The UL test punched holes in the underside of the 1/2 inch thick panel to secure the Thermo-lag to the rungs of the tray. This technique has never been used at RBS. There is no reference in the test report to indicate if the holes were patched with trowel-grade material after tightening the tie wire.

5. A third band was installed in the UL test for the top panel. This was not done in the RBS installation.

6. The UL report references a "thin coating of trowel-grade" installed between the gap formed by the top/bottom and the siderail panels. For RBS installation this gap would be required to be <u>"filled"</u> with trowel-grade material.

7. The ends of the UL test articles were sealed with glass fiber insulation and duct tape. A typical installation at RBS would be kaowool (ceramic fiber) or low density silicon elastomer (LDSE).

8. Depth of cable fill is three inches in the UL test versus one and one-half inches in the TSI test and the RBS installed configuration. Since the effects of depth versus ampacity are non-linear the derating factors are more severe than if a one and one-half inch depth had been tested.

9. Steel wire ties used to secure cable to the tray rungs could cause inductive heating if not insulated to prevent a conducting path around the cable.

10. Ampacity for conduit with one-half inch wrap is higher than the baseline. The report does not rationalize this discrepancy.

Since construction differences as identified above may affect ampacity derating factors, GSU does not believe that it is appropriate to adopt the UL ampacity derating factors.

The installation method used in the UL test for covering the four inch conduit is identical to the method used at RBS. The derating factor identified in the UL test for conduits is lower than the derating factor used at RBS, therefore; no further actions were taken.

It is not clear at this time if valid ampacity derating factors are available. The NRC concern that GSU may not have used the most conservative derating factors may be a common problem throughout the nuclear industry. This issue was discussed at a recent meeting of a NUMARC ad hoc committee on Thermo-lag concerns. Final resolution of this concern will be coordinated with other utilities through NUMARC.

GSU's Response to Section 4.2.5, "Fire Test Acceptance Criteria"

The NRC has indicated that the fire test criteria used by GSU for fire barrier testing deviates from the NRC criteria stipulated in Generic Letter 86-10 which states that transmission of heat through the barrier, "...shall not have been such as to raise the temperature on its unexposed surface more than 250 degrees F above its initial temperature."

RBS was reviewed and licensed in 1985, prior to the issuance of NRC Generic Letter (GL) 86-10. Electrical cables which run inside 1-hour and 3-hour fire barriers at RBS have passed the flame test in IEEE 383-1974. Degradation of the insulation used on IEEE 383 rated cable does not begin until jacket temperatures reach 450 degrees F to 650 degrees F. The criteria of 325 degrees F plus ambient assures that cable jacket temperatures do not reach these levels. The maximum ambient temperature for any fire test related to RBS has been less than 90 degrees F, therefore, the criteria of 325 degrees F plus ambient assures that temperatures are sufficiently below the temperatures where jacket degradation begins. From the aspect of elevated temperature, this assures that cables are maintained free of fire damage in accordance with Appendix R, Section III.G requirements as committed to in USAR Section 9A.2.

Although this variation from Generic Letter 86-10 guidance is not explicitly addressed and accepted by the NRC in the RBS SER, it is implicitly accepted. Penetrations are an integral part of the barriers and NRC guidance in BTP CMEB 9.5-1 Section 5.a.3 requires penetrations to be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. Based on this, the criteria for cold side temperature would be the same for fire barriers and penetration seals. USAR Section 9B.4.13 specifically identifies the cold side temperature criteria of 325 degrees F above ambient used for penetration seals. Also, the NRC specifically reviewed and accepted in SSER-3, Section 9.5.1.4, RBS test reports for internal conduit seals which used ANI/MAERP criteria (325 degrees F plus ambient) for cold side temperature criteria prior to the issuance of GL 86-10. Based on the above, NRC acceptance of this 325 degrees F plus ambient criteria is implied. The NRC inspection report states that this matter is with NRR for review. A decision from the NRC is required prior to implementing TSI upgrades.

## ATTACHMENT 2

Response to Unresolved Item 50-458/9204-02

REFERENCE

Inspection Report - Letter from A.B. Beach to J.C. Deddens, dated March 27, 1992.

