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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 9, 1997

MEMORANDUM TO: L.B. Marsh, Chief
Plant Systems Branch
Office of Nuclear Reactor Regulation

FROM: K. Steven West, Chief
Fire Protection Engineering Section
Plant Systems Branch
Office of Nuclear Reactor Regulation

SUBJECT: TRIP REPORT - TRIP TO UNDERWRITERS LABORATORIES, INCORPORATED TO OBSERVE THREE HOUR FIRE TEST OF ONE AND THREE HOUR VERSAWRAP RACEWAY FIRE BARRIER SYSTEMS (TAC M82809)

During April 10 and 11, 1997, I visited to Underwriters Laboratories, Incorporated (UL), Northbrook, Illinois, to observe a full-scale fire endurance test of 1- and 3-hour Versawrap fire barrier systems. Attachment 1 is a list of individuals that observed or participated in the test. I interacted mostly with the individuals marked with asterisks.

Transco Products, Incorporated (Transco) is developing Versawrap as a stand-alone fire barrier or as an upgrade for such existing raceway fire barriers as Thermo-Lag 330-1. In general, Versawrap barriers are installed (from the item to be protected outward) as individual layers of foil, water filled mylar tubes, fiber blankets, foil, and intumescent-coated fiberglass cloth. The numbers and arrangements of the individual barrier components are dependent on the type of item to be protected (e.g., raceway, cable, support, etc.) and the desired fire rating. (Attachment 1 to a memorandum of April 15, 1997, from K.S. West to L.B. Marsh describes the components of a typical Versawrap barrier and their general arrangements.) Entergy Operations, Incorporated, is considering installing 1- and 3-hour Versawrap fire barriers at Arkansas Nuclear One, Unit 1, and Northern States Power is considering installing a 1-hour Versawrap barrier at Prairie Island Nuclear Power Station.

Attachment 2 is Transco Test Procedure TR-228, "Three Hour Fire Test of One and Three Hour VERSAWRAP Raceway Fire Barrier Systems for Conduits and Cable Trays," Revision 2, February 7, 1997. The test was a single 3 hour fire exposure followed by a solid-stream hose stream test that was intended to demonstrate the ability of both 1- and 3-hour Versawrap fire barrier systems (in the same test) to meet the acceptance criteria of Generic Letter 86-10, Supplement 1 (GL 86-10, S 1).

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The test specimen had been constructed and installed on the test furnace before I arrived at UL. Therefore, I did not observe fire barrier installation or thermocouple placement. The overall test specimen consisted of a steel and concrete deck from which 18 individual 1- and 3-hour test articles were suspended into UL's large floor furnace. According to Kevin Hawks, Transco, (1) Transco personnel installed the Versawrap fire barriers on the test articles in accordance with Transco instructions and procedures, (2) the test articles were instrumented in accordance with GL 86-10, S 1 (3) Transco quality control witnessed and documented test specimen construction, (4) UL quality control also independently witnessed and documented test specimen construction, (5) UL will prepare the fire test report. The test articles and the conditions which they were intended to bound are described in Attachment 2. I made pen and ink changes to Attachment 2 to reflect changes that Transco had made to the test articles after it issued the test procedure. Attachment 3 shows the test article layout, construction details, and thermocouple locations. The test articles, which did not contain cable fill, were instrumented with 438 thermocouples.

On the basis of my observations, it appeared that UL exposed the test specimen in accordance with the ASTM E-119 standard time-temperature curve for 3 hours. UL programmed its data acquisition computers to electronically record the test article thermocouple temperatures every two minutes. UL also printed the thermocouple temperatures about every five minutes. UL will use the electronically recorded temperature data to judge the fire endurance performance of the individual test articles. The printed temperatures were provided for contemporaneous information during the test. About midway through the fire exposure, Transco noticed some apparently anomalous thermocouple readings. For example, closely-spaced thermocouples were reporting vastly different temperatures. Upon examination, Transco found that the insulation had melted off of some thermocouple wires that were running on top of and in direct contact with the steel test deck. Apparently, at these points the thermocouples were measuring the temperature of the test deck rather than the temperatures of the test articles. After UL and Transco placed insulating blankets between the affected thermocouple wires and the steel test deck, the printed temperatures returned (dropped) to what appeared to be a more normal range. Transco indicated that UL would assess the impact of this event on the overall test results in its fire test report.

Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 61 minutes, it appeared that test articles A, B, C, D, L, O, and R met the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 1-hour fire rating while test articles E and Q did not. Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 2 hours and 55 minutes (the temperatures at 3 hours were not printed), it also appeared that test articles F, G, H, and I may meet the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 3-hour fire rating, but test articles J, K, M, N, and P will not.

Following the 3 hour fire exposure, UL subjected the test specimen to a solid hose stream test for 2-1/2 minutes. With the exception of test article P, most of the outer layers of intumescent-coated fiberglass cloth, foil, and fiber blankets were knocked off of the bottom and side surfaces of the test article fire barriers by the force of the hose stream. The barrier on test article P remained intact and may not have been hit by the hose stream. In addition,

with the exception of test article B, a 30-inch wide steel cable tray with a 1-hour Versawrap fire barrier, it appeared that at least the innermost layer of foil (the foil attached directly to the raceway) remained intact during the hose stream test. For test article B, the foil on the bottom surface of the tray was breached, apparently by the force of the solid hose stream. GL 86-10, S 1, states, in part, that the fire endurance qualification test for fire barrier materials are successful if "[t]he cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component (e.g., cables) is visible.

On April 11, 1997, I observed Transco disassemble the fire barriers that remained on test articles H and P after the fire and hose stream tests. For both of these proposed 3-hour fire barrier designs, the inner layers of foil, water filled mylar tubes, and fiber blankets remained largely intact. Many of these mylar tubes appeared to contain their original inventory of water and those that had leaked contained some water. In addition, the ordinary adhesive-backed strapping tape that was used to attach the tubes to the raceways was largely free of fire damage.

One interesting part of the test was a test of a 12-inch by 12-inch by 8-inch thick silicone foam penetration seal that was penetrated by a ¾-inch diameter steel conduit (test article N). In addition to the normal fire resistant damming board, the seal assembly included an outer layer of intumescent-coated fiberglass cloth (on the fire side). According to Mr. Hawks, Transco considered this a "throw away" or research and development scoping test and did not instrument the seal assembly with thermocouples to obtain unexposed side temperatures. After the 3-hour fire exposure and hose stream test, Transco disassembled the penetrations seal. The seal assembly was intact. About 2 to 3 inches of the silicone foam material was consumed during the fire exposure. A full 5 to 6 inches of unreacted silicone foam material remained.

UL will base its determinations on the thermal performance of the test articles on its observations during the fire endurance and hose stream tests, analyses of the electronically recorded thermocouple data, and consideration of both the maximum single point temperatures and the average unexposed side temperatures. Presumably, UL will also consider the effects of the problems with the thermocouples that were experienced during the test. Attachment 4 is UL's record of test observations.

Docket Nos.: 50-313, 50-282, and 50-306

Attachments: As stated

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ATTACHMENT 1

List of Observers and Participants
Fire Endurance Test of Versawrap Fire Barrier
Underwriters Laboratories, Inc., Northbrook, Illinois
April 10, 1997

K. Steven West	U.S. Nuclear Regulatory Commission
Robert Goss*	Transco Products, Inc.
Kevin Hawks*	Transco Products, Inc.
Greg Jaroz*	Transco Products, Inc.
Sandra Bradford*	Transco Products, Inc.
John Kmetz	Transco Products, Inc.
Jeff Deminski	Transco Products, Inc.
Gary Sharisky	Transco Products, Inc.
Ed Johanson*	Underwriters Laboratories, Inc.
Chris Johnson	Underwriters Laboratories, Inc.
Michael Allen Boomgarden	Underwriters Laboratories, Inc.
Bill Joy	Underwriters Laboratories, Inc.
Mark Pastor	Underwriters Laboratories, Inc.
Herb Muller	Underwriters Laboratories, Inc.
Mark Izydorek	Underwriters Laboratories, Inc.
Sam Oolie	No Fire Technologies
Ron Rispoli*	Entergy Operations, Inc.
Woody Walker*	Entergy Operations, Inc.
Tom Lillehei	Northern States Power
Dan Langel	Sargent and Lundy

ATTACHMENT 2

TRANSCO PRODUCTS INC.

Transco Products Inc.
Test Procedure #TR-228

for

Three Hour Fire Test of
One and Three Hour *VERSAWRAP* Raceway Fire Barrier Systems
for Conduits and Cable Trays

(TRANSCO PRODUCTS INC. PROJECT #AR-256)

Rev.:	Description:	By:	Date:	Ck:	Date:	App.:	Date:
0	For Review and Test Specimen Fabrication	G.J. Jarosz	02/07/97	K.Hawks	02/07/97	R. Goss	02/07/97
1	For Review and Test Specimen Fabrication	J. Jarosz	03/01/97	K.Hawks	03/01/97	B.C. Mach-chhar	03/01/97
2	For Review and Test Specimen Fabrication	G.J. Jarosz	03/16/97	[signature]	03/17/97	[signature]	3/17/97

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SECTION 1.0
SYNOPSIS:

Transco Fire Test #TR-228 will be a single fire test conducted in accordance with the performance requirements of NRC GL 86-10, Supplement 1 and the ASTM E-119 time/temperature curve. The purpose of this test is to demonstrate the ability of both one and three hour *VERSAWRAP* raceway fire barrier systems (in the same test) to protect a variety of raceway conditions that are representative of those commonly found in nuclear power plants. Even though some of the barrier systems to be tested are only intended for one hour applications, they will be subjected to the full three hour fire test. In these cases, the one hour barrier specimens will be considered to be successful thermally if they meet the raceway temperature pass/fail criteria of GL 86-10 for the first hour of the fire test. After the conclusion of the three hour fire test, both one and three hour specimens will be subjected to a hose stream test in accordance with Section 7.0 of this procedure. Testing will be performed at Underwriters Laboratories (Northbrook, Illinois).

The overall test specimen will consist of a metal and concrete deck from which a number of simulated conduit and cable tray raceways will be suspended. The sizes and shapes of these raceways are intended to represent conditions that bound equivalent or less severe raceway configurations in the field. These bounding conditions to be qualified by this test are described below. The metal/concrete deck with its individual raceway specimens will be placed on top of a large floor furnace where the raceways will be subjected to the three hour fire endurance test. Immediately after the conclusion of the fire test, the deck and raceway specimens are lifted as a single unit from the furnace and will then be exposed to the hose stream test.

The raceway items to be tested and conditions they are intended to bound are as follows:

ITEM: DESCRIPTION:

"A" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track - This item is intended to bound one hour *VERSAWRAP* installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled steel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum raceways. Because this is a one hour wrap, it is only required to meet the thermal pass/fail requirements of GL 86-10 Supplement 1 for one hour whereas the hose stream test for this specimen will be performed immediately after the three hour fire test. This specimen will demonstrate both horizontal and vertical raceway sections, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper cable and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading.

"B" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound one hour *VERSAWRAP* systems installed on 30" x 4" (and all smaller sizes) of both aluminum and/or steel cable trays (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "A" above*) as well as bundled conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a

"Unistrut" hanger thermal short interface. This tray will be empty except for a single #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum raceways up to this size for hose stream test qualifications of *VERSAWRAP*. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap.

"C" ¾" Diameter Rigid Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit and will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"D" 4" Diameter Rigid Steel Conduit - This item is intended to demonstrate one hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway specimen will fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"E" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass) located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will use condulets at each end of the specimen on the exposed side of the deck. A conduit connector will also be installed on the conduit. (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"F" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~one~~ three hour *VERSAWRAP* systems installed on ¾" diameter conduit (as the most severe thermal mass) connected to a "Unistrut" hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped with *VERSAWRAP* as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"G" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track -This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled sateel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum trays. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. This item will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for small raceways.

"H" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound three hour *VERSAWRAP* systems installed on 30" x 4" and all smaller sizes of both aluminum and steel cable tray (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "G" above*) and bundled steel or aluminum conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum trays up to this size for hose stream test qualifications. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for both large tray and/or box wraps.

"I" ¾" Diameter Rigid Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel conduit and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"J" 4" Diameter Rigid Steel Conduit -This item is intended to demonstrate three hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway assembly will be fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for large and small conduit wraps.

"K" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit (the most severe thermal mass) found in the field that is located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize condulets at each end of the specimen. A conduit connector will also be installed on the conduit (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered as a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a single #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"L" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~three~~ one hour *VERSAWRAP* systems installed on a ¾" diameter rigid steel conduit as the smallest size of conduit found in the field (the most severe thermal mass) connected to a hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"M" 1-½" Diameter Steel Conduit ~~and T6I "Thermo-Lag"~~ Raceway Covered with Modified VERSAWRAP - This item is intended to bound "modified" one hour *VERSAWRAP* systems installed on 1-½" (and larger) diameter conduits in the field. The test raceway assembly will be fabricated from standard 1-½" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. ~~The one hour Thermo-Lag material will be installed with "dry joints" (no trowel-grade Thermo-Lag will be used).~~ A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on these raceway types. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed

according to Section 5.0 of this procedure.

"N" 12" x 12" x 12" x 16 Gauge Steel Box Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* conduit systems ~~that interface with a one hour "Darmatt KM1" raceway barrier system~~ installed on the box. The conduit will pass through a penetration seal to show wrap terminations as such. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1.

"O" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

"P" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

aluminum hanger

"Q" 3C-500MCM Aluminum armored Cable - This item is intended to bound one hour *VERSAWRAP* systems installed on a 3C-500MCM aluminum armored cable as supplied by Northern States Power for their Prairie Island Nuclear Power Station. The 10' (minimum) span of cable will be temporarily supported by a ~~rope~~ about mid-span. During the test, the ~~rope~~ will ~~burn~~ melt and will allow the wrapped cable to be unsupported for the remainder of the fire test. The intent here is to show that the wrap will still be effective even if the cable suddenly becomes unsupported between hanger points (maximum distance as tested herein) in the field. (In the field, the cable is located in an aluminum tray suspended on steel hangers. The utility wishes to evaluate the possibility of wrapping only the cable instead of the entire tray. It is felt that if the aluminum tray is not wrapped, it will melt or be consumed during a fire thus leaving the cable unsupported except at points where the tray was suspended on steel hangers.)

aluminum unistrut trapeze-style hanger

"R" 3" x 3" angle - structural steel.

SECTION 2.0
TEST FURNACE:

The furnace to be used is Underwriters Laboratories' standard large floor furnace. The furnace shall be operated in accordance with the requirements of ASTM E-119 for the three hour fire test

SECTION 3.0
ITEMS TO BE PROTECTED:

The following is a description of the items to be used as raceway elements for the fire test:

> *(See Section 1.0, Synopsis for a general description of these items. Note: all steel trays and boxes will be manufactured from 16 gauge steel while all conduit will be standard, rigid conduit. All "free-cable air drops" will consist of single pieces of stranded 8 AWG bare copper wire according to GL 86-10, Supplement 1 requirements. All hangers will be fabricated from standard "Unistrut" type material [hangers may be welded to the raceways for the test in lieu of using clips, straps, etc].)*

An accurate description of specimen fabrication shall be included in the final test report (as verified by Transco Products Inc. Quality Control). Hardware substitutions are permitted provided substitute material (etc.) does not increase the heat mass of the specimen and are documented by Transco QC and UL.

SECTION 4.0
FIRE BARRIER MATERIAL INSTALLATION:

The *VERSAWRAP* and Transco Products Inc. TCO-001 materials shall be installed by Transco Products Inc. personnel in accordance with the manufacturer's instruction and/or procedures. If written instructions are not available at the time of installation, then Transco Products Inc. QC personnel shall document/verify step-by-step methods used for installation. Test installation records will be included as an appendix to the final test report.

Materials used for this test shall be purchased, received, and installed in accordance with latest approved revision of Transco Products Inc.'s Quality Assurance Program and applicable procedures. All fire barrier envelope installation will be witnessed by Transco Products Inc. Quality Control personnel. Material components (except for tie wire and ceramic blanket) will be identified with the responsible QC's initials as each layer is installed.

Note: This test will be performed as a "Safety Related" quality program in accordance with the latest approved revision of Transco Products Inc.'s Quality Assurance Manual (10CFR, Part 21 applies) with the exception that all materials will be provided as "Q-Class" with Certificates of Conformances.

SECTION 5.0
THERMOCOUPLES:

A.) Fire Barrier Envelope:

The fire barrier envelope is considered all areas of the specimen on the exposed side of the test slab. For these areas, thermocouples shall be mounted to the specimen to gather temperature data for the duration of the fire test. At a minimum, temperatures shall be documented at nominal two minute intervals for the duration of the test. Thermocouple placement for the fire barrier envelope (quantity and locations) shall be as specified in NRC GL 86-10 and Supplement 1 as follows:

"... **Cable Trays** - The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray shall be measured by placing the thermocouples every 152 mm (6 - inches) on the exterior surface of each tray side rails between the cable tray side rail and the fire barrier material.

Internal raceway temperatures shall be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm (6- inches) along the length of the copper conductor. Thermocouples shall be placed immediately adjacent to all structural members, supports, and barrier penetrations. ..."(1)

"... **Conduits** - The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite of the test deck and closest to the furnace fire source. The internal raceway temperatures should be measured by a stranded AWG 8 bare copper

conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations...."(1)

Free-Cable Air Drops: Thermocouples will be installed on the stranded 8 AWG wire used for demonstrating the "free-cable air drop" every 152 mm [6 inches] in accordance with the same requirements for monitoring internal conduit/cable tray temperatures.

(Note: *In accordance with NRC GL 86-10, Supplement 1 requirements, "for the thermocouples installed on conduits, cable tray side rails, and bare copper conductors, a ± 13 mm (±1/2 inch) installation tolerance is acceptable". Hence, this tolerance shall be considered acceptable for use in this test. The tolerance is considered to be from the point of individual thermocouple placement and not compounded from one thermocouple to the next (i.e., all thermocouples can not be 6 1/2" from each other but rather must be ±1/2" from the measured 6" [minimum] mark on the item being monitored.)*

Junction box thermocouples will be installed in accordance with the requirements of Generic Letter 86-10, Supplement 1.

B.) Penetration Seal:

Thermocouple placement for the unexposed penetration seal surface (test item "N") will comply with the typical requirements of ASTM E814. As an optional method for protecting thermocouple tips, the thermojunctions of each thermocouple may be embedded into the seal surface or seal surface/penetrating member interface approximately ⅛ -¼" below the seal surface (because of the nature of the seal material, this placement can be performed at any time after the installation of the seal material). For this alternate method, insulation pads for covering the thermocouple tips will not be used.

All specimen temperatures shall be monitored using thermocouples (with special limits of error equal or less than 1.1°C). Thermojunctions of all specimen thermocouples shall be electrically welded. All thermocouple wire shall be supplied with certifications of purity, accuracy, and calibration.

Furnace atmosphere thermocouples shall be placed 12" below the furnace deck/slab as well as 12" away from representative elements of the test specimen accordance with ASTM E-119-88 requirements (not less than nine [9] thermocouples will be used to monitor furnace atmosphere temperatures). Additional furnace atmosphere thermocouples be employed around the specimen as it protrudes into the furnace. These will be placed at the laboratories discretion to supplement data acquisition in areas where furnace atmosphere thermocouples can not be mounted to satisfy ASTM E-119 requirements because of the specimen's configuration, et cetera.

The installation and location of each uniquely identified thermocouple (for both the specimen and furnace) shall

be mapped and verified (measured) by Transco Products Inc. Quality Control. Verification may be performed as hand written notes and shall become part of the permanent records of the test. Also, all thermocouple certifications shall also become a permanent record of the test.

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[1] Generic Letter 86-10 and Supplement 1

SECTION 6.0
FIRE TEST:

The fire test shall be conducted in accordance with the ASTM E-119 time/temperature curve (and temperature tolerance) for a minimum of three (3) hours. As a minimum, temperature data provided by both furnace and specimen thermocouples should be monitored and documented at nominal two (2) minute intervals. The laboratory shall verify and document visual specimen performance and occurrences (*i.e.*, smoke, et cetera) for the duration of the test.