Licensee Event Report No. 91-008 (Supplement 1) - Letter from W.H. Odell to U.S. NRC, dated February 18, 1992.

Supplement to Response to Violation - Letter from W.H. Odell to U.S. NRC, dated February 7, 1992.

Licensee Event Report No. 91-008 - Letter from W.H. Odell to U.S. NRC, dated May 15, 1991.

Response to Violation (Rev 2) - Letter from W.H. Odell to U.S. NRC, dated December 12, 1990.

Response to Violation (Rev 1) - Letter from W.H. Odell to U.S. NRC, dated September 18, 1990.

Response to Violation - Letter from J.C. Deddens to U.S. NRC, dated May 7, 1990.

Notice of Violation - Letter from S.J. Collins to J.C. Deddens, dated April 6, 1990.

Enforcement Conference Summary - Letter from S.J. Collins to J.C. Deddens, dated March 26, 1990.

Notice of Enforcement Conference - Dated March 6, 1990.

Inspection Report - Letter from S.J. Collins to J.C. Deddens, dated February 26, 1990.

Licensee Event Report No. 89-036 (Rev 1) - Letter from J.E. Booker to NRC, dated January 31, 1990.

Licensee Event Report No. 89-036 - Letter from J.E. Booker to NRC, dated November 16, 1989.

History of Fire Hazards Analysis Issues at River Bend Station

In response to the violation identified in the Notice of Violation for NRC Inspection Report No. 50-458/90-02, GSU undertook a comprehensive review and documentation of the Fire Hazards Analysis (FHA). In January, 1990, Design Engineering completed an initial review of the FHA. From January 1 to February 7, 1990, Quality Assurance performed a Safety System Functional Inspection (SSFI) as related to the energized valves identified in the violation. The mini-SSFI identified several recommendations which were implemented by March 8, 1990. A detailed and thorough review of the FHA by an independent contractor was completed in January, 1991. During the review of the FHA, 106 discrepancies were identified which required further evaluation. These discrepancies were prioritized for immediate corrective actions based on potential safety significance. Of the 106 discrepancies, 23 were identified as potentially affecting Pre-fire Strategies, safe shutdown separation, or the USAR. These 23 items were reviewed and corrective actions were identified by April 15, 1991. Evaluations for the remaining 83 items were completed prior to January 24, 1992. Results of the review of all 106 items are categorized as follows:

**RESULTS OF FHA REVIEW**

| | |
|---|---|
| 6 | REPORTABLE CONDITIONS (LER 91-008 SUPPLEMENT 1) |
| 9* | MISSING OR INCORRECT MANUAL ACTIONS IN PRE-FIRE STRATEGIES |
| 2 | ADDITIONS TO DESIGN AND LICENSING BASIS |
| 30 | IMPROVED DOCUMENTATION |
| 23 | CORRECT INCONSISTENCIES IN DOCUMENTS |
| 36 | NO ACTION REQUIRED |

*4 REPORTABLE (LER 91-008 SUPPLEMENT 1)

GSU's Response to Section 5.1.1, "Electrical Separation for Spent Fuel Pool"

During the final FHA review, two fire areas were identified where loss of spent fuel pool cooling (SFC) may occur as a result of a fire. One is Fire Area C-25 (main control room) and the other is a fire area in the fuel building (Fire Area FB-1). Both involve equipment required for SFC only and not equipment required for safe shutdown of the reactor vessel. Each area is discussed individually below.

Fire Area C-25:

The FHA identifies Fire Area C-25 as an area where alternate shutdown capability is provided. FHA Table 3 (Method 1E - Main Control Room Fire Required Items) lists specific spent fuel pool cooling & cleanup (SFC) system and fuel building ventilation (HVF) system equipment as being required and therefore, independent of the fire in the control room. The review of circuits for this equipment determined that the circuits are not electrically independent from the control room and potential fire damage could cause loss of the equipment which may result in loss of spent fuel pool cooling.

GSU took immediate actions and implemented administrative controls to address the concerns with spent fuel pool cooling until permanent corrective actions could be identified and implemented. Engineering analysis determined that the time required for the spent fuel pool temperature to reach the cooling system design limit of 155.6 degrees F with the existing fuel load conditions prior to RF-4 was approximately 5.3 days. Administrative controls were implemented and AOP-0031 (Shutdown From Outside Main Control Room) was revised to provide the necessary manual actions to restore spent fuel pool cooling in case of a fire in the main control room. The entire reactor core was offloaded to the fuel building spent fuel pool for RF-4. With the increased heat load in the fuel pool, the minimum time required to reach the cooling system design limit of 155.6 degrees F is approximately 4 hours. This is sufficient time to take the manual actions identified in AOP-0031.

The corrective action for addressing the concerns with spent fuel pool cooling is to complete an analysis which demonstrates a design which allows a higher spent fuel pool temperature and still allows sufficient time to restore spent fuel pool cooling. With this revised design bases, the spent fuel pool cooling equipment presently identified as required by the FHA would not be immediately required. This analysis is scheduled to be completed by July 10, 1992. Any modifications found necessary will be scheduled during Fuel Cycle 5. MR 92-0038 has been approved to complete analysis of long term corrective actions. The administrative controls and manual actions discussed above will be maintained until long term corrective actions are implemented.

Fire Area FB-1:

Fuel building ventilation dampers 1HVF*AOD037A, 102 and 122 are identified in the FHA as equipment required for spent fuel pool cooling. Potential fire damage to electrical cables, located in Fire Area FB-1, for these dampers may cause spurious operation of the dampers which could potentially cause loss of ventilation to the one remaining spent fuel pool cooling pump and thus loss of spent fuel pool cooling. Previously, the Pre-fire Strategies for this area stated that these dampers must be verified to be in their proper position and if not, power must be removed so that they remain in the correct position. Removing power to these dampers may not cause the dampers to go to the correct position since a potential hot short could cause the damper to remain in an incorrect position.

The immediate corrective action GSU took was to treat the electrical cables as having missing fire barriers and initiate a continuous fire watch per RBS Technical Specification. After the actions identified above for the main control room were implemented and Pre-fire Strategies for Fire Area FB-1 were revised to identify the manual actions required to place the dampers in the correct position, the continuous fire watch was removed. The permanent corrective action for this condition will be addressed with completion of the analysis and any modifications, if required, as discussed above for the main control room.

GSU's Response to Section 5.1.2, "Lack of Automatic Control of Dampers in Fuel Building"

This condition is addressed in GSU's response to Section 5.1.1, since it also involves the potential loss of spent fuel pool cooling.

GSU's Response to 5.1.3, "Twenty Foot Separation in Reactor Building"

The FHA identifies containment unit coolers 1HVR*UC1A (Method 1) and 1HVR*UC1B (Method 2) as equipment required for safe shutdown. These unit coolers are needed for equipment qualification only and are not directly involved with safe shutdown.

The FHA states that the unit coolers are separated from each other by a distance of 24 ft. and a 10 ft. missile barrier which serves as a radiant energy shield. During the final review of the FHA it was found that cables required for operation of the unit coolers did not meet the 20 ft. horizontal separation criteria as stated in 10 CFR 50 Appendix R, Section III.G. The immediate corrective action taken was to treat the cables as having missing fire barriers and initiate an hourly fire watch per RBS Technical Specification.

The permanent corrective action for this condition will be to provide an analysis which demonstrates that the unit coolers are not required for safe shutdown or install noncombustible radiant energy shields to provide separation in accordance with Appendix R, Section III.G.2.f. modification request (MR) 92-0037 has been approved to install the required radiant energy shields if needed. The analysis to demonstrate that the unit coolers are not required and the preparation of MR 92-0037 will proceed concurrently. This approach will allow the analysis to be completed and/or installation of the radiant energy shields to be completed prior to startup from RF-4.