It is intent of the test to demonstrate as many different raceway configurations as possible. As such, several raceway test specimens exhibit multiple features (*i.e.*, the 3 hour large tray demonstrates the tray wrap, a "free- air" cable and interface, a wrap-to-concrete interface, *etc.*). If one of these features fails thermally or during the hose stream test, it is the intent of the test to then exclude that feature from the configuration being qualified. In the case of the large tray for example, if the "free-air" cable or wrap-to-concrete interface fails for any reason, it is does not cause the tray to fail provided the rest of the tray specimen meets the acceptance criteria of Generic Letter 86-10, Supplement 1. Any failed portion of a specimen will then not be qualified by this test.

SECTION 7.0
HOSE STREAM TEST:

After the conclusion of the three hour fire test, the fire barrier envelope specimen (along with the surrounding penetration seal) shall be subjected to a minimum of one of the following hose stream tests (as identified in NRC GL 86-10, Supplement 1):

(a.) "The stream applied at random to all exposed surfaces of the test specimen through a 3.8 cm (1-1/2-inch) fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 1.5 meters (5 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3 -hour barriers); or[2]

(b.) "The stream applied at random to all exposed surfaces of the test specimen through a 6.4 cm (2 ½-inch) national standard playpipe with a 2.9 cm (1-1/8 -inch) orifice at a pressure of 207 kPa (30psi) at a distance of 6.1 meters (20 feet) from the specimen, (Duration of the hose stream application - 1 minute for a 1-hour barrier and 2 ½ minutes for a 3-hour barrier); or"[2]

(c.) "The stream applied at random to all exposed surfaces of the test specimen through 3.8 cm (1 ½-inch) fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa (75psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 3 meters (10 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3-hour barriers)."[2]

2. Generic Letter 86-10 and Supplement 1

The responsible QC shall verify and document the type of hose stream, distance, time et cetera employed in each hose stream test.

SECTION 8.0
TEST REPORT:

The laboratory performing the test shall provide a written report which accurately describes the following minimum elements of the test:

1.) Verification of specimen materials and dimensions used;

2.) Verification of fire barrier envelope materials, dimensions, and installation techniques (procedures) used;

3.) Verification of general furnace construction/dimensions and locations of burner, thermocouples, et cetera;

4.) Verification of specimen thermocouple locations (along with copies of thermocouple material certifications);

5.) Verification of standards used for conducting fire test along with record of both furnace atmosphere and specimen temperature data acquired during test;

6.) Record of furnace pressure during fire test;

7.) Record of visual occurrences/observations of fire and hose stream tests;

8.) Record of hose stream test(s);

9.) Photographic records of specimen before fire barrier envelope installation, after fire barrier installation, and post fire/hose stream tests;

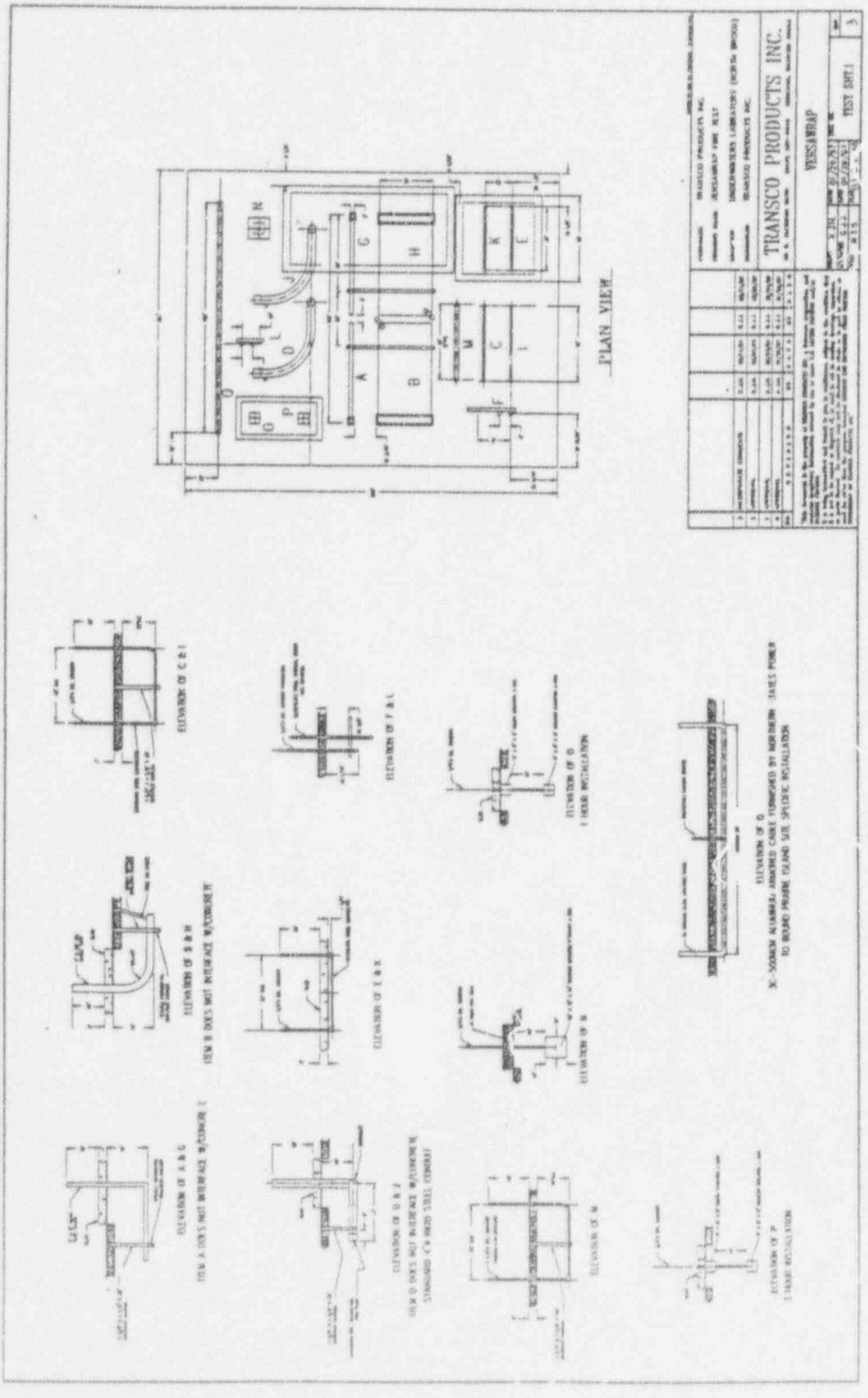
10.) Post test observations including measurements of material loss/degradation, et cetera;

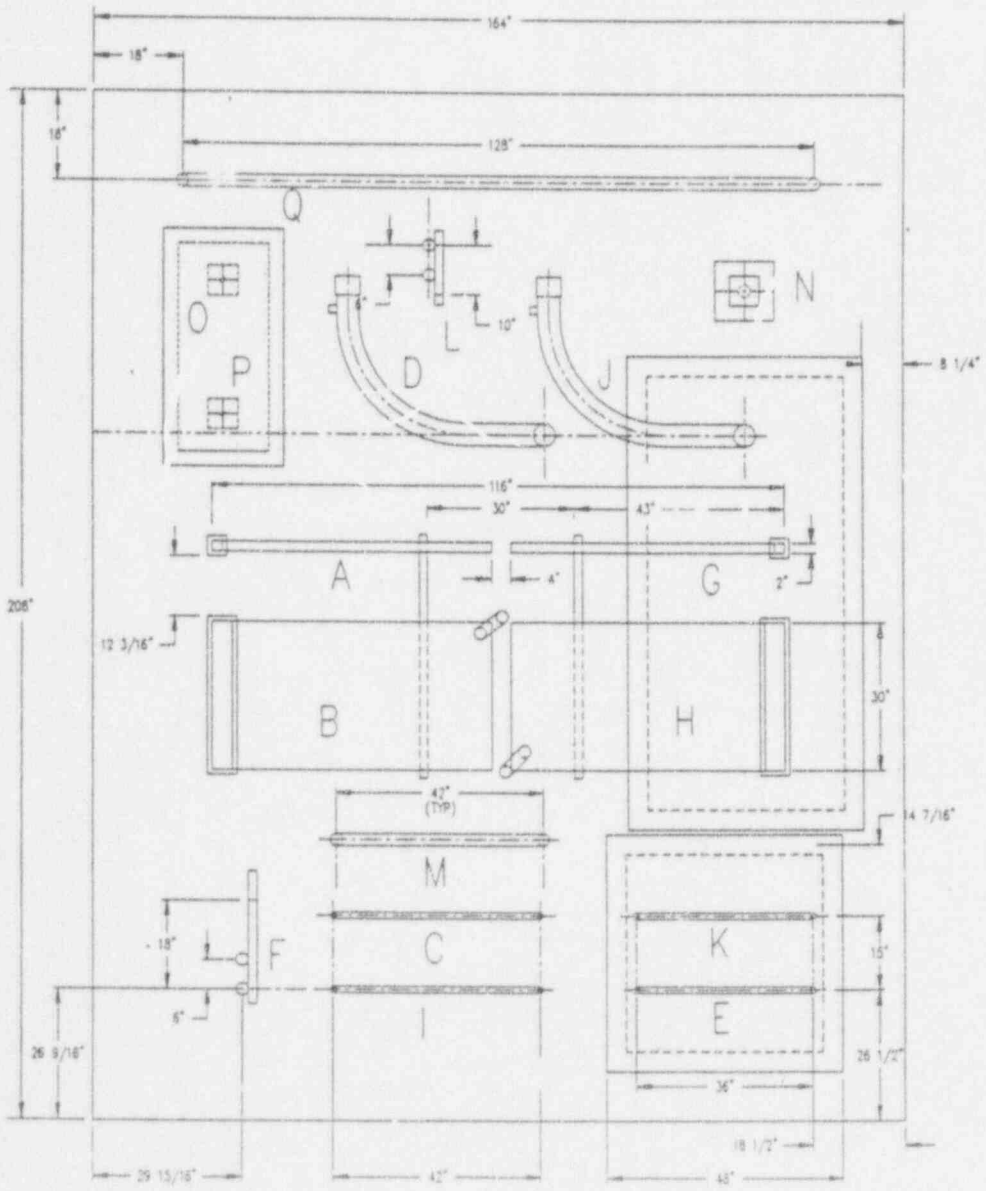
11.) Certification of the report by the agency performing test; and,

12.) QC records and notes from installation and test as an appendix to the report.

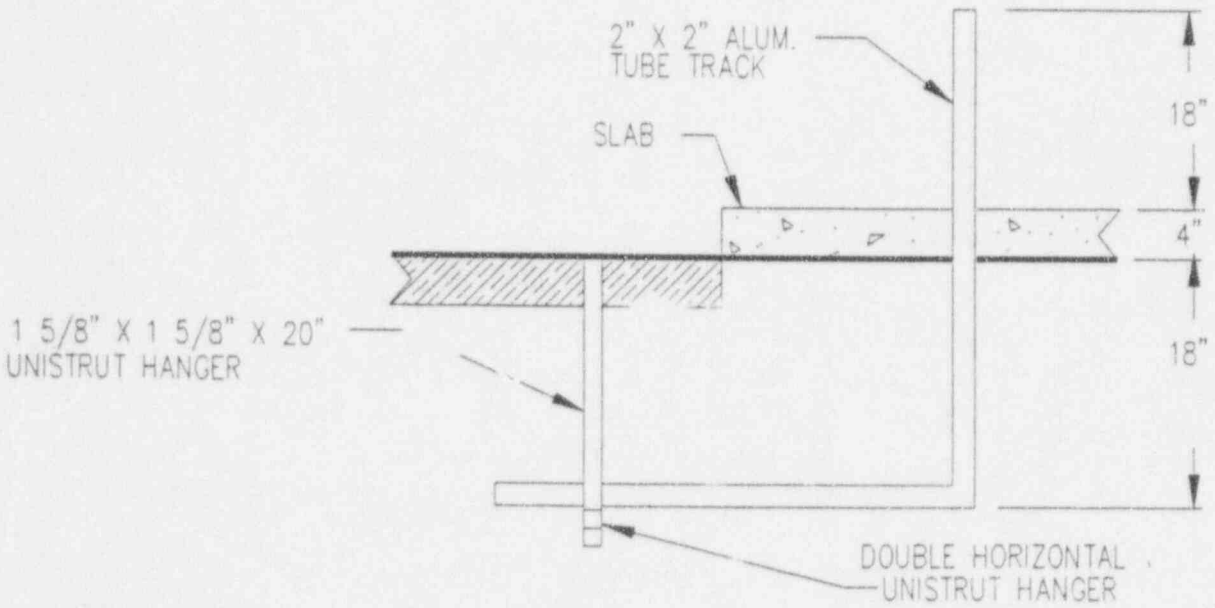
13.) Record of test items thermocouple temperature readings.

ALL TEST RECORDS, NOTES, CERTIFICATIONS, REQUIRED BY THIS TEST WILL BE LEGIBLE AND SUITABLE FOR REPRODUCTION.


PLAN VIEW
TRANSCO PRODUCTS INC.
VESSEL MAP

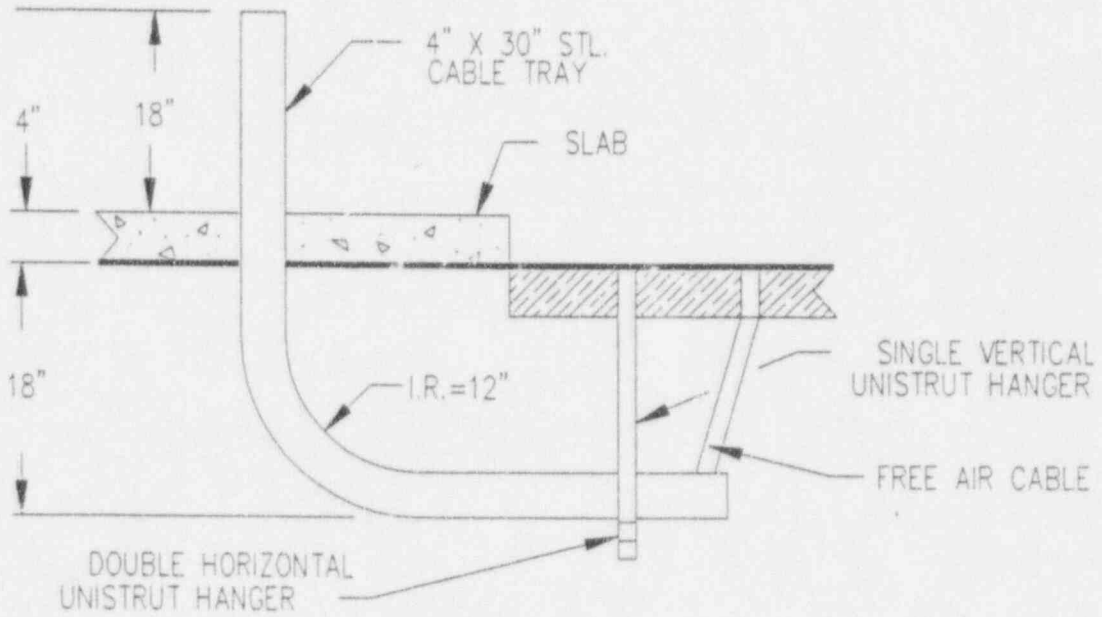

164"
18"
16"
128"
Q
O
P
L
10"
D
J
N
8 1/4"
116"
30"
43"
A
4"
G
2"
208"
12 3/16"
B
H
30"
42"
(TYP)
14 7/16"
M
18"
F
C
K
16"
5"
I
E
26 9/16"
26 1/2"
36"
18 1/2"
29 15/16"
42"
48"