GSU's Response to Section 5.1.4, "Lack of Fire Hazards Analysis"

During the final FHA review, all fire areas except one were found to have an adequate fire hazards analysis. The additional room, AB-070-507, was believed to have been analyzed as part of an adjoining fire area, either AB-2 or AB-7. All of the areas are separated by 3-hour rated walls or floors, however, the cable chase was not assigned a fire area designation. The additional room is a small cable chase located in the northeast corner of D-tunnel. The room contains Division II cable only and is separated from adjacent fire areas by 3-hour barriers on all sides. An investigation of the cables routed through the room showed three Division II cables could cause three Division II motor operated valves, required for Method 1 shutdown, to become inoperable. The valves are Division II components used in the Method 1 safe shutdown analysis. These valves include two reactor core isolation cooling (RCIC) valves and one spent fuel pool cooling system (SFC) valve. The RCIC valves are used in Method 1 to maintain reactor vessel level. The SFC valve is used for cooling of the containment fuel pool system.

As corrective action, an analysis of all the Division II cables required for safe shutdown routed through room AB-070-507 was conducted. This analysis revealed that the high pressure core spray (HPCS) system would not be affected by a fire in the room. A Pre-fire Strategy was written for room AB-070-507 which informed Operations of the possible spurious operation of the RCIC valves and that the HPCS system is free of fire damage in this room and may be used in lieu of RCIC to maintain reactor pressure vessel (RPV) water level control. For the SFC valve, the Pre-fire Strategy informs Operations that a manual action may be required to maintain cooling for the containment fuel pools and refers to the necessary procedure for proper valve alignment.

MR 92-0013 has been initiated to revise the FHA to incorporate the evaluation of this room and will be completed by October 30, 1992. Also, Licensing Change Notice (LCN) No. 9A.2-18 has been initiated to add the room to USAR Tables 9A.2-5 and 9A.2-6.

GSU's Response to Section 5.1.5, "Breaker/Fuse Coordination Study"

During the design and development of the Fire Hazards Analysis proper electrical protection coordination was employed. Standard engineering practice provides that the protective device closest to the load will open first to isolate the load and its cable from the electrical bus, thus allowing continued operation of other loads powered from the same bus. Although not required per Appendix A to BTP APCSB 9.5-1, GSU has decided to perform such an analysis and develop a single source document to enhance control of breaker/fuse coordination for 125 VDC and 120 VAC control circuits. This analysis is scheduled to be completed and design improvements, if required, identified by October 30, 1992.

GSU's Response to Section 5.1.6, "Lack of High Impedance Fault Analysis"

Multiple high impedance faults involving associated circuits as identified in Generic Letter 86-10, Section 5.3.8 have not been specifically analyzed. Although a high impedance fault analysis or compensatory procedure for operator action are not required per Appendix A to BTP APCSB 9.5-1, GSU has decided to prepare a procedure which provides information necessary to recover from a multiple high impedance fault event during a fire. This procedure will be implemented, with training completed, prior to startup from RF-4.