PLAN VIEW



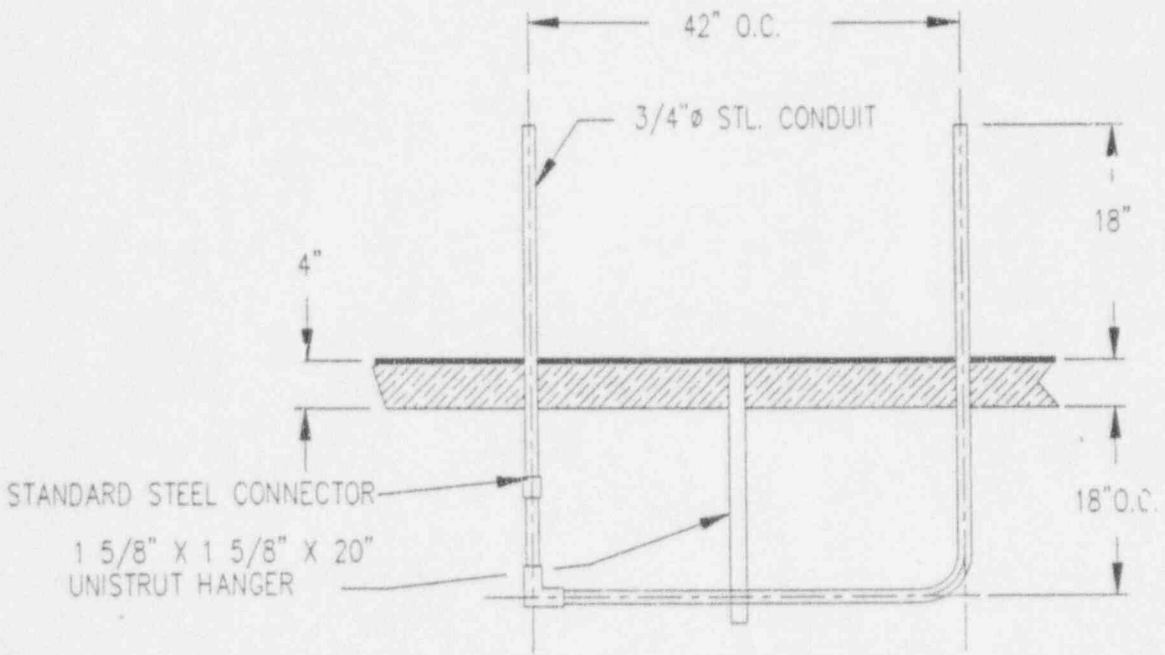
ELEVATION OF A & G

ITEM A DOES NOT INTERFACE W/CONCRETE

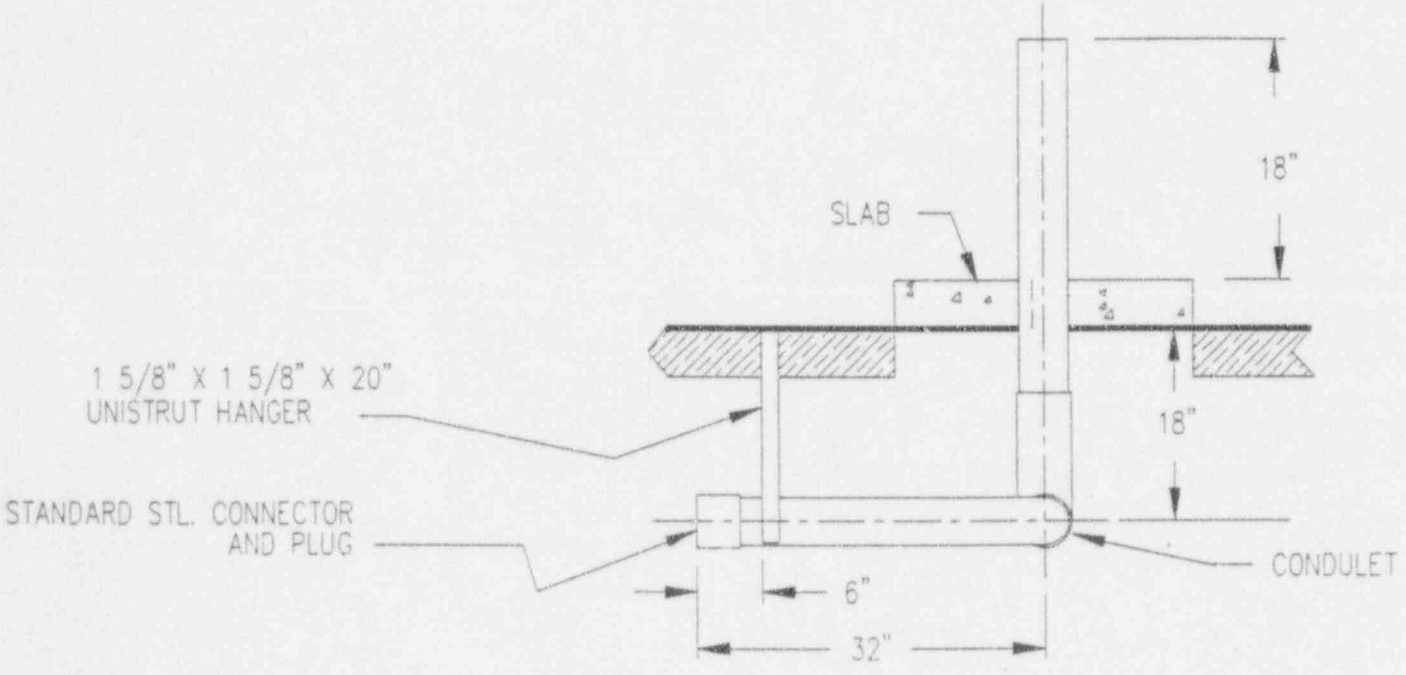


ELEVATION OF B & H

ITEM B DOES NOT INTERFACE W/CONCRETE



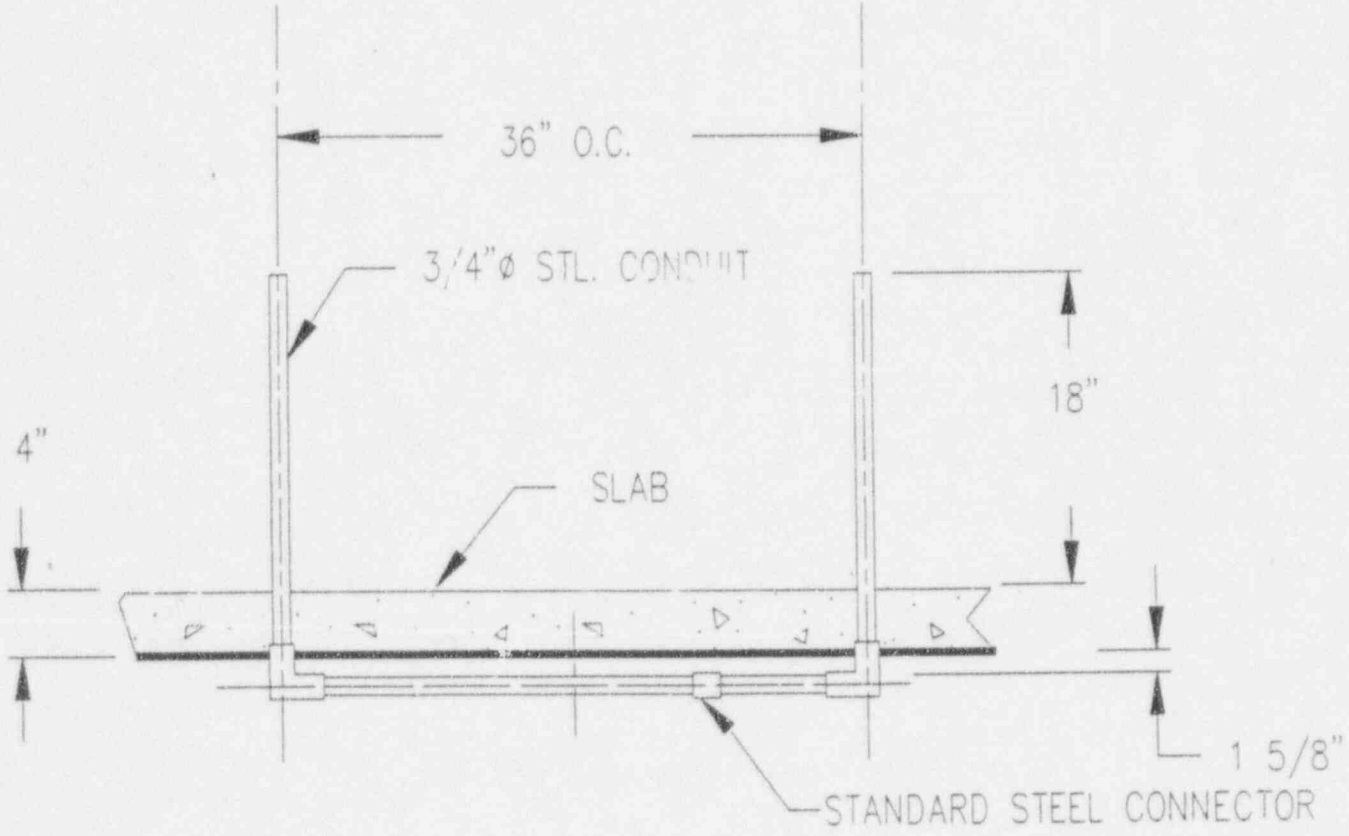
ELEVATION OF C & I



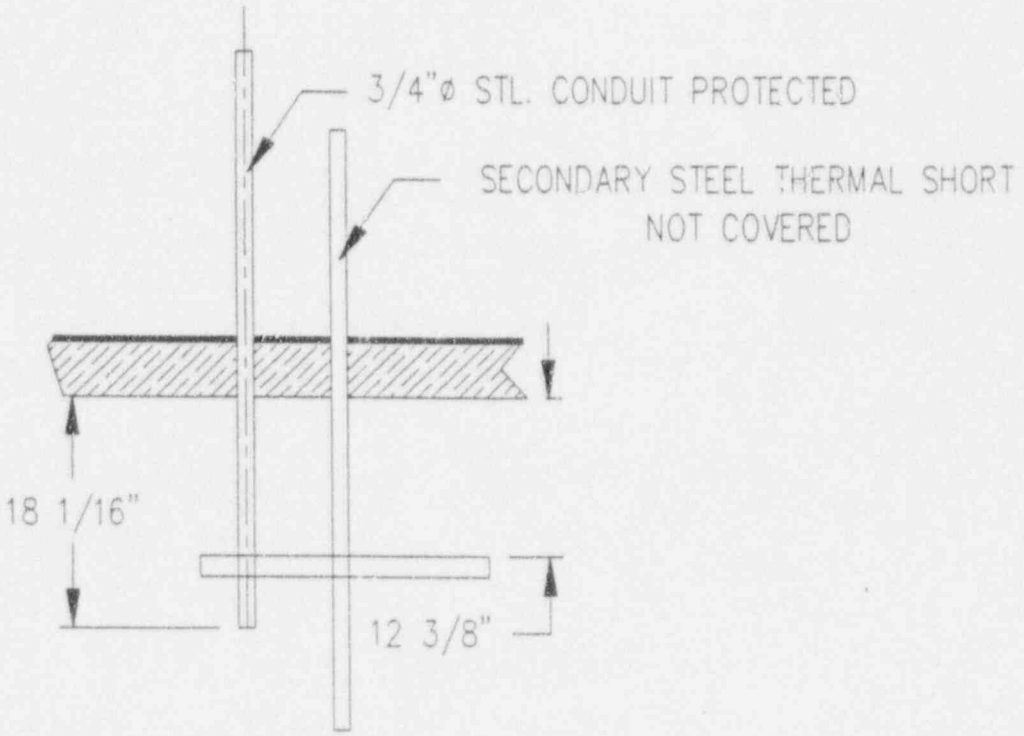
ELEVATION OF D & J

ITEM D DOES NOT INTERFACE W/CONCRETE

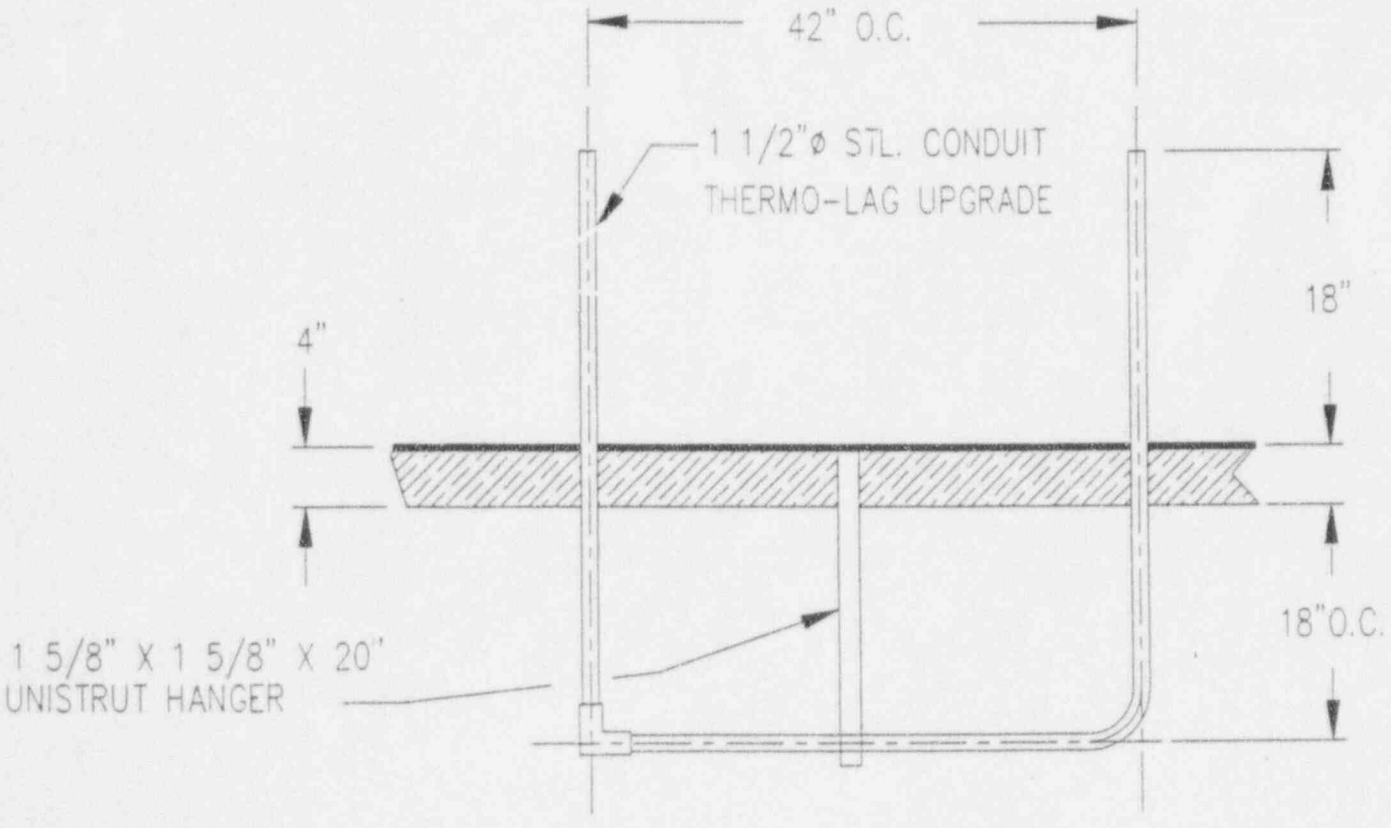
STANDARD 4"ø RIGID STEEL CONDUIT



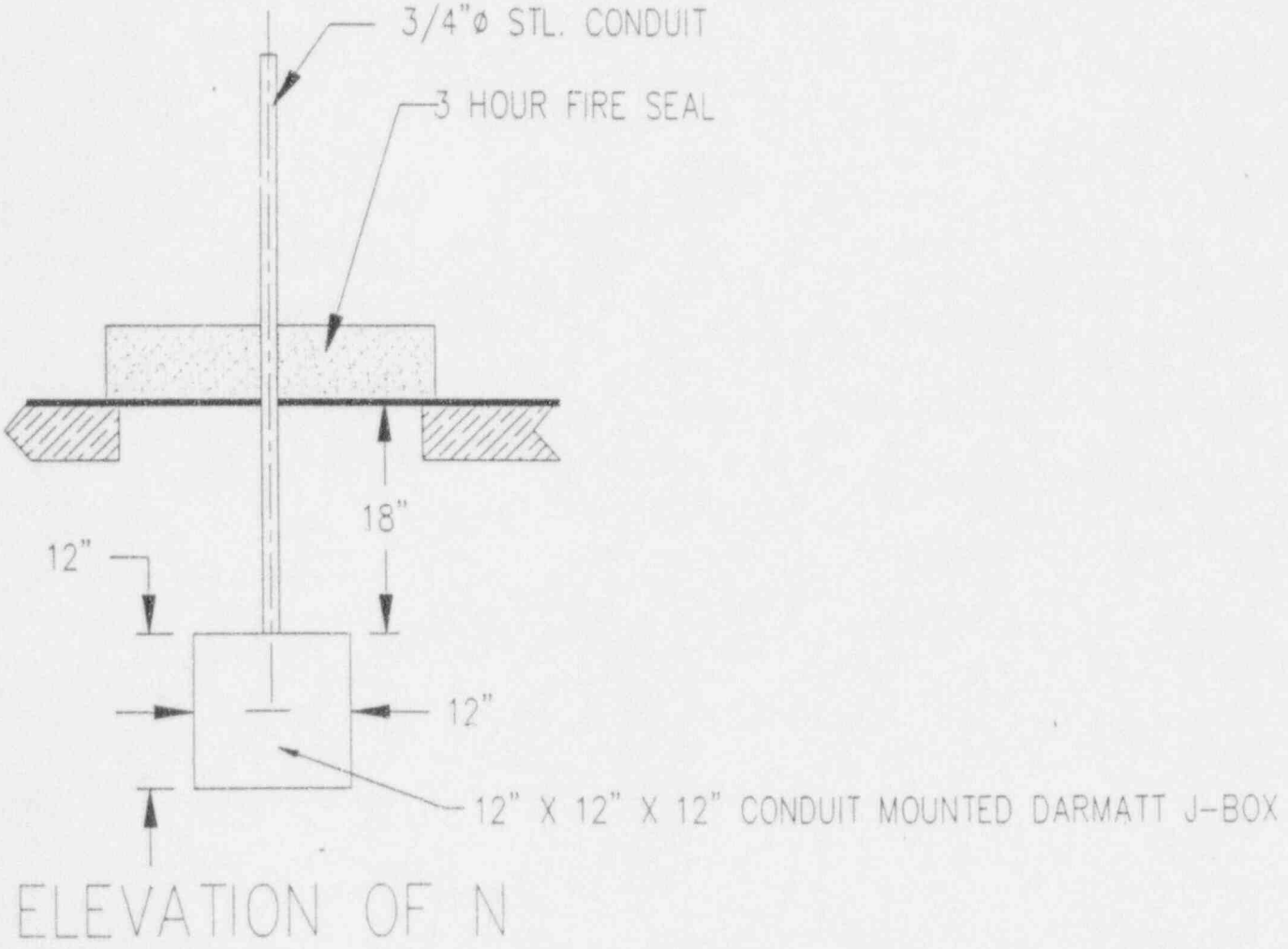
ELEVATION OF E & K



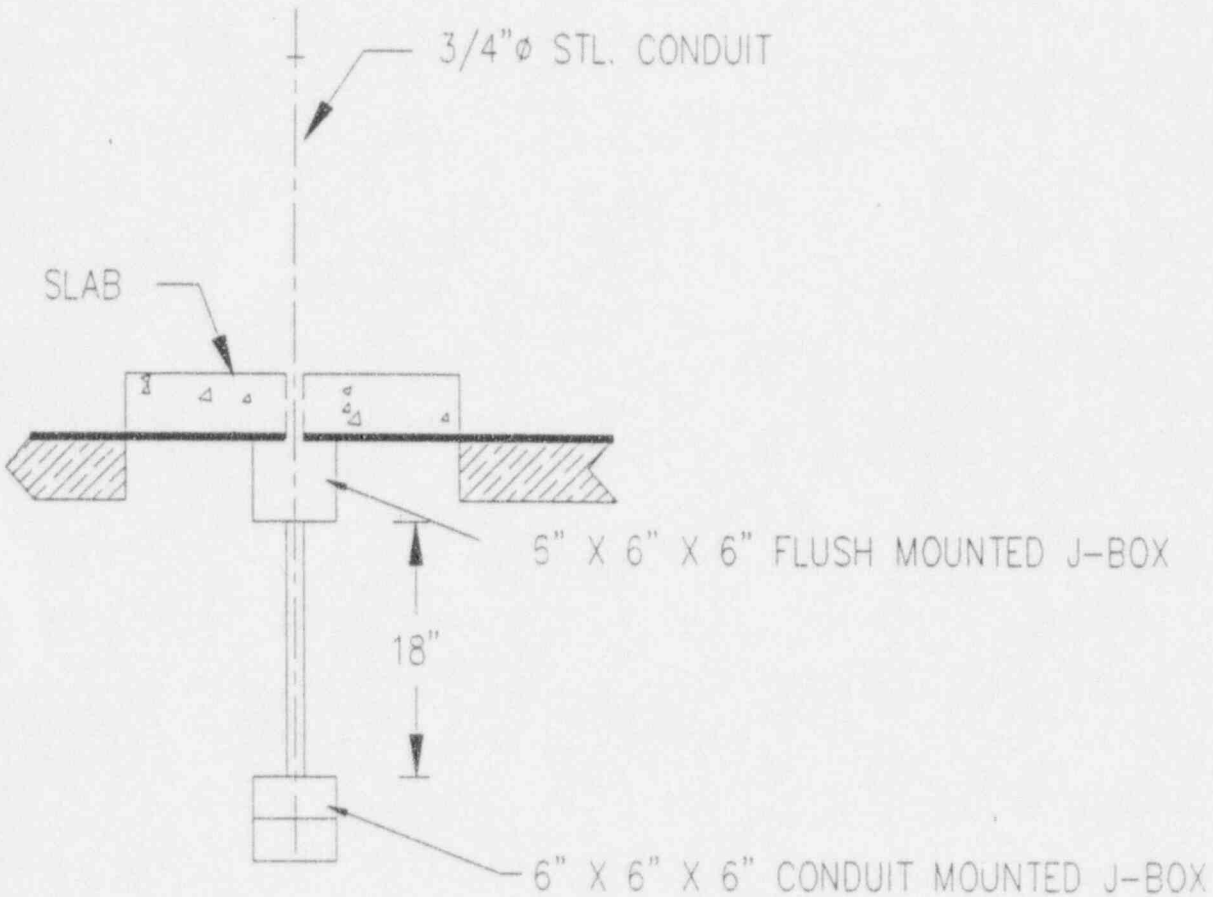
ELEVATION OF F & L



ELEVATION OF M

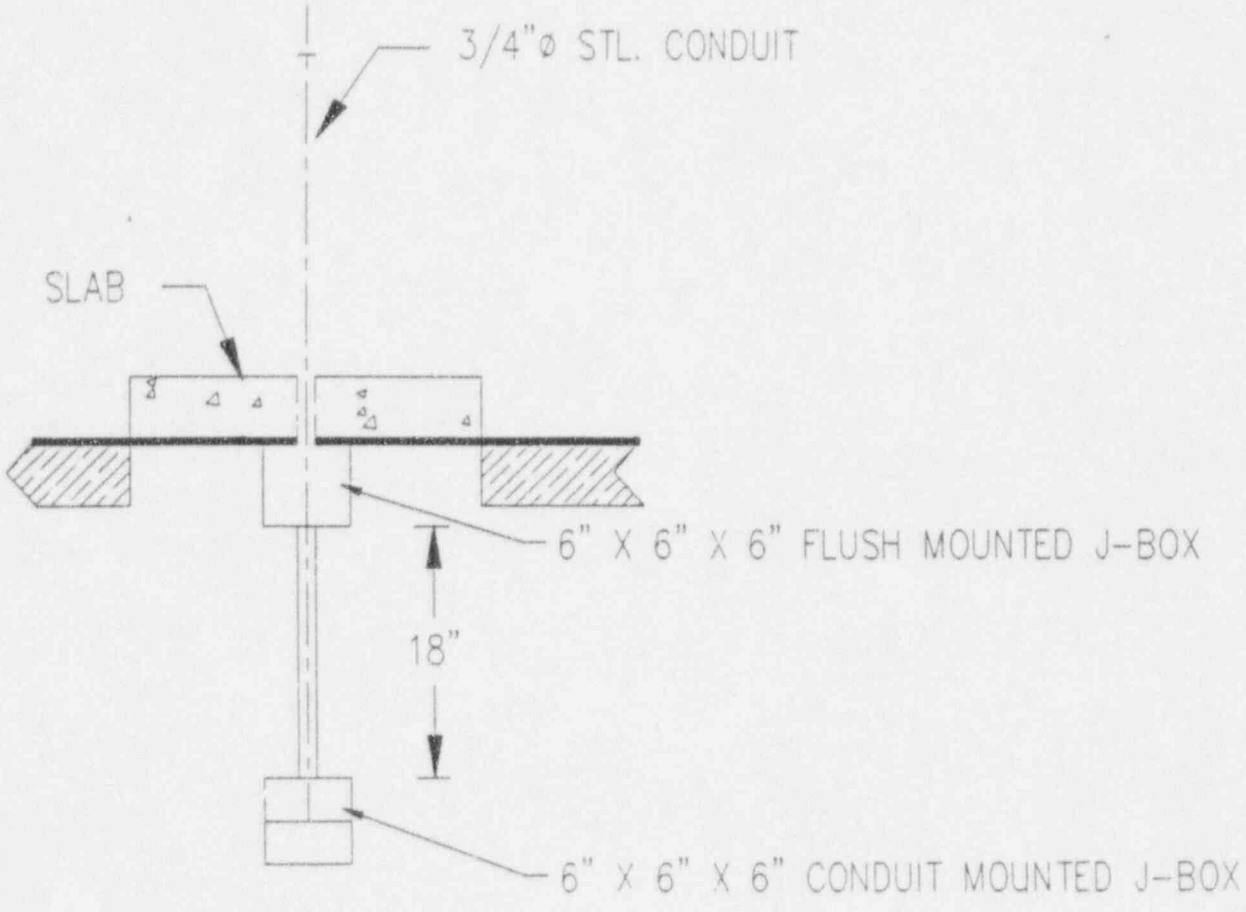


ELEVATION OF N



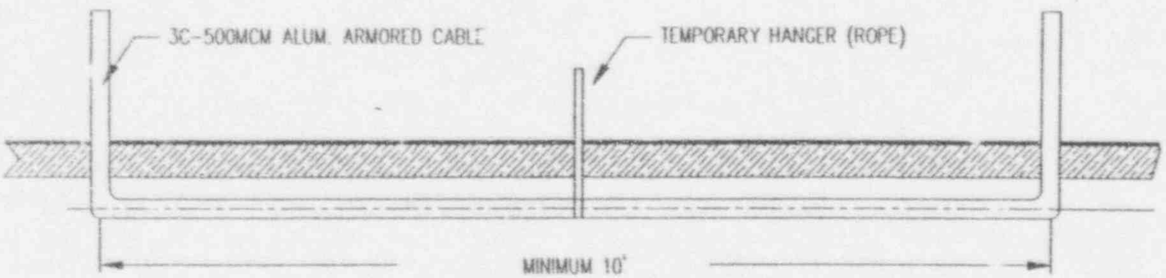
ELEVATION OF O

1 HOUR INSTALLATION



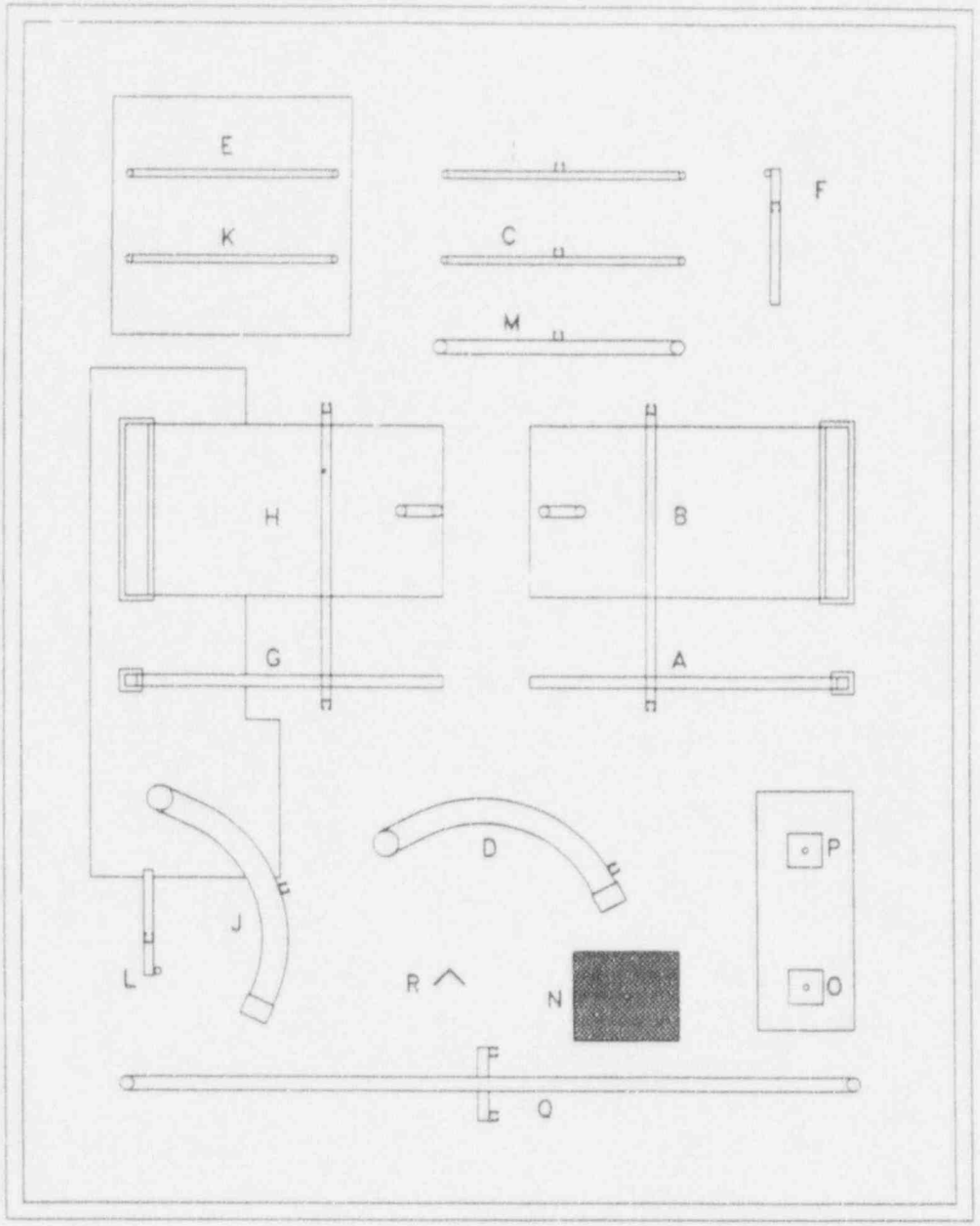
ELEVATION OF P

3 HOUR INSTALLATION



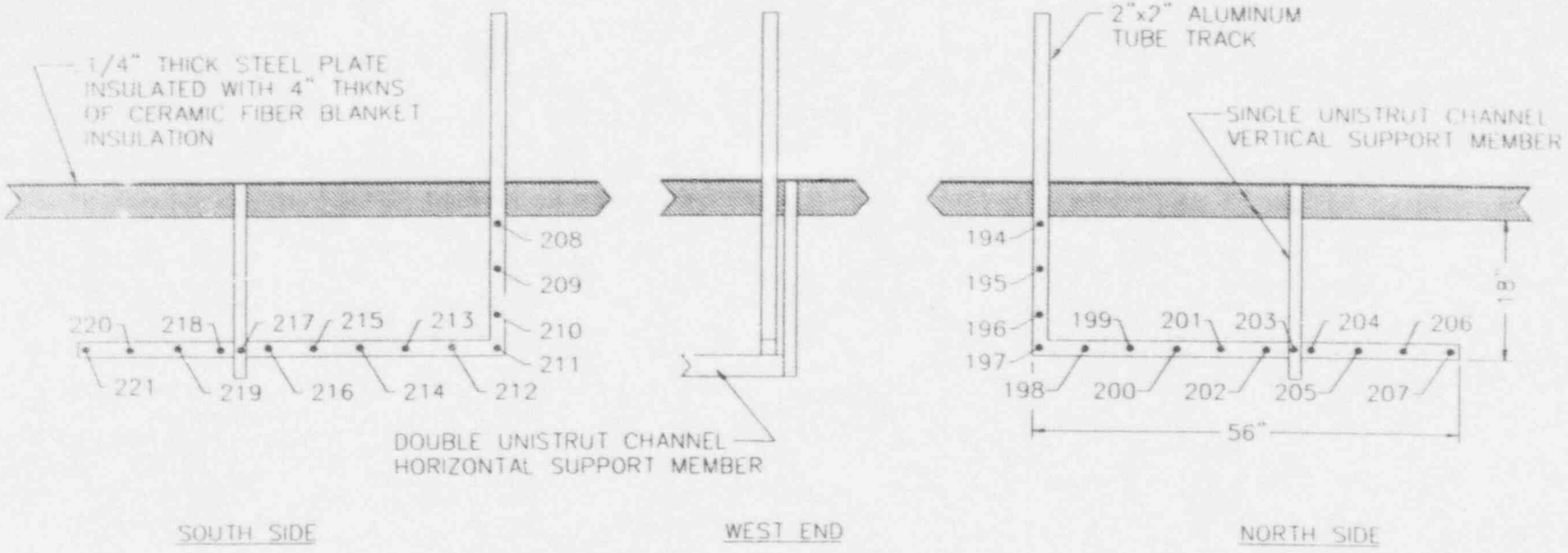
ELEVATION OF Q