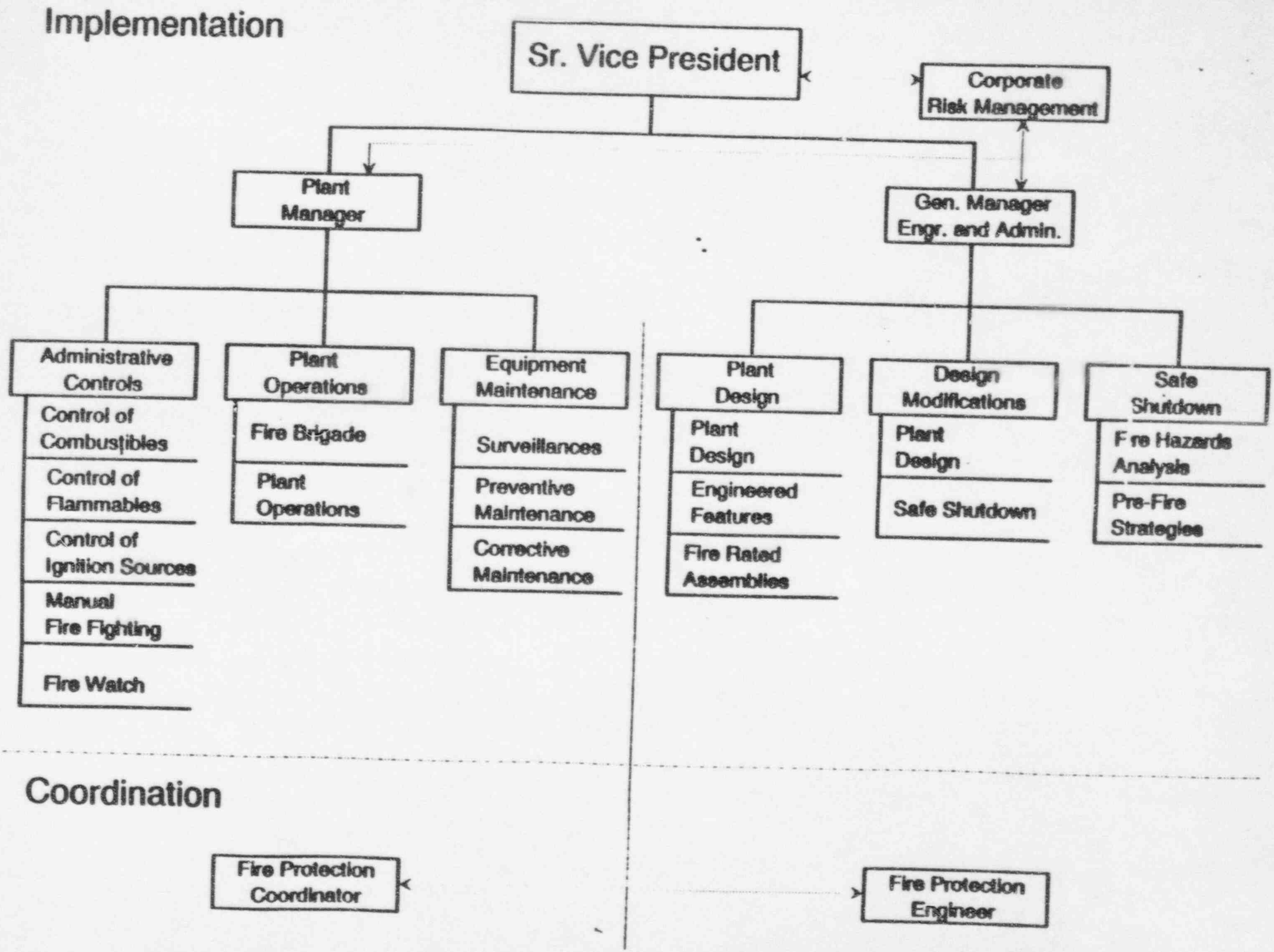
# ATTACHMENT 3

GSU's Response to Section 5.2, "Management Oversight of the Fire Protection Area"

The fire protection program at RBS is an integrated effort involving many departments. However, overall responsibility is maintained by the Sr. Vice President - River Bend Nuclear Group, Mr. J. C. Deddens. Through his management, fire protection activities are formulated. Implementation by the individual departments is based on organizational responsibilities and specialized expertise. The coordination of these activities is achieved through an efficient chain of communication. (See Figure 3-1)

Currently, GSU is participating in a NUMARC ad hoc committee on Thermo-lag in an effort to achieve a salient solution to the Thermo-lag issue. Also, GSU has incorporated the assistance of its RBS architect and engineer, Stone & Webster Engineering Corporation, to resolve questions concerning the fire protection program.

As shown through their efforts to identify and correct discrepancies in the FHA, inspect fire barriers as well as test materials and configurations, and consistently disclose findings to the NRC, GSU management's role in the RBS fire protection program has been and still remains very proactive. It is this proactive effort which will allow the correction of all known deficiencies by January, 1995.


Implementation
Sr. Vice President
Corporate Risk Management
Plant Manager
Gen. Manager Engr. and Admin.
Administrative Controls
Control of Combustibles
Control of Flammables
Control of Ignition Sources
Manual Fire Fighting
Fire Watch
Plant Operations
Fire Brigade
Plant Operations
Equipment Maintenance
Surveillances
Preventive Maintenance
Corrective Maintenance
Plant Design
Plant Design
Engineered Features
Fire Rated Assemblies
Design Modifications
Plant Design
Safe Shutdown
Safe Shutdown
Fire Hazards Analysis
Pre-Fire Strategies
Coordination
Fire Protection Coordinator
Fire Protection Engineer

ATTACHMENT 4

## Penetration Seals Program

### REFERENCES

Licensee Event Report No. 89-010 (Rev 3) - Letter from W.H. Odell to U.S. NRC, dated July 31, 1990

Licensee Event Report No. 89-010 (Rev 2) - Letter from J.E. Booker to U.S. NRC, dated August 30, 1989

Licensee Event Report No. 89-010 (Rev 1) - Letter from J.E. Booker to U.S. NRC, dated June 9, 1989

Licensee Event Report No. 89-010 - Letter from J.E. Booker to U.S. NRC, dated April 17, 1989

### History of Penetration Seals Program at River Bend Station

During routine sampling inspections of penetration seals, GSU identified several penetrations which were unsealed. An investigation of the open penetrations in 1989 found that conduits lacking internal seals consisted of scheduled and unscheduled conduits. Unscheduled conduits included fire detection, lighting, security and communications conduits. A review of the penetration seal data bases indicated the above described internal seals were never installed. Therefore, it is concluded they were never sealed by the subvendor responsible for sealing penetrations during construction.

### Corrective Actions Taken by GSU

GSU senior management review of the penetration seal program resulted in the formation of a Fire Protection Task Force consisting of Engineering, Projects, and Quality Control personnel to develop a corrective action program. Part of their task was to develop a detailed program for the complete inspection of all fire barriers including penetration seals and internal conduit seals for type of seal and adequacy of installation, and to rework or disposition the deficient penetration seals as appropriate. Inspection and rework, if required, of structural steel fireproofing was also included as part of the task force scope. A 100% inspection program of the approximately 3000 penetration seals began in February, 1991 and is currently in progress. Identified construction deficiencies and degraded material are being reworked on an ongoing basis to ensure that protection remains in place. Apparently unqualified configurations will be addressed through engineering evaluation or testing. Corrective actions are scheduled to be completed by January, 1994.

Periodic working level meetings are held between Engineering, Quality Control and Maintenance to discuss progress and problems. Senior management awareness of the status of the penetration seal program is maintained through monthly status reports and presentations given to the Nuclear Review Board and in senior management staff meetings. Through these means GSU management is able to continually assess progress.

## ATTACHMENT 5

Prefire Strategies

The Prefire Strategies are a tool for operator and fire brigade use in the event of a fire, providing information and recommendations for actions. They are not a source of direction for required operator actions. In fact, the note on the first page of Section 9, "Evaluation of Fire and Shutdown," of the Prefire Strategies states:

> "It is expected that Normal, Abnormal and Emergency procedures be followed for plant shutdown/operations as required. Prefire strategies should not be misinterpreted to be the required method of shutdown..."

This clarification along with the extensive fire protection training operators receive would prevent any misinterpretation of the Prefire Strategies intended application.

As an enhancement to the fire protection program at RBS, Section 9 will be removed from the Prefire Strategies and developed into an Abnormal Operating Procedure (AOP). This new AOP will be broken down by fire area for easy reference. The scheduled completion date is August, 1992.

## ATTACHMENT 6

Information Notice 92-18, "Potential for Loss of Remote Shutdown Capability During a Control Room Fire"

References

Licensee Event Report No. 92-007 - Letter from W.H. Odell to U.S. NRC, dated April 27, 1992

NRC Information Notice 92-18: Potential for Loss of Remote Shutdown Capability During a Control Room Fire" - Letter from C.E. Ross to GSU, dated February 28, 1992

On March 26, 1992, during GSU's review of NRC Information Notice 92-18, "Potential for Loss of Remote Shutdown Capability During a Control Room Fire," GSU identified a design deficiency in the control circuits for motor operated valves (MOVs) required for alternate shutdown of the plant. These control circuits could operate spuriously during a control room fire. If a fire in the control room forces reactor operators to evacuate the control room, these MOVs can be operated from the remote shutdown panel. However, energized short circuits ("hot shorts") combined with the absence of thermal overload protection, could permit bypassing of the torque switch and limit switches, and thus cause valve damage before operators are able to transfer control of the valves to the remote shutdown panel. This design is contrary to the River Bend Station Fire Hazards Analysis and constitutes a condition outside the design basis. Therefore, a report, LER 92-007, dated April 27, 1992, was submitted pursuant to 10CFR50.73(a)(2)(ii)(B).