3C-500MCM ALUMINUM ARMORED CABLE FURNISHED BY NORTHERN STATES POWER
TO BOUND PRAIRIE ISLAND SITE SPECIFIC INSTALLATION

NORTH



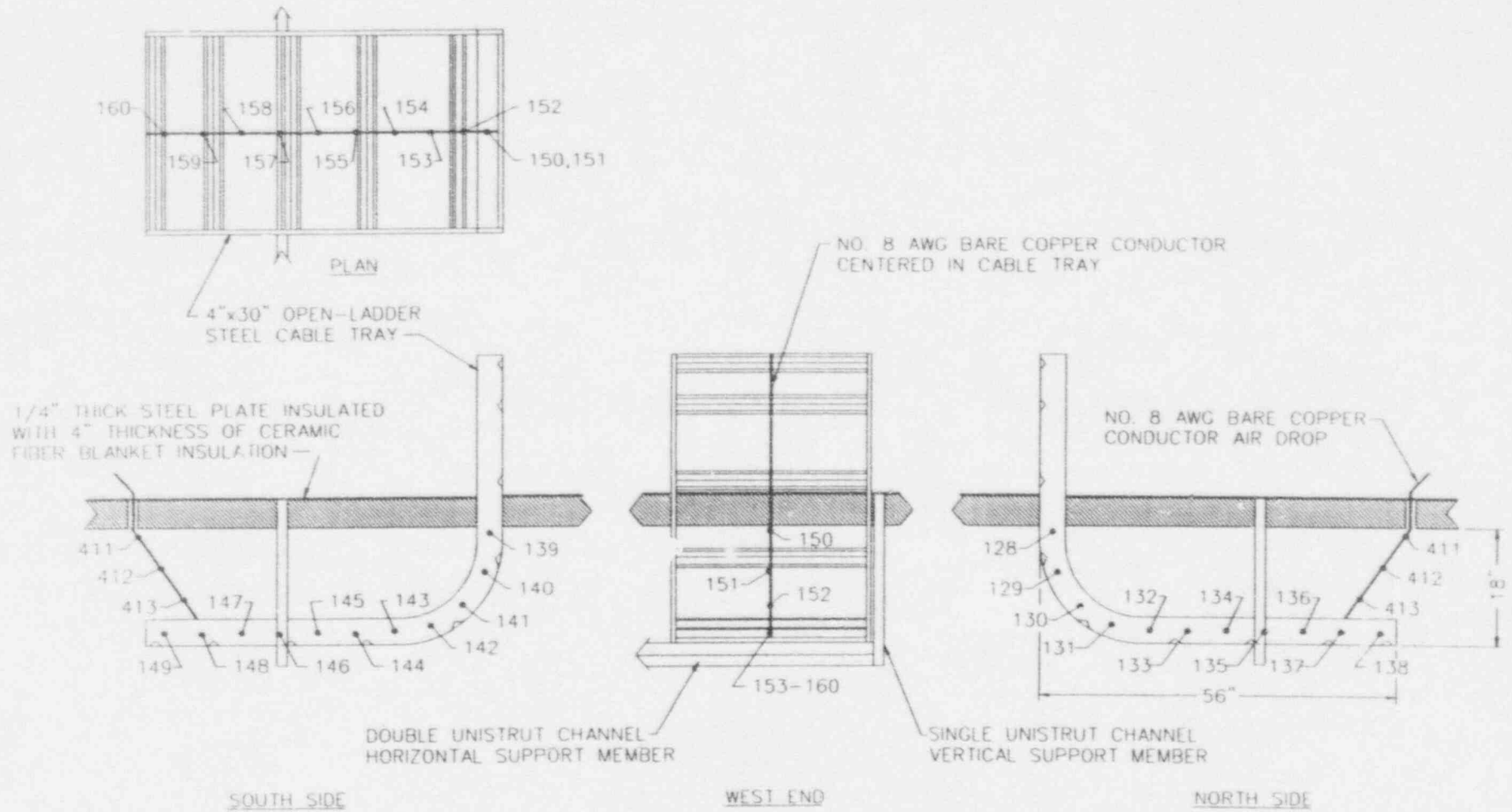
ARTICLE	TC NOS.	ARTICLE	TC NOS
A	194-234	J	324-349 & 426
B	128-160 & 411-413	K	112-127
C	39-67	L	377-384 & 427
D	350-376	M	68-95
E	96-111	N	407-410 & 417-420
F	1-8 & 428	O	299-323
G	235-273	P	274-298
H	161-193 & 414-416	Q	429-438
I	9-38	R	385-406

TEST ARTICLE LAYOUT &
THERMOCOUPLE LOCATIONS

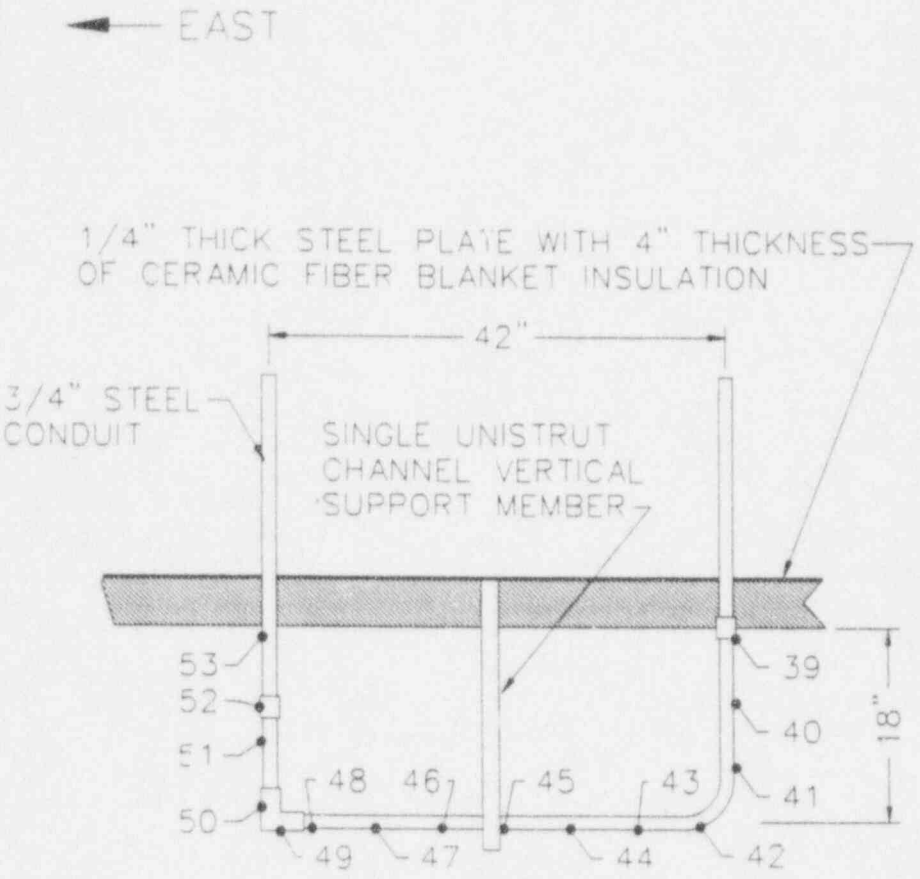


TC NOS. 222-234 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 222 COINCIDES WITH TC NOS. 194 AND 208 ON TUBE TRACK.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE A

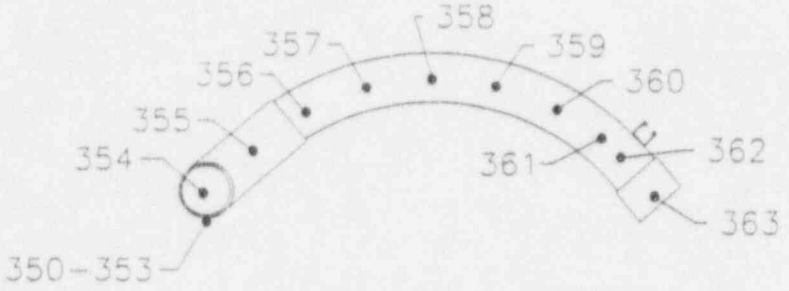


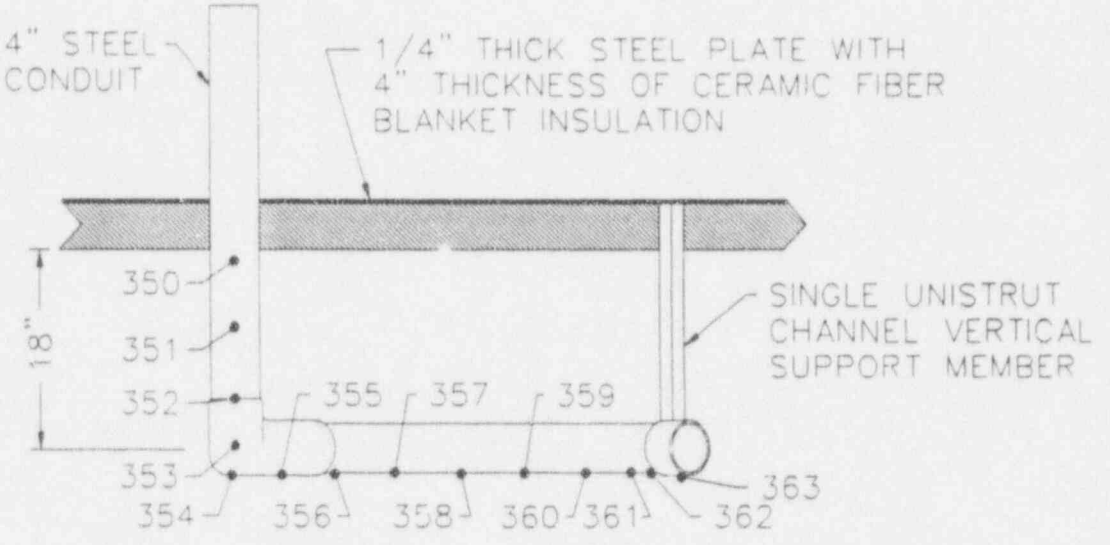
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE B



TC NOS. 54–67 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 54 COINCIDES WITH TC NO. 39.