The control circuit design deficiency identified by Information Notice 92-18 is an emerging generic issue in the nuclear industry. A contributing factor was the lack of thermal overload protection as specified in Regulatory Guide 1.106. Typical control circuits are designed with thermal overload protection to protect the motor operator. The special application of a motor operated valve required for alternate shutdown combined with the Regulatory Guide 1.106 design to bypass the thermal overloads resulted in a design deficiency.

The control circuitry for the 50 affected MOVs will be reworked or otherwise dispositioned by the end of RF-4 so that the limit switches and torque switches cannot be bypassed by hot shorts. The core damage frequency due to hot shorts generated by fires in main control room (MCR) panels is not an insignificant contributor to the total core damage frequency of RBS. However, the current probabalistic risk assessment results (rev. 0) are conservative. In addition, this contribution to the total core damage frequency is not as significant as the contribution due to fires in MCR panels (without considering the hot short phenomena) or that due to internal events. Pursuant to Generic Letter 88-20, Supplement 4, RBS will be performing the Individual Plant Examination (IPE) for External Events which will include a detailed fire risk analysis. This issue of hot shorts in MCR panels will be addressed in that analysis in a more detailed manner. It is expected that the results of that analysis will identify the true importance of this issue in relation to overall fire risk.

8 May 1992

RUBIN FELDMAN, P.E.
*President*

U S Nuclear Regulatory Commission
Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, Maryland 20852

Attention: Mr. Ashok C. Thadani, Director
Division of Systems Technology
Office of Nuclear Reactor Regulation

Dear Mr. Thadani:

The NRC has previously received communications from Thermal Science, Inc. relating to the proposed generic letter circulated by the NRC in February 1992. The purpose of this letter is to provide you with additional information on TSI's current activities.

Thermal Science, Inc. has engaged Omega Point Laboratories in San Antonio, Texas to conduct a series of fire resistive tests on 36" wide open top, ladder back cable trays and small diameter conduits (c. 3/4"). Both one and three hour fire resistive tests are planned. The tests will be conducted in accordance with the applicable prerequisites of:

Test Plan No. 31192-A Engineering Test Plan to Perform One Hour Fire Endurance Tests Followed by Water Hose Stream Tests On a 36 Inch Wide Steel Open Top, Ladder Back Cable Tray (With One Layer Of Generic Cables) and Steel Conduit Test Articles Protected With The THERMO-LAG 330 Fire Barrier System

ANI's Bulletin B.7.2, 11/87 "ANI/MAERP RA Guidelines For Fire Stop and Wrap Systems At Nuclear Facilities - Attachment B, Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class IEEE Electrical Circuits", Revision I, dated November 1987, as applicable

U S Nuclear Regulatory Commission's Generic Letter 86-10
To All Power Reactor Licensees And Applicants For Power Reactor Licenses, dated 24 April 1986 "Implementation Of Fire Protection Requirements", as applicable

ASTM E119 (88) "Standard Methods of Fire Tests of Building Construction and Materials", as applicable

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This test program is currently underway, under the total control of Omega Point Laboratories which includes:

- The construction of the test articles,
- The installation of the fire barrier system materials,
- Test article instrumentation,
- The performance of the fire endurance and water hose stream tests.
- The performance electrical circuitry integrity monitoring,
- All pertinent Quality Control Documentation,
- Publishing the test report

An "Ad Hoc" one hour fire resistive test has just been completed at the facilities of Omega Point Laboratories in San Antonio Texas. It was comprised of the following:

- 36 inch wide open top ladder back cable tray
- Loaded with one layer of generic cables
- Power, instrumentation and control cables were employed
- Chromel Alumel thermocouples were attached to surface of selected cables
- Selected cables were instrumented for cable to ground monitoring
- The fire simulation was comprised of ASTM E 119 type environment
- No water stream tests were performed