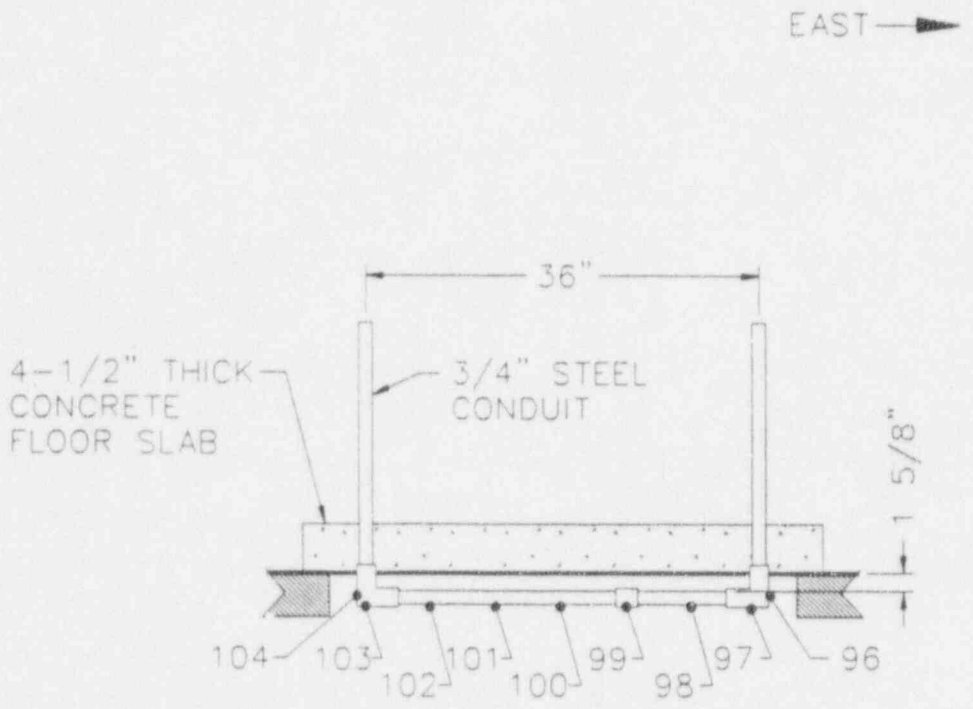
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS – ARTICLE C





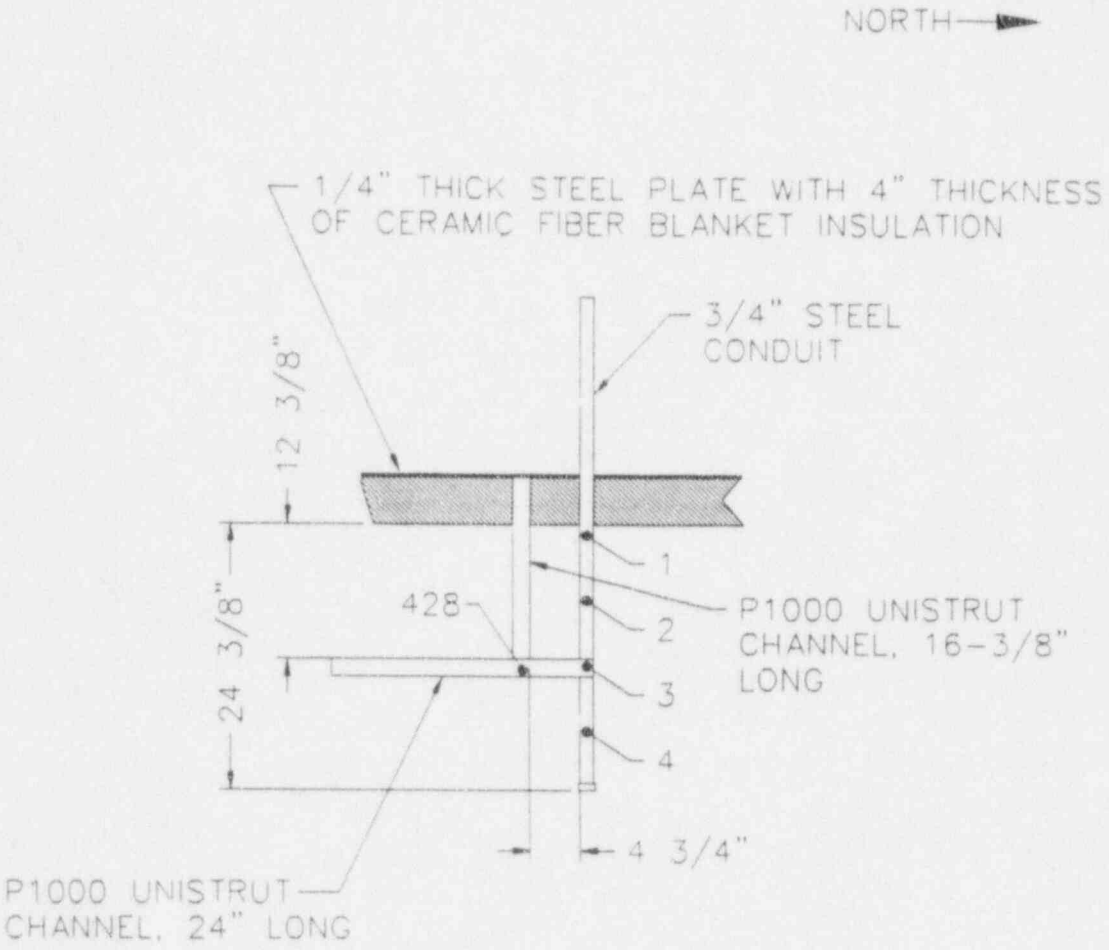
TC NOS. 364-376 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE D



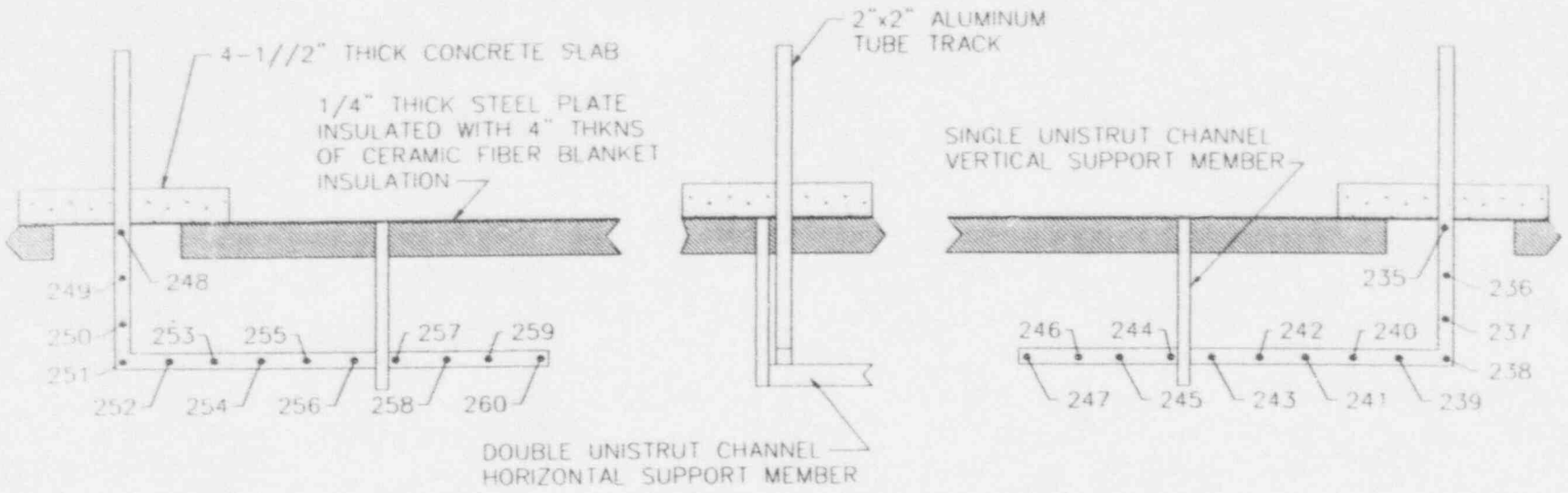
TC NOS. 105-111 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 105 COINCIDES WITH TC NO. 96.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE E



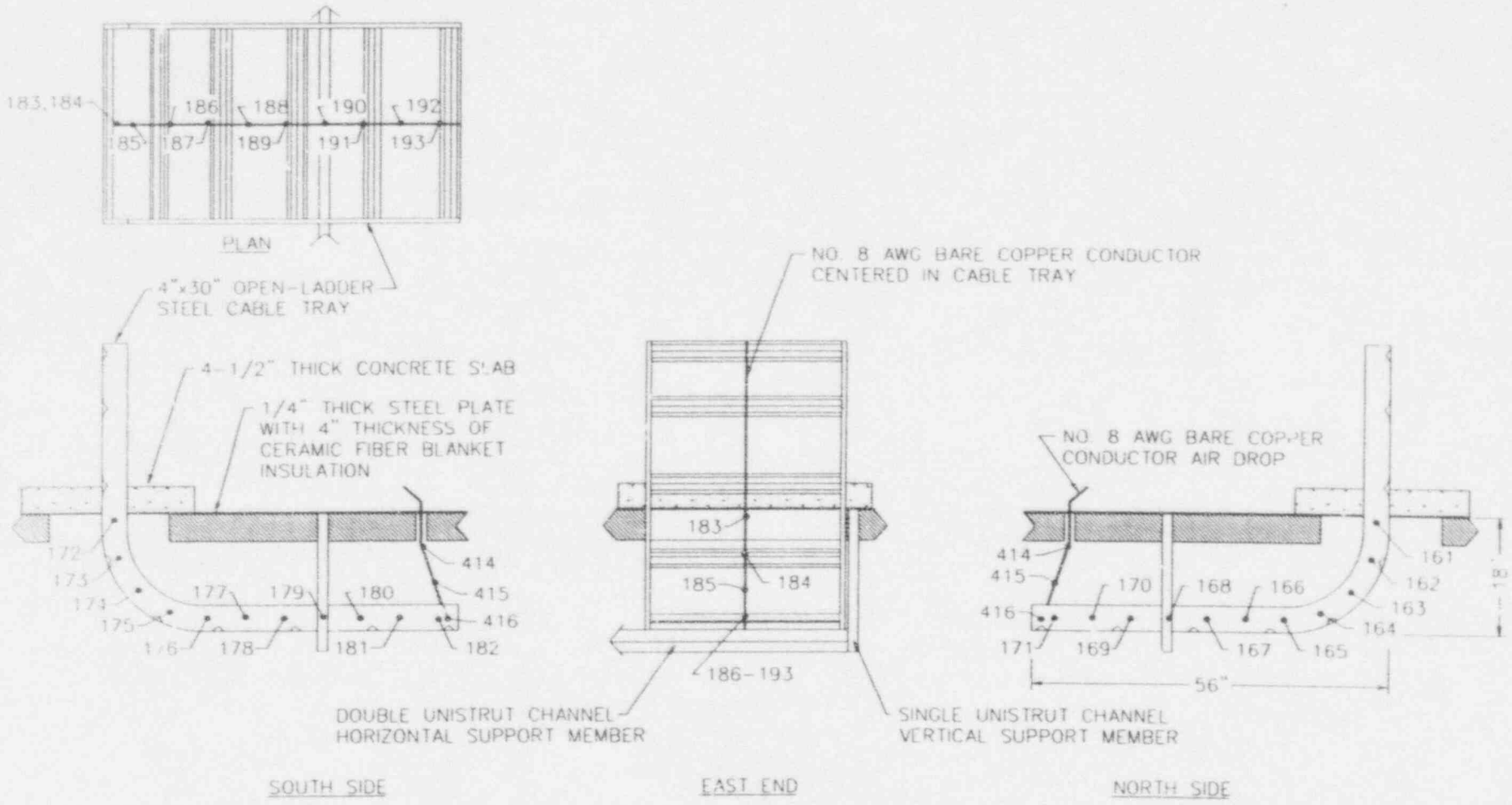
TC NOS. 1-4 ON WEST SIDE OF CONDUIT.
TC NOS. 5-8 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITH'N CONDUIT.
TC NO. 5 COINCIDES WITH TC NO. 1.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE F

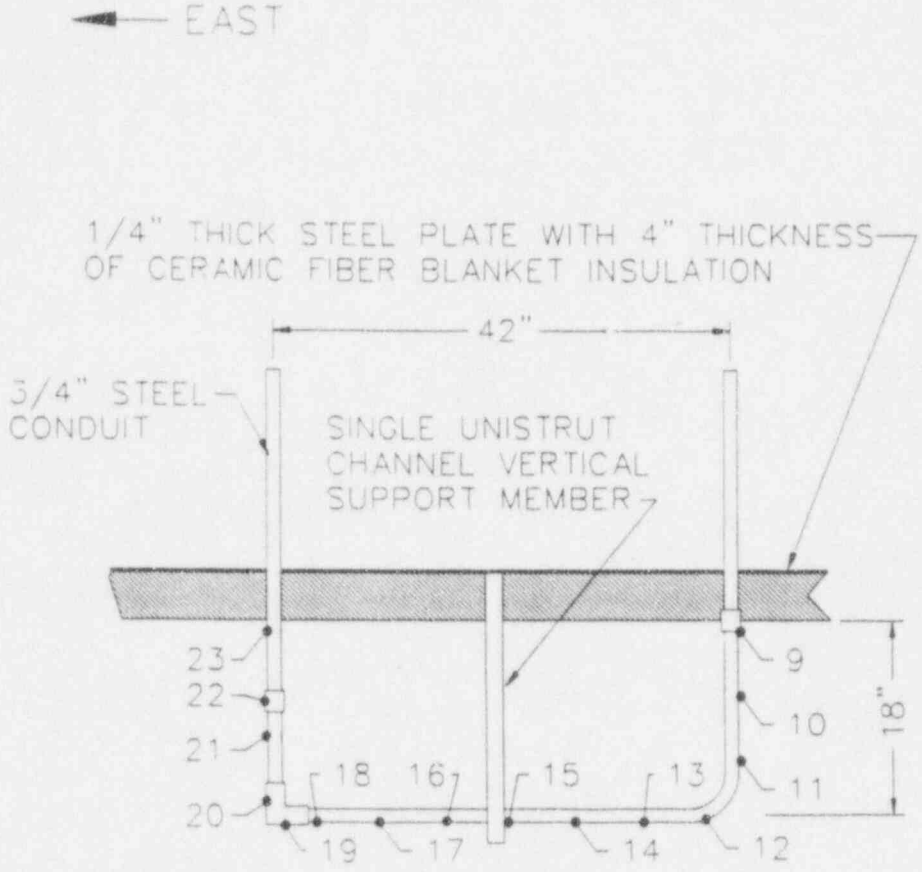


TC NOS. 261-273 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 261 COINCIDES WITH TC NOS. 235 AND 248 ON TUBE TRACK

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE G

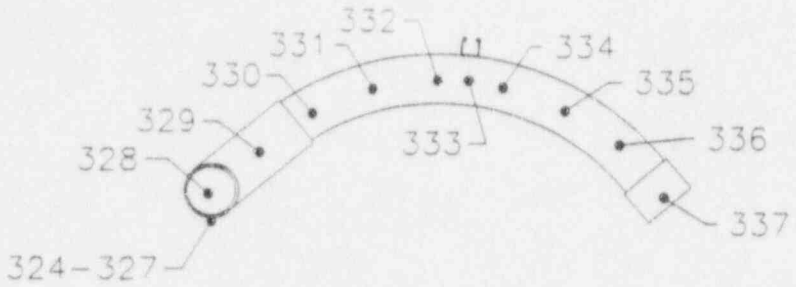


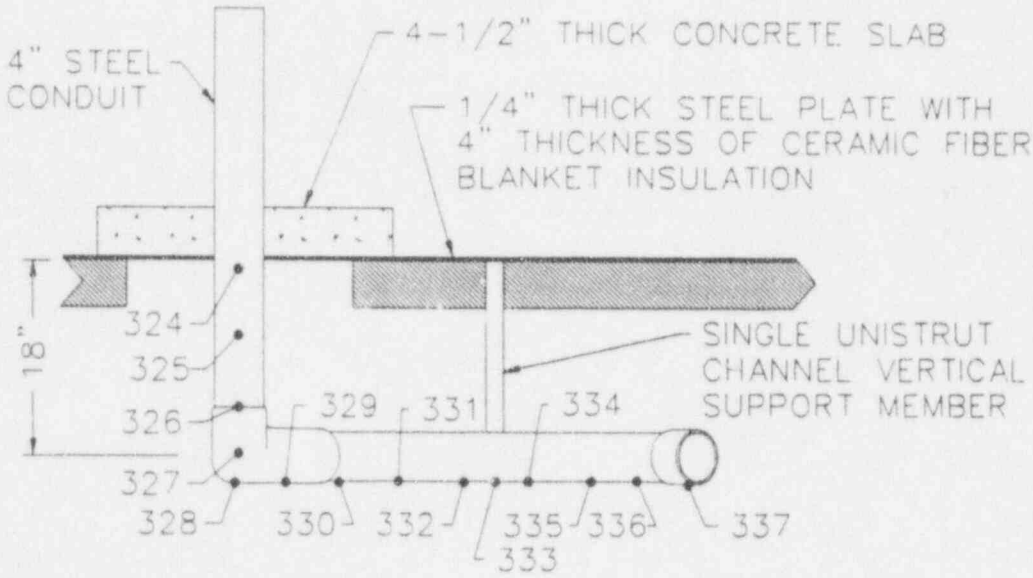
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE H



TC NOS. 25–38 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 25 COINCIDES WITH TC NO. 9.

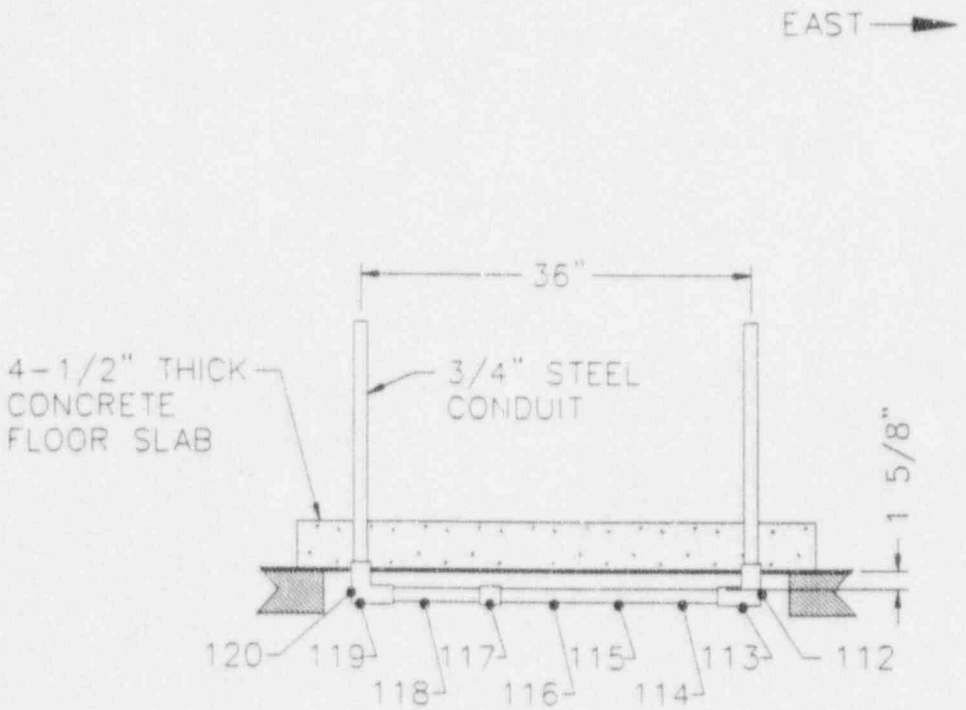
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE I





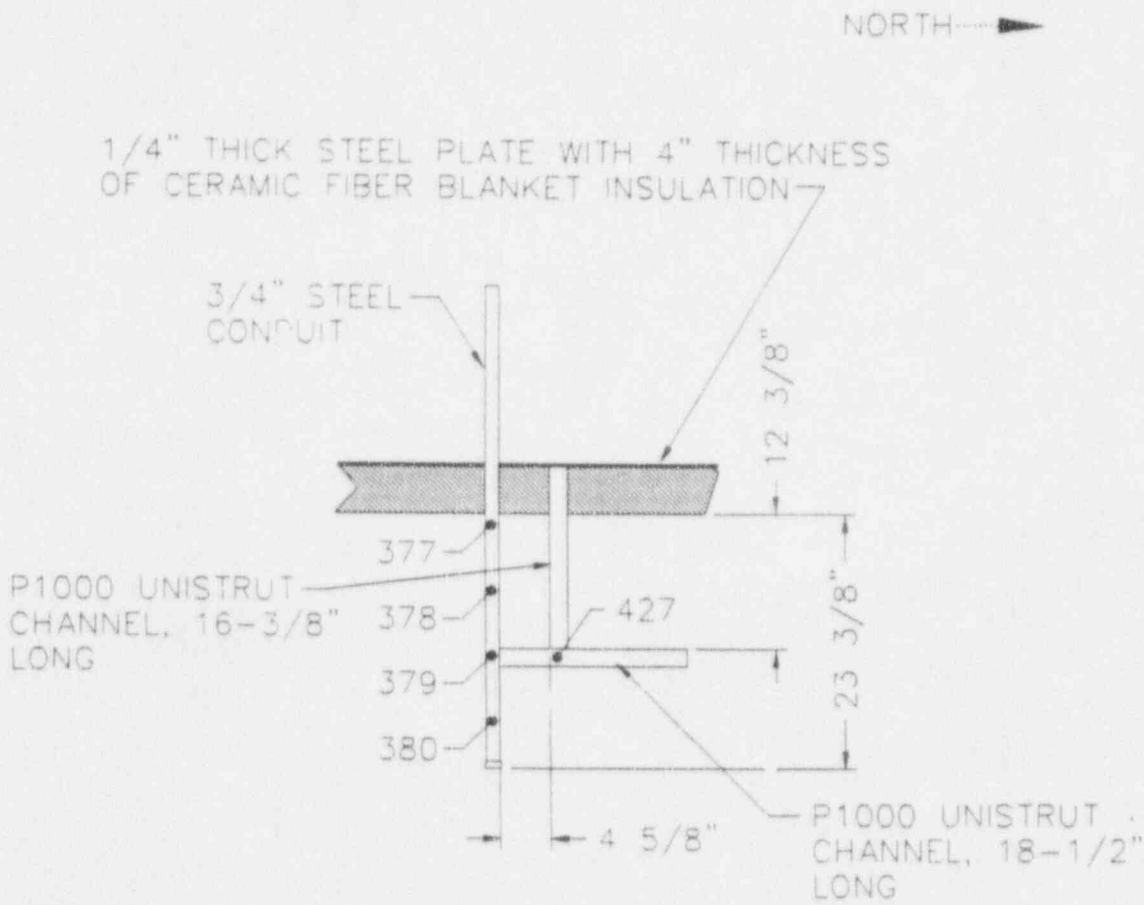
TC NOS. 338-349 & 426 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350. TC NO. 426 COINCIDES WITH TC NO. 337.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS-ARTICLE J



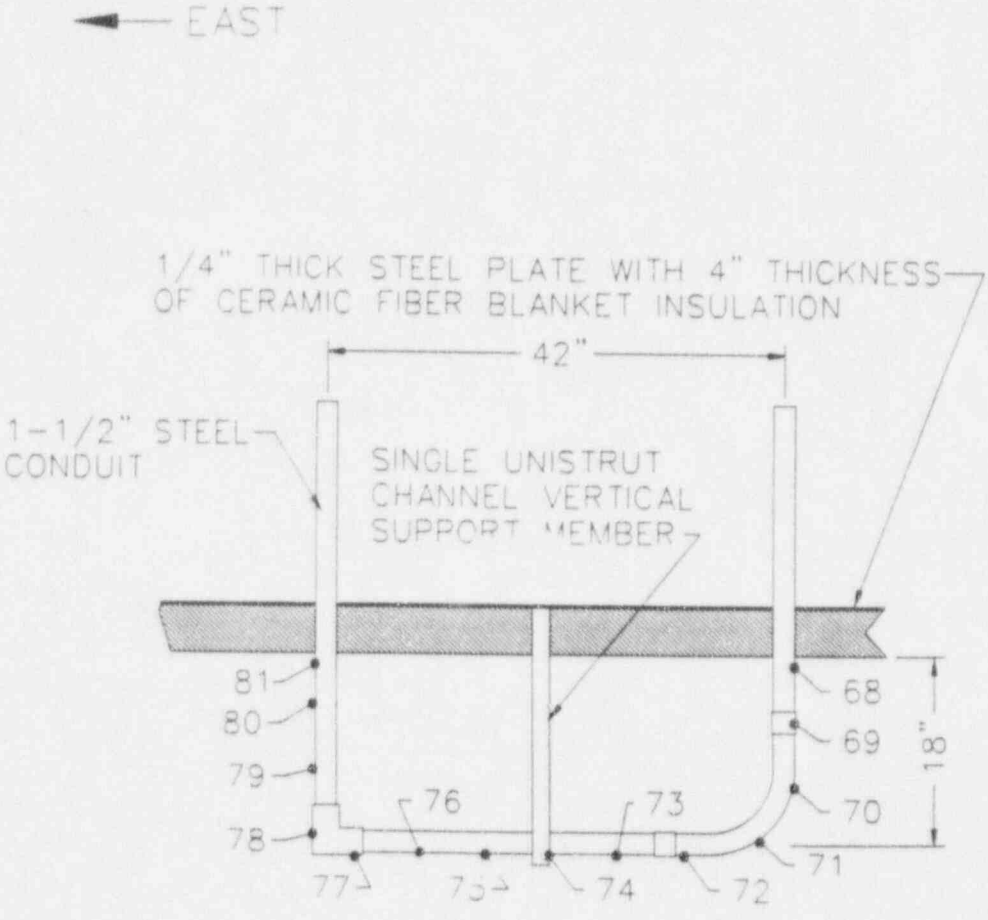
TC NOS. 121-127 (6" OC) ON NO. 8 AWG
BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 121COINCIDES WITH TC NO. 112.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE K



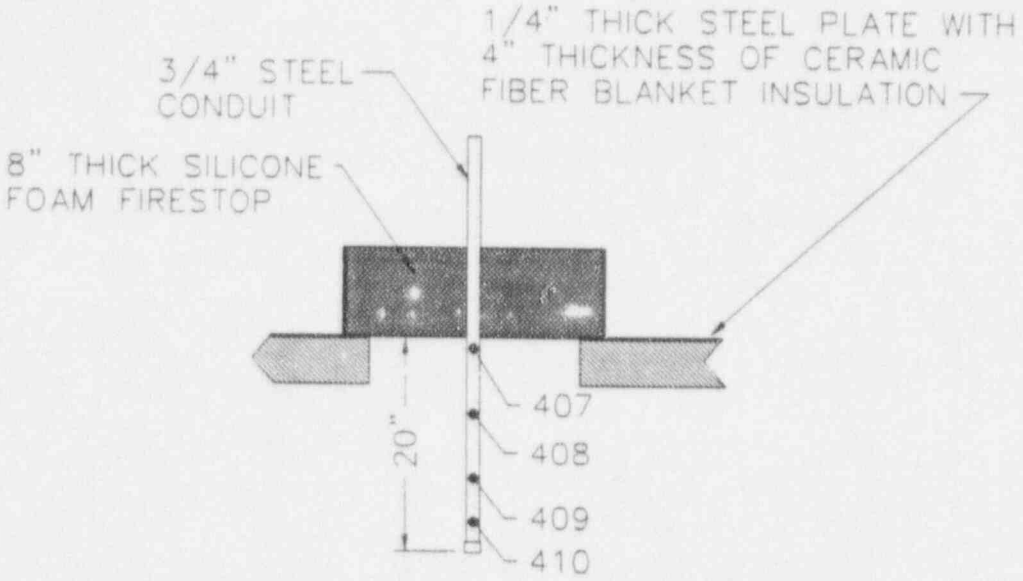
TC NOS. 377-380 ON EAST SIDE OF CONDUIT.
TC NOS. 381-384 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 381 COINCIDES WITH TC NO. 377.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE L



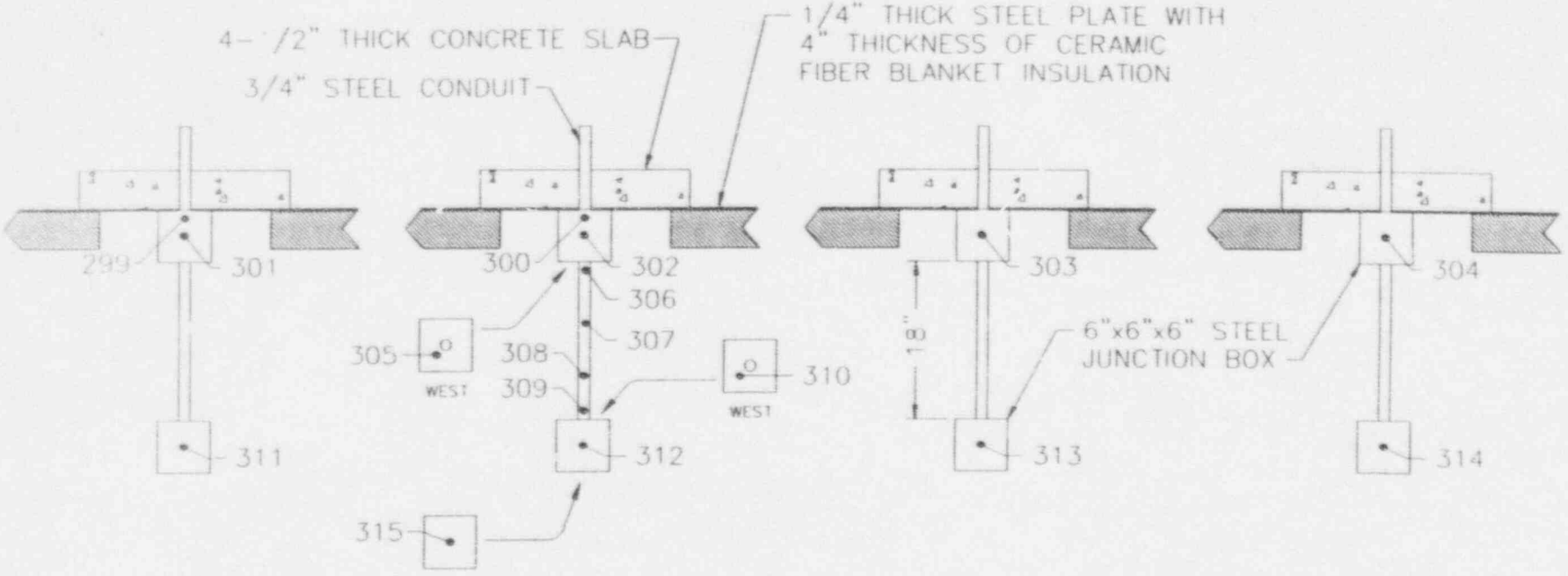
TC NOS. 82-95 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 82 COINCIDES WITH TC NO. 68.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE M



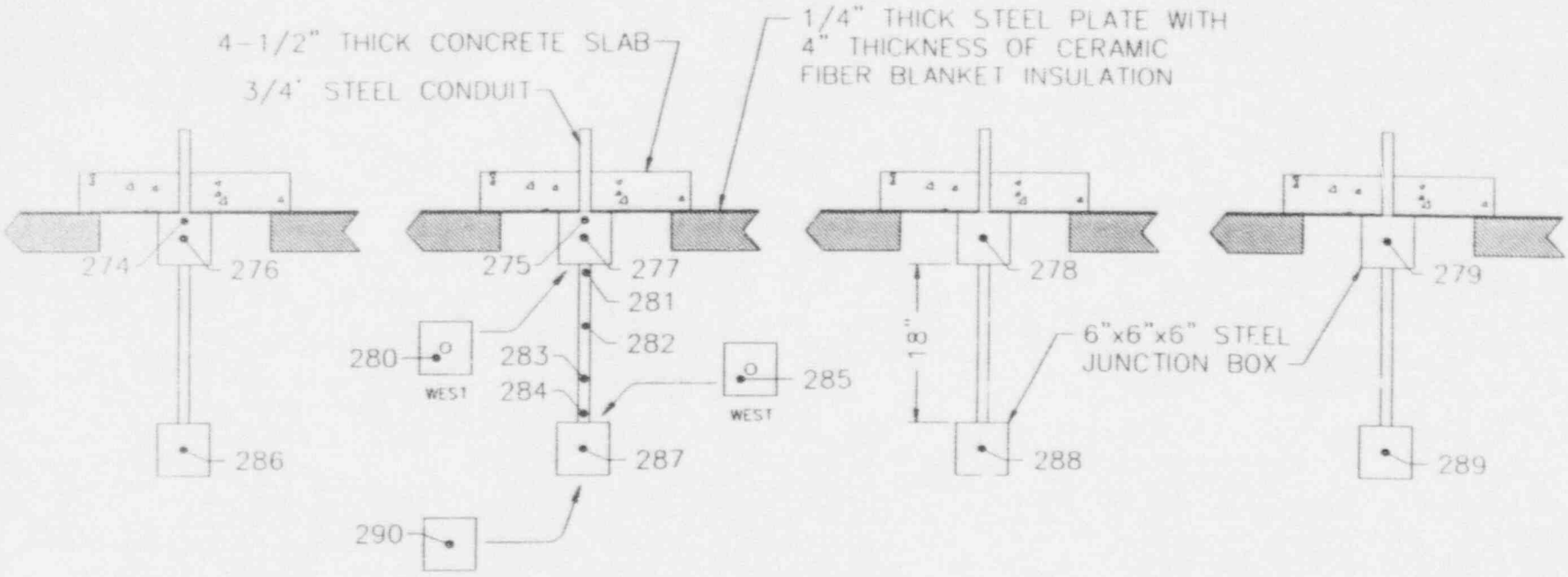
TC NOS. 417–420 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 417 COINCIDES WITH TC NO. 407.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE N



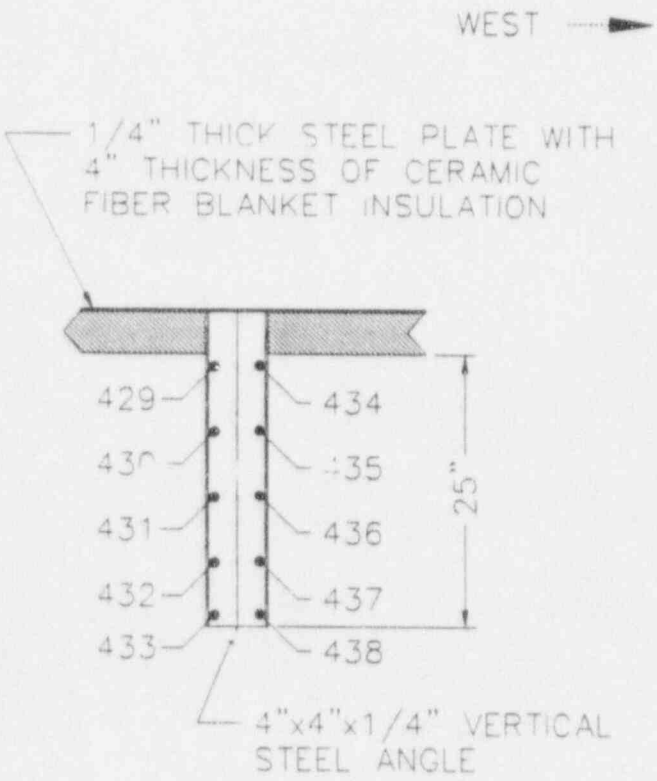
TC NOS. 316-323 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 316 COINCIDES WITH TC NOS. 299 & 300. TC NOS. 321-323 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE 0

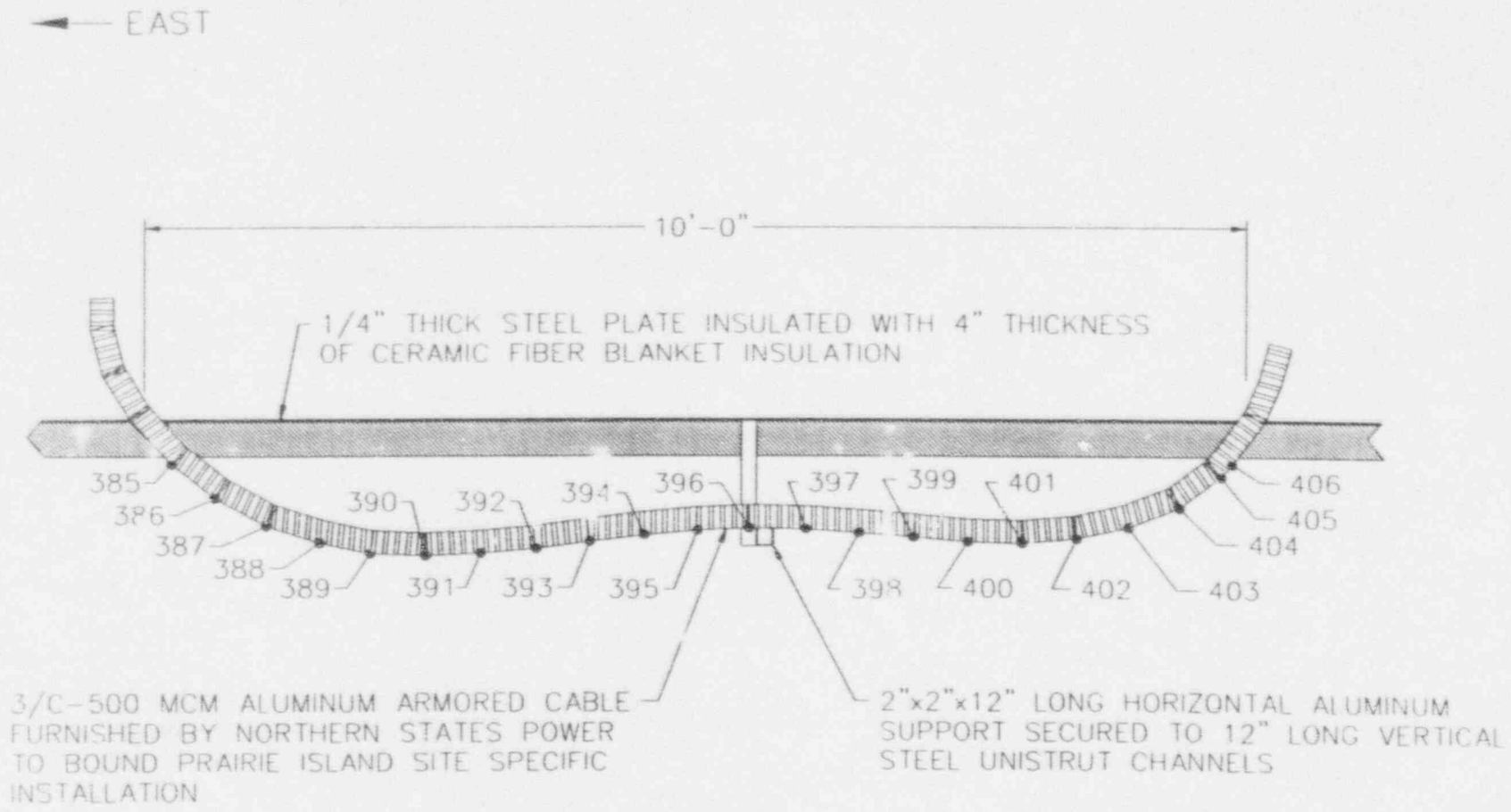


TC NOS. 291-298 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 291 COINCIDES WITH TC NOS. 274 & 275. TC NOS. 296-298 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE P



CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE R



CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE Q

NBK – FACSIMILE REQUEST FORM ATTACHMENT 4

Underwriters Laboratories Inc.®

FAX NUMBERS
MF - (516) 271-8259
RTP - (919) 549-1842
SC - (408) 296-3256
CAM - (360) 817-6000
TW-FUS - 01-886-2-717-2405
TW-ES - 01-886-2-891-7644
HK - 01-852-695-8190

TO: ☑ 5A NBK COMMUNICATIONS CENTER
(5A Reception)

Date: 4-22-97

FAX No. (847) 272-2020 (If PROBLEMS (847) 272-8800 X 2021)
PLEASE TRANSMIT TO: (Circle or Check as Appropriate)

MEL SC CAM RTP HK TW (FUS) TW (ES) OTHER _____

TOTAL No. PAGES 3

NAME. Steven West

ORGANIZATION: US NRC

CITY, STATE, COUNTRY:

FAX NO.: 301 415 3577

SUBJECT: Transco

MESSAGE: Following are the test observation which you requested

Regards
Edward A. Johnson

SPECIAL INSTRUCTIONS:

REQUESTED BY: Johanson EMPLOYEE NO.: 17811

DEPARTMENT/SECTION: 4411 B EXT.: 42075

NUMBER OF ATTEMPTS: OPERATOR:

2000-5A
1/96

SENDER WILL BE NOTIFIED IF TRANSMISSION DELAYED MORE THAN TWO HOURS

Record of Test Observations

File No.: R18500
Project No.: 97NK4087
Date: April 10, 1997

Client: Transco Inc.
Recorded By: M. Izydorek

Test Time Hr:Min:Sec	Exposed (E) or Unexposed (U) Surface	Article No.	Observation
0:0:5:00	E	All	All of the exposed material was charred and black in color.
0:0:6:15	E	N	The bottom piece of material (the cap) fell form the article.
0:08:22	E	B	Flames were issuing from the sample.
0:09:40	E	All	Flames issued from the exposed surfaces of the articles near the top of the exposed surface.
0:12:56	U	All	Smoke was issuing from the entire unexposed surface with the heaviest amount from Article H.
0:15:07	E	H	A crack, running in a North-South direction had developed at the West side of the article. the crack was 1/8 in. deep.
0:19:21	E	B,F,C,M	Flames continued to issue from the exposed surface of the articles.
0:20:03	E	All	The surfaces were becoming beige in color.
0:31:23	E	H	There were gaps present between the banding straps and the bottom surface of the protection material.
0:37:36	E	All	The surfaces were becoming white in color.
0:41:43	E	P	There was a slight separation in the material on the bottom surface of the protection material.
0:52:57	E	H	A Westerly view of the article shows a 1 in. separation near the West end on the bottom of the article.
1:10:26	E	J	On the South end of the article at the interface of the vertical and horizontal runs, there were two 1/4 in. wide openings in the protection material.
1:29:37	E	H	The area described at 0:15:07 had opened to a width of 2 in.
1:30:17	E	J	The openings described at 1:10:26 had closed.
1:33:28	E	G	A "flap" of protection material, 3 x 4 in., was hanging at the interface with the hanger.
1:35:18	E	Q	Heavy black smoke accompanied by flames was issuing from the article at the center and at both ends where it entered the furnace chamber. These flames were impinging on Article N.
1:49:24	E	B	Flames and black smoke issued from the top of

			the sample.
1:50:31	E	B	An area of flames issued from the bottom of the article at the interface with the support near the center of the article.
2:00:00	E	All	No significant changes observed.
2:16:00	E	A	the West half of the article fell to the furnace floor.
2:35:35	E	Q	The heavy black smoke ceased. Gray smoke issued from the center of the article at the bottom. The smoke was issuing from a crack.
2:40:00	E	All	Slight changes in color had occurred
2:41:03	E	Q	The crack described at 2:40:00 was 2 in. wide.
3:00:00	E & U	All	Fire test terminated.

with the exception of test article B, a 30-inch wide steel cable tray with a 1-hour Versawrap fire barrier, it appeared that at least the innermost layer of foil (the foil attached directly to the raceway) remained intact during the hose stream test. For test article B, the foil on the bottom surface of the tray was breached, apparently by the force of the solid hose stream. GL 86-10, S 1, states, in part, that the fire endurance qualification test for fire barrier materials are successful if "[t]he cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component (e.g., cables) is visible.