The purpose of the test was to establish the feasibility of key design features such as:

- Gap - seam width definition between adjoining sections of THERMO-LAG 330 Prefabricated Panels
- Scoring techniques used in shaping the Prefabricated Panels
- Prebuttering of adjoining surfaces of sections of THERMO-LAG 330 Prefabricated Panels used in construction of cable tray wraps

• Alternate method of structural enhancement of thermo-structural integrity of joints when the gap width exceeds the maximum established limits such as:

- ••• THERMO-LAG Stress Skin Type 330-69 over the joint including THERMO-LAG 330 Subliming Trowel Grade Material
- ••• Stainless steel tie wires spaced at specified distances
- ••• Stainless steel band spacing

The results of this Ad Hoc test established the feasibility of the following features of an acceptable One Hour Fire Resistive THERMO-LAG 330 Enclosure for 36 inch wide steel open top, ladder back, cable trays which are lightly loaded with generic cable

| | |
|---|---|
| THERMO-LAG 330 Prefabricated Panel Thickness: | 0.625"± 0.125 |
| Stainless Steel Banding Material (0.5" x 0.020" Min) | Spacing 8 inches |
| Maximum gap width with Prebuttering : | 0.030 inches |

Gaps having a width in excess of 0.030 inches require thermo-structural enhancement as follows:

•• Either:

THERMO-LAG Stress Skin Type 330-69 with a 0.125 layer of THERMO-LAG 330-1 Subliming Trowel Grade Material wrapped over the entire circumference of the wide gap , covering the tray at least 5 inches on both sides of the gap, having a overlap held in place by stainless steel bands, with its seam fastened by specified mechanical fasteners.

•• Or:

Stainless Steel Tie Wires (0.032" minimum) placed at 6 inch intervals on longitudinal seams and 2 inches apart on vertical seams.

Due to the "information only" nature of this test, the Laboratory only provided testing services without quality control surveillance, and a formal report is not planned. The formal test is targeted to be conducted in June utilizing the above criteria. It will be fully documented by the test laboratory. Successful completion of this testing effort will yield a very detailed installation procedure using the results of the construction methods in the test program. It is expected to supersede previous TSI information on this subject.

We will advise you as soon as the testing has been satisfactorily completed.

Yours truly,

Rubin Feldman
President

RF/meg

May 13, 1992

Mr. Alex Marion
Manager, Technical Division
Nuclear Management and Resources Council
1776 Eye Street, N.W., Suite 300
Washington, D.C. 20006-2496

Dear Mr. Marion:

Our March 12, 1992, letter transmitted our intent to provide you with more detailed information to facilitate your review of the proposed generic letter on Thermo-Lag fire barriers. Our review team has completed a technical report which documents its review and the technical bases for its findings and recommendations. This letter formally transmits the enclosed report, Final Report-Special Review Team for the Review of Thermo-Lag Fire Barrier Performance, dated April 17, 1992, previously hand carried to you. After you have had an opportunity to review this report, a follow-up meeting should be arranged within 30 days to discuss the draft generic letter, your previous comments, and any additional industry questions. Please forward any further comments on the draft generic letter to us prior to this meeting to allow a thorough review by our staff.

Please contact Ralph Architzel at (301) 504-2804 within 30 days to arrange a meeting with our staff on this issue. We appreciate NUMARC's contribution to the development of technically sound generic communication which can provide a timely resolution to our concerns.

Sincerely,
ORIGINAL SIGNED BY A. C. THADANI

Ashok C. Thadani, Director
Division of Systems Technology
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc w/o encl:
T. Murley
W. Russell

DISTRIBUTION w/o enclosure:
TSI File
Docket File
RArchitzel
CMcCracken
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| SPLB:DST * | PLB:DST * | SPLB:DST * | SPLB:DST | SPLB:DST |
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| IMoghissi:sb | Architzel | McCracken | GHolahan | AThadani |
| 5/ /92 | 5/ /92 | 5/ /92 | 5/ /92 | 5/12/92 |

[G:MARIFELD.REA]

* see previous concurrence

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