On April 11, 1997, I observed Transco disassemble the fire barriers that remained on test articles H and P after the fire and hose stream tests. For both of these proposed 3-hour fire barrier designs, the inner layers of foil, water filled mylar tubes, and fiber blankets remained largely intact. Many of these mylar tubes appeared to contain their original inventory of water and those that had leaked contained some water. In addition, the ordinary adhesive-backed strapping tape that was used to attach the tubes to the raceways was largely free of fire damage.

One interesting part of the test was a test of a 12-inch by 12-inch by 8-inch thick silicone foam penetration seal that was penetrated by a ¾-inch diameter steel conduit (test article N). In addition to the normal fire resistant damming board, the seal assembly included an outer layer of intumescent-coated fiberglass cloth (on the fire side). According to Mr. Hawks, Transco considered this a "throw away" or research and development scoping test and did not instrument the seal assembly with thermocouples to obtain unexposed side temperatures. After the 3-hour fire exposure and hose stream test, Transco disassembled the penetrations seal. The seal assembly was intact. About 2 to 3 inches of the silicone foam material was consumed during the fire exposure. A full 5 to 6 inches of unreacted silicone foam material remained.

UL will base its determinations on the thermal performance of the test articles on its observations during the fire endurance and hose stream tests, analyses of the electronically recorded thermocouple data, and consideration of both the maximum single point temperatures and the average unexposed side temperatures. Presumably, UL will also consider the effects of the problems with the thermocouples that were experienced during the test. Attachment 4 is UL's record of test observations.

Docket Nos.: 50-313, 50-282, and 50-306

Attachments: As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 9, 1997

MEMORANDUM TO: L.B. Marsh, Chief
Plant Systems Branch
Office of Nuclear Reactor Regulation

FROM: K. Steven West, Chief
Fire Protection Engineering Section
Plant Systems Branch
Office of Nuclear Reactor Regulation

SUBJECT: TRIP REPORT - TRIP TO UNDERWRITERS LABORATORIES, INCORPORATED TO OBSERVE THREE HOUR FIRE TEST OF ONE AND THREE HOUR VERSAWRAP RACEWAY FIRE BARRIER SYSTEMS (TAC M32809)

During April 10 and 11, 1997, I visited to Underwriters Laboratories, Incorporated (UL), Northbrook, Illinois, to observe a full-scale fire endurance test of 1- and 3-hour Versawrap fire barrier systems. Attachment 1 is a list of individuals that observed or participated in the test. I interacted mostly with the individuals marked with asterisks.

Transco Products, Incorporated (Transco) is developing Versawrap as a stand-alone fire barrier or as an upgrade for such existing raceway fire barriers as Thermo-Lag 330-1. In general, Versawrap barriers are installed (from the item to be protected outward) as individual layers of foil, water filled mylar tubes, fiber blankets, foil, and intumescent-coated fiberglass cloth. The numbers and arrangements of the individual barrier components are dependent on the type of item to be protected (e.g., raceway, cable, support, etc.) and the desired fire rating. (Attachment 1 to a memorandum of April 15, 1997, from K.S. West to L.B. Marsh describes the components of a typical Versawrap barrier and their general arrangements.) Entergy Operations, Incorporated, is considering installing 1- and 3-hour Versawrap fire barriers at Arkansas Nuclear One, Unit 1, and Northern States Power is considering installing a 1-hour Versawrap barrier at Prairie Island Nuclear Power Station.

Attachment 2 is Transco Test Procedure TR-228, "Three Hour Fire Test of One and Three Hour VERSAWRAP Raceway Fire Barrier Systems for Conduits and Cable Trays," Revision 2, February 7, 1997. The test was a single 3 hour fire exposure followed by a solid-stream hose stream test that was intended to demonstrate the ability of both 1- and 3-hour Versawrap fire barrier systems (in the same test) to meet the acceptance criteria of Generic Letter 86-10, Supplement 1 (GL 86-10, S 1).

CONTACT: K.S. West, NRR
301-415-1220

The test specimen had been constructed and installed on the test furnace before I arrived at UL. Therefore, I did not observe fire barrier installation or thermocouple placement. The overall test specimen consisted of a steel and concrete deck from which 18 individual 1- and 3-hour test articles were suspended into UL's large floor furnace. According to Kevin Hawks, Transco, (1) Transco personnel installed the Versawrap fire barriers on the test articles in accordance with Transco instructions and procedures, (2) the test articles were instrumented in accordance with GL 86-10, S 1 (3) Transco quality control witnessed and documented test specimen construction, (4) UL quality control also independently witnessed and documented test specimen construction, (5) UL will prepare the fire test report. The test articles and the conditions which they were intended to bound are described in Attachment 2. I made pen and ink changes to Attachment 2 to reflect changes that Transco had made to the test articles after it issued the test procedure. Attachment 3 shows the test article layout, construction details, and thermocouple locations. The test articles, which did not contain cable fill, were instrumented with 438 thermocouples.

On the basis of my observations, it appeared that UL exposed the test specimen in accordance with the ASTM E-119 standard time-temperature curve for 3 hours. UL programmed its data acquisition computers to electronically record the test article thermocouple temperatures every two minutes. UL also printed the thermocouple temperatures about every five minutes. UL will use the electronically recorded temperature data to judge the fire endurance performance of the individual test articles. The printed temperatures were provided for contemporaneous information during the test. About midway through the fire exposure, Transco noticed some apparently anomalous thermocouple readings. For example, closely-spaced thermocouples were reporting vastly different temperatures. Upon examination, Transco found that the insulation had melted off of some thermocouple wires that were running on top of and in direct contact with the steel test deck. Apparently, at these points the thermocouples were measuring the temperature of the test deck rather than the temperatures of the test articles. After UL and Transco placed insulating blankets between the affected thermocouple wires and the steel test deck, the printed temperatures returned (dropped) to what appeared to be a more normal range. Transco indicated that UL would assess the impact of this event on the overall test results in its fire test report.

Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 61 minutes, it appeared that test articles A, B, C, D, L, O, and R met the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 1-hour fire rating while test articles E and Q did not. Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 2 hours and 55 minutes (the temperatures at 3 hours were not printed), it also appeared that test articles F, G, H, and I may meet the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 3-hour fire rating, but test articles J, K, M, N, and P will not.

Following the 3 hour fire exposure, UL subjected the test specimen to a solid hose stream test for 2-1/2 minutes. With the exception of test article P, most of the outer layers of intumescent-coated fiberglass cloth, foil, and fiber blankets were knocked off of the bottom and side surfaces of the test article fire barriers by the force of the hose stream. The barrier on test article P remained intact and may not have been hit by the hose stream. In addition,

ATTACHMENT 1

List of Observers and Participants
Fire Endurance Test of Versawrap Fire Barrier
Underwriters Laboratories, Inc., Northbrook, Illinois
April 10, 1997

K. Steven West	U.S. Nuclear Regulatory Commission
Robert Goss*	Transco Products, Inc.
Kevin Hawks*	Transco Products, Inc.
Greg Jaroz*	Transco Products, Inc.
Sandra Bradford*	Transco Products, Inc.
John Kmetz	Transco Products, Inc.
Jeff Deminski	Transco Products, Inc.
Gary Sharisky	Transco Products, Inc.
Ed Johanson*	Underwriters Laboratories, Inc.
Chris Johnson	Underwriters Laboratories, Inc.
Michael Allen Boomgarden	Underwriters Laboratories, Inc.
Bill Joy	Underwriters Laboratories, Inc.
Mark Pastor	Underwriters Laboratories, Inc.
Herb Muller	Underwriters Laboratories, Inc.
Mark Izydorek	Underwriters Laboratories, Inc.
Sam Oolie	No Fire Technologies
Ron Rispoli*	Entergy Operations, Inc.
Woody Walker*	Entergy Operations, Inc.
Tom Lillehei	Northern States Power
Dan Langel	Sargent and Lundy

ATTACHMENT 2

TRANSCO PRODUCTS INC.

Transco Products Inc.
Test Procedure #TR-228

for

Three Hour Fire Test of
One and Three Hour *VERSAWRAP* Raceway Fire Barrier Systems
for Conduits and Cable Trays

(TRANSCO PRODUCTS INC. PROJECT #AR-256)

Rev.:	Description:	By:	Date:	Ck:	Date:	App.:	Date:
0	For Review and Test Specimen Fabrication	G.J. Jarosz	02/07/97	K.Hawks	02/07/97	R. Goss	02/07/97
1	For Review and Test Specimen Fabrication	G.J. Jarosz	03/01/97	K.Hawks	03/01/97	B.C. Mach-chhar	03/01/97
2	For Review and Test Specimen Fabrication	G.J. Jarosz	03/16/97	[signature]	03/17/97	[signature]	3/17/97

TABLE OF CONTENTS:

SECTION 1.0
SYNOPSIS:

Transco Fire Test #TR-228 will be a single fire test conducted in accordance with the performance requirements of NRC GL 86-10, Supplement 1 and the ASTM E-119 time/temperature curve. The purpose of this test is to demonstrate the ability of both one and three hour *VERSAWRAP* raceway fire barrier systems (in the same test) to protect a variety of raceway conditions that are representative of those commonly found in nuclear power plants. Even though some of the barrier systems to be tested are only intended for one hour applications, they will be subjected to the full three hour fire test. In these cases, the one hour barrier specimens will be considered to be successful thermally if they meet the raceway temperature pass/fail criteria of GL 86-10 for the first hour of the fire test. After the conclusion of the three hour fire test, both one and three hour specimens will be subjected to a hose stream test in accordance with Section 7.0 of this procedure. Testing will be performed at Underwriters Laboratories (Northbrook, Illinois).

The overall test specimen will consist of a metal and concrete deck from which a number of simulated conduit and cable tray raceways will be suspended. The sizes and shapes of these raceways are intended to represent conditions that bound equivalent or less severe raceway configurations in the field. These bounding conditions to be qualified by this test are described below. The metal/concrete deck with its individual raceway specimens will be placed on top of a large floor furnace where the raceways will be subjected to the three hour fire endurance test. Immediately after the conclusion of the fire test, the deck and raceway specimens are lifted as a single unit from the furnace and will then be exposed to the hose stream test.

The raceway items to be tested and conditions they are intended to bound are as follows:

ITEM: DESCRIPTION:

"A" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track - This item is intended to bound one hour *VERSAWRAP* installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled steel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum raceways. Because this is a one hour wrap, it is only required to meet the thermal pass/fail requirements of GL 86-10 Supplement 1 for one hour whereas the hose stream test for this specimen will be performed immediately after the three hour fire test. This specimen will demonstrate both horizontal and vertical raceway sections, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper cable and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading.

"B" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound one hour *VERSAWRAP* systems installed on 30" x 4" (and all smaller sizes) of both aluminum and/or steel cable trays (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "A" above*) as well as bundled conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a

"Unistrut" hanger thermal short interface. This tray will be empty except for a single #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum raceways up to this size for hose stream test qualifications of *VERSAWRAP*. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap.

"C" ¾" Diameter Rigid Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit and will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"D" 4" Diameter Rigid Steel Conduit - This item is intended to demonstrate one hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway specimen will fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"E" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass) located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will use condulets at each end of the specimen on the exposed side of the deck. A conduit connector will also be installed on the conduit. (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"F" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~one~~ three hour *VERSAWRAP* systems installed on ¾" diameter conduit (as the most severe thermal mass) connected to a "Unistrut" hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped with *VERSAWRAP* as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"G" 2" x 2" Aluminum Solid-Back Cable Tray Tube Track -This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled sateel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum trays. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. This item will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for small raceways.

"H" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound three hour *VERSAWRAP* systems installed on 30" x 4" and all smaller sizes of both aluminum and steel cable tray (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "G" above*) and bundled steel or aluminum conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum trays up to this size for hose stream test qualifications. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for both large tray and/or box wraps.

"I" ¾" Diameter Rigid Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"J" 4" Diameter Rigid Steel Conduit - This item is intended to demonstrate three hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway assembly will be fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for large and small conduit wraps.

"K" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit (the most severe thermal mass) found in the field that is located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize condulets at each end of the specimen. A conduit connector will also be installed on the conduit (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered as a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a single #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"L" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~three~~ one hour *VERSAWRAP* systems installed on a ¾" diameter rigid steel conduit as the smallest size of conduit found in the field (the most severe thermal mass) connected to a hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"M" 1-½' Diameter Steel Conduit ~~and TSI "Thermo-Lag"~~ Raceway Covered with Modified VERSAWRAP - This item is intended to bound "modified" one hour *VERSAWRAP* systems installed on 1-½" (and larger) diameter conduits in the field. The test raceway assembly will be fabricated from standard 1-½" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. ~~The one hour Thermo-Lag material will be installed with "dry joints" (no trowel-grade Thermo-Lag will be used).~~ A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on these raceway types. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed

according to Section 5.0 of this procedure.

"N" 12" x 12" x 12" x 16 Gauge Steel Box Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* conduit systems ~~that interface with a one hour "Darmatt KM1" raceway barrier system~~ installed on the box. The conduit will pass through a penetration seal to show wrap terminations as such. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1.

"O" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

"P" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

aluminum hanger

"Q" 3C-500MCM Aluminum Armored Cable - This item is intended to bound one hour *VERSAWRAP* systems installed on a 3C-500MCM aluminum armored cable as supplied by Northern States Power for their Prairie Island Nuclear Power Station. The 10' (minimum) span of cable will be temporarily supported by a ~~rope~~ about mid-span. During the test, the ~~rope~~ will ~~burn~~ melt and will allow the wrapped cable to be unsupported for the remainder of the fire test. The intent here is to show that the wrap will still be effective even if the cable suddenly becomes unsupported between hanger points (maximum distance as tested herein) in the field. (In the field, the cable is located in an aluminum tray suspended on steel hangers. The utility wishes to evaluate the possibility of wrapping only the cable instead of the entire tray. It is felt that if the aluminum tray is not wrapped, it will melt or be consumed during a fire thus leaving the cable unsupported except at points where the tray was suspended on steel hangers.)

aluminum un-strut trapeze-style hanger

"R" 3" x 3" angle - structural steel

SECTION 2.0
TEST FURNACE:

The furnace to be used is Underwriters Laboratories' standard large floor furnace. The furnace shall be operated in accordance with the requirements of ASTM E-119 for the three hour fire test

SECTION 3.0
ITEMS TO BE PROTECTED:

The following is a description of the items to be used as raceway elements for the fire test:

> *(See Section 1.0, Synopsis for a general description of these items. Note: all steel trays and boxes will be manufactured from 16 gauge steel while all conduit will be standard, rigid conduit. All "free-cable air drops" will consist of single pieces of stranded 8 AWG bare copper wire according to GL 86-10, Supplement 1 requirements. All hangers will be fabricated from standard "Unistrut" type material [hangers may be welded to the raceways for the test in lieu of using clips, straps, etc].)*

An accurate description of specimen fabrication shall be included in the final test report (as verified by Transco Products Inc. Quality Control). Hardware substitutions are permitted provided substitute material (etc.) does not increase the heat mass of the specimen and are documented by Transco QC and UL.

SECTION 4.0
FIRE BARRIER MATERIAL INSTALLATION:

The *VERSAWRAP* and Transco Products Inc. TCO-001 materials shall be installed by Transco Products Inc. personnel in accordance with the manufacturer's instruction and/or procedures. If written instructions are not available at the time of installation, then Transco Products Inc. QC personnel shall document/verify step-by-step methods used for installation. Test installation records will be included as an appendix to the final test report.

Materials used for this test shall be purchased, received, and installed in accordance with latest approved revision of Transco Products Inc.'s Quality Assurance Program and applicable procedures. All fire barrier envelope installation will be witnessed by Transco Products Inc. Quality Control personnel. Material components (except for tie wire and ceramic blanket) will be identified with the responsible QC's initials as each layer is installed.

Note: This test will be performed as a "Safety Related" quality program in accordance with the latest approved revision of Transco Products Inc.'s Quality Assurance Manual (10CFR, Part 21 applies) with the exception that all materials will be provided as "Q-Class" with Certificates of Conformances.

SECTION 5.0
THERMOCOUPLES:

A.) Fire Barrier Envelope:

The fire barrier envelope is considered all areas of the specimen on the exposed side of the test slab. For these areas, thermocouples shall be mounted to the specimen to gather temperature data for the duration of the fire test. At a minimum, temperatures shall be documented at nominal two minute intervals for the duration of the test. Thermocouple placement for the fire barrier envelope (quantity and locations) shall be as specified in NRC GL 86-10 and Supplement 1 as follows:

"**.... Cable Trays** - The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray shall be measured by placing the thermocouples every 152 mm (6 - inches) on the exterior surface of each tray side rails between the cable tray side rail and the fire barrier material.

Internal raceway temperatures shall be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm (6- inches) along the length of the copper conductor. Thermocouples shall be placed immediately adjacent to all structural members, supports, and barrier penetrations. ..."(1)

"....**Conduits** - The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite of the test deck and closest to the furnace fire source. The internal raceway temperatures should be measured by a stranded AWG 8 bare copper

conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations...."(1)

Free-Cable Air Drops: Thermocouples will be installed on the stranded 8 AWG wire used for demonstrating the "free-cable air drop" every 152 mm [6 inches] in accordance with the same requirements for monitoring internal conduit/cable tray temperatures.

(Note: *In accordance with NRC GL 86-10, Supplement 1 requirements, "for the thermocouples installed on conduits, cable tray side rails, and bare copper conductors, a ± 13 mm (±1/2 inch) installation tolerance is acceptable". Hence, this tolerance shall be considered acceptable for use in this test. The tolerance is considered to be from the point of individual thermocouple placement and not compounded from one thermocouple to the next (i.e., all thermocouples can not be 6 1/2" from each other but rather must be ±1/2" from the measured 6" [minimum] mark on the item being monitored.)*

Junction box thermocouples will be installed in accordance with the requirements of Generic Letter 86-10, Supplement 1.

B.) Penetration Seal:

Thermocouple placement for the unexposed penetration seal surface (test item "N") will comply with the typical requirements of ASTM E814. As an optional method for protecting thermocouple tips, the thermojunctions of each thermocouple may be embedded into the seal surface or seal surface/penetrating member interface approximately ⅛ -¼" below the seal surface (because of the nature of the seal material, this placement can be performed at any time after the installation of the seal material). For this alternate method, insulation pads for covering the thermocouple tips will not be used.

All specimen temperatures shall be monitored using thermocouples (with special limits of error equal or less than 1.1°C). Thermojunctions of all specimen thermocouples shall be electrically welded. All thermocouple wire shall be supplied with certifications of purity, accuracy, and calibration.

Furnace atmosphere thermocouples shall be placed 12" below the furnace deck/slab as well as 12" away from representative elements of the test specimen accordance with ASTM E-119-88 requirements (not less than nine [9] thermocouples will be used to monitor furnace atmosphere temperatures). Additional furnace atmosphere thermocouples be employed around the specimen as it protrudes into the furnace. These will be placed at the laboratories discretion to supplement data acquisition in areas where furnace atmosphere thermocouples can not be mounted to satisfy ASTM E-119 requirements because of the specimen's configuration, et cetera.

The installation and location of each uniquely identified thermocouple (for both the specimen and furnace) shall

be mapped and verified (measured) by Transco Products Inc. Quality Control. Verification may be performed as hand written notes and shall become part of the permanent records of the test. Also, all thermocouple certifications shall also become a permanent record of the test.

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[1] Generic Letter 86-10 and Supplement 1

SECTION 6.0
FIRE TEST:

The fire test shall be conducted in accordance with the ASTM E-119 time/temperature curve (and temperature tolerance) for a minimum of three (3) hours. As a minimum, temperature data provided by both furnace and specimen thermocouples should be monitored and documented at nominal two (2) minute intervals. The laboratory shall verify and document visual specimen performance and occurrences (*i.e.*, smoke, et cetera) for the duration of the test.

It is intent of the test to demonstrate as many different raceway configurations as possible. As such, several raceway test specimens exhibit multiple features (*i.e.*, the 3 hour large tray demonstrates the tray wrap, a "free- air" cable and interface, a wrap-to-concrete interface, *etc.*). If one of these features fails thermally or during the hose stream test, it is the intent of the test to then exclude that feature from the configuration being qualified. In the case of the large tray for example, if the "free-air" cable or wrap-to-concrete interface fails for any reason, it is does not cause the tray to fail provided the rest of the tray specimen meets the acceptance criteria of Generic Letter 86-10, Supplement 1. Any failed portion of a specimen will then not be qualified by this test.

SECTION 7.0
HOSE STREAM TEST:

After the conclusion of the three hour fire test, the fire barrier envelope specimen (along with the surrounding penetration seal) shall be subjected to a minimum of one of the following hose stream tests (as identified in NRC GL 86-10, Supplement 1):

(a.) "The stream applied at random to all exposed surfaces of the test specimen through a 3.8 cm (1-1/2-inch) fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 1.5 meters (5 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3 -hour barriers); or[2]

(b.) "The stream applied at random to all exposed surfaces of the test specimen through a 6.4 cm (2 ½-inch) national standard playpipe with a 2.9 cm (1-1/8 -inch) orifice at a pressure of 207 kPa (30psi) at a distance of 6.1 meters (20 feet) from the specimen, (Duration of the hose stream application - 1 minute for a 1-hour barrier and 2 ½ minutes for a 3-hour barrier); or"[2]

(c.) "The stream applied at random to all exposed surfaces of the test specimen through 3.8 cm (1 ½-inch) fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa (75psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 3 meters (10 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3-hour barriers)."[2]

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2. Generic Letter 86-10 and Supplement 1

The responsible QC shall verify and document the type of hose stream, distance, time et cetera employed in each hose stream test.

SECTION 8.0
TEST REPORT:

The laboratory performing the test shall provide a written report which accurately describes the following minimum elements of the test:

1.) Verification of specimen materials and dimensions used;

2.) Verification of fire barrier envelope materials, dimensions, and installation techniques (procedures) used;

3.) Verification of general furnace construction/dimensions and locations of burner, thermocouples, et cetera;

4.) Verification of specimen thermocouple locations (along with copies of thermocouple material certifications);

5.) Verification of standards used for conducting fire test along with record of both furnace atmosphere and specimen temperature data acquired during test;

6.) Record of furnace pressure during fire test;

7.) Record of visual occurrences/observations of fire and hose stream tests;

8.) Record of hose stream test(s);

9.) Photographic records of specimen before fire barrier envelope installation, after fire barrier installation, and post fire/hose stream tests;

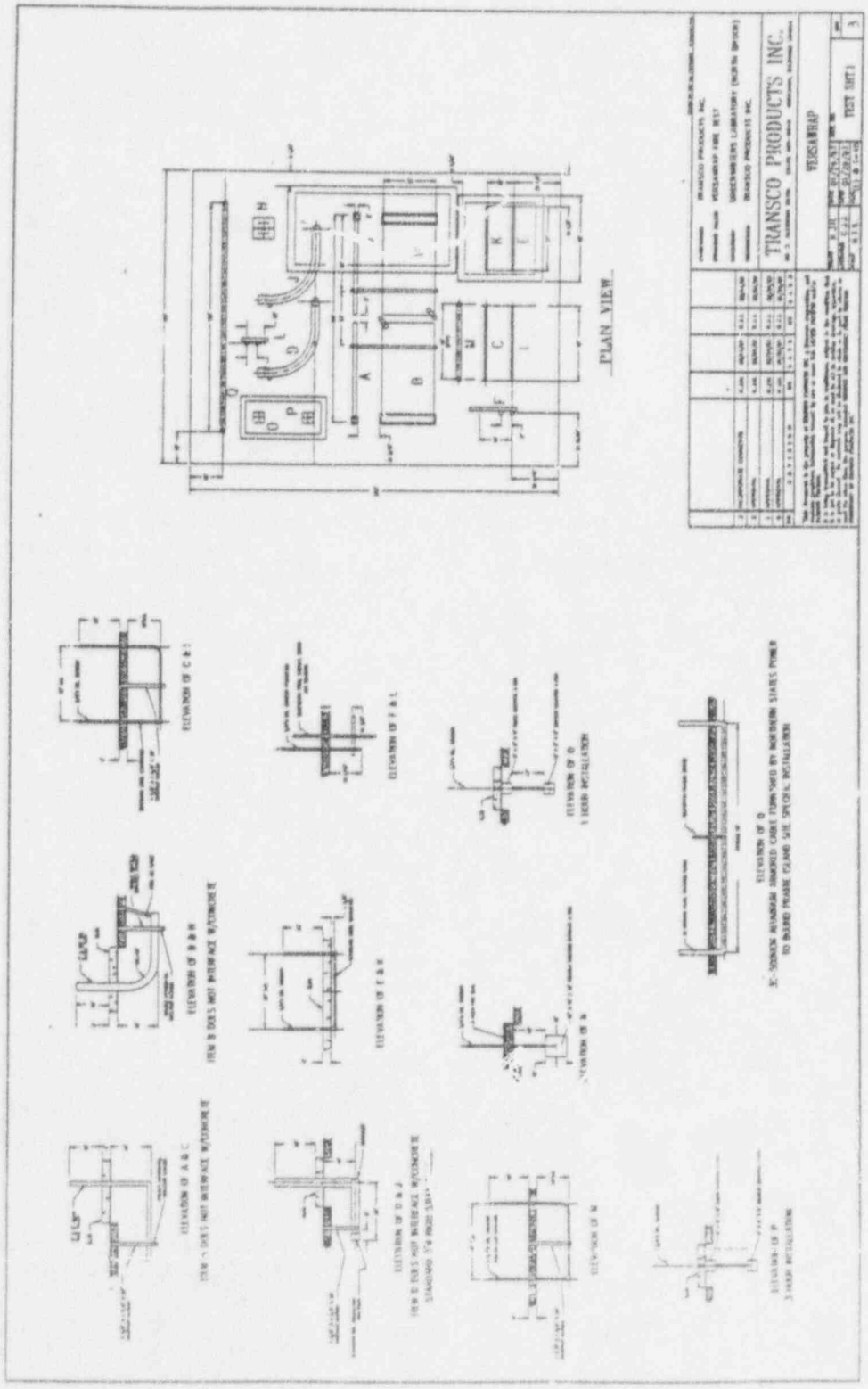
10.) Post test observations including measurements of material loss/degradation, et cetera;

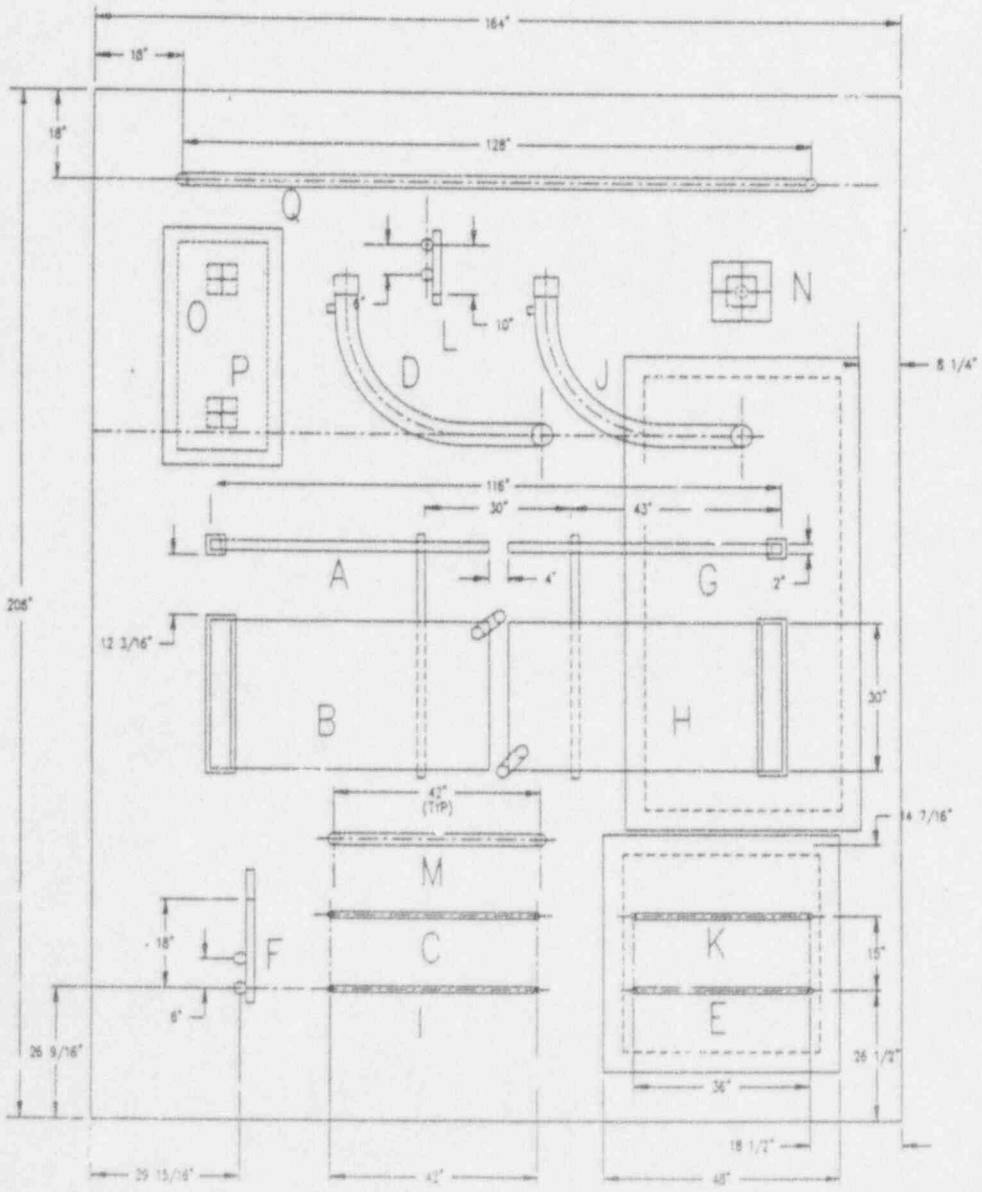
11.) Certification of the report by the agency performing test; and,

12.) QC records and notes from installation and test as an appendix to the report.

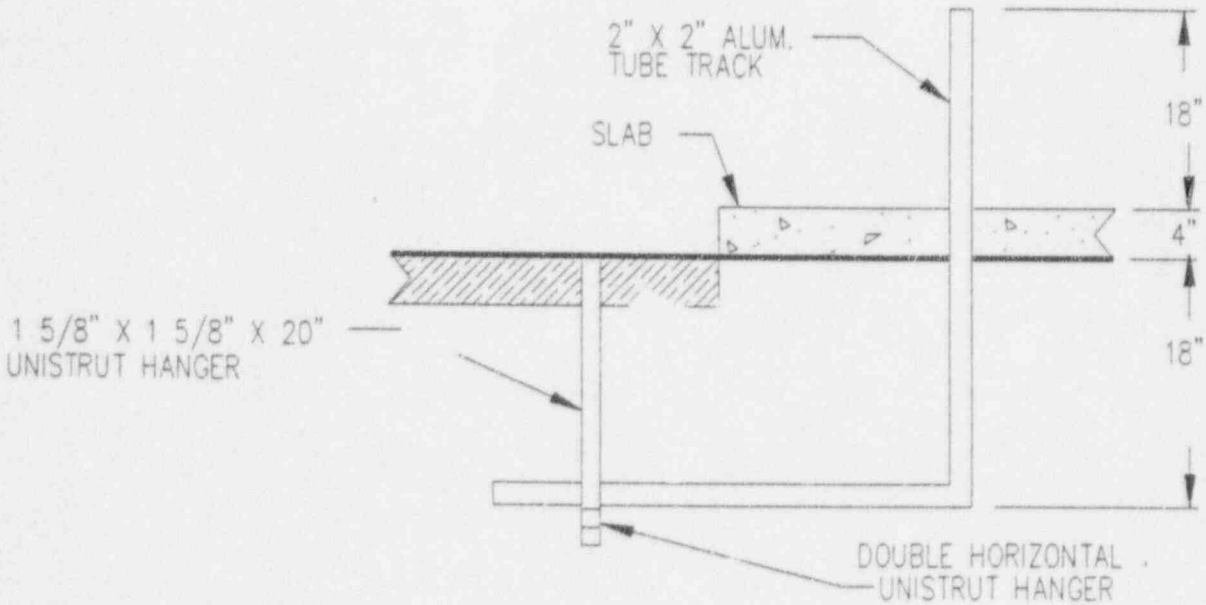
13.) Record of test items thermocouple temperature readings.

ALL TEST RECORDS, NOTES, CERTIFICATIONS, REQUIRED BY THIS TEST WILL BE LEGIBLE AND SUITABLE FOR REPRODUCTION.


PLAN VIEW
TRANSCO PRODUCTS INC.
VERSAWRAP

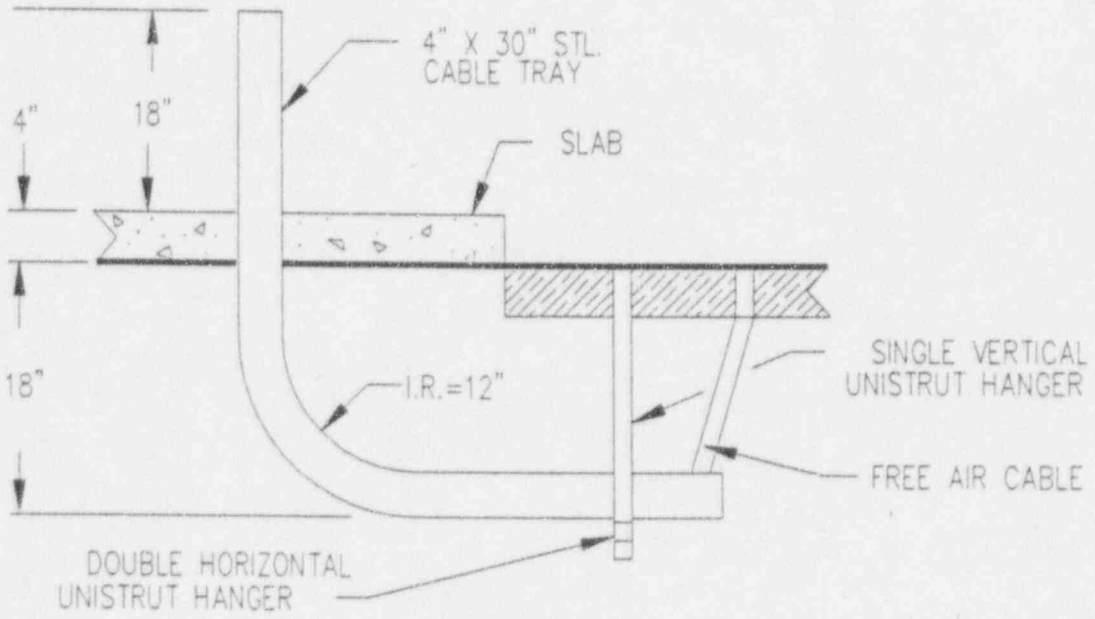

164"
18"
18"
128"
Q
O
P
L
10"
D
J
N
8 1/4"
118"
30"
43"
A
4"
G
2"
205"
12 3/16"
B
H
30"
42"
(TYP)
14 7/16"
M
18"
F
C
K
15"
6"
I
E
26 9/16"
26 1/2"
36"
18 1/2"
29 15/16"
42"
48"

PLAN VIEW



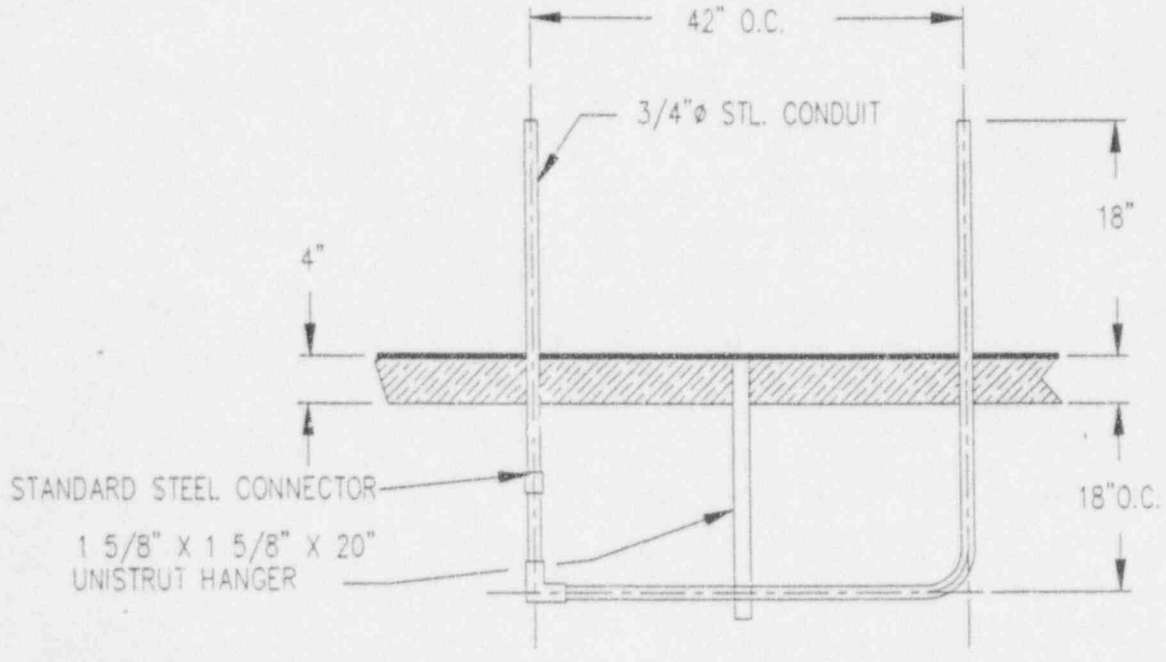
ELEVATION OF A & G

ITEM A DOES NOT INTERFACE W/CONCRETE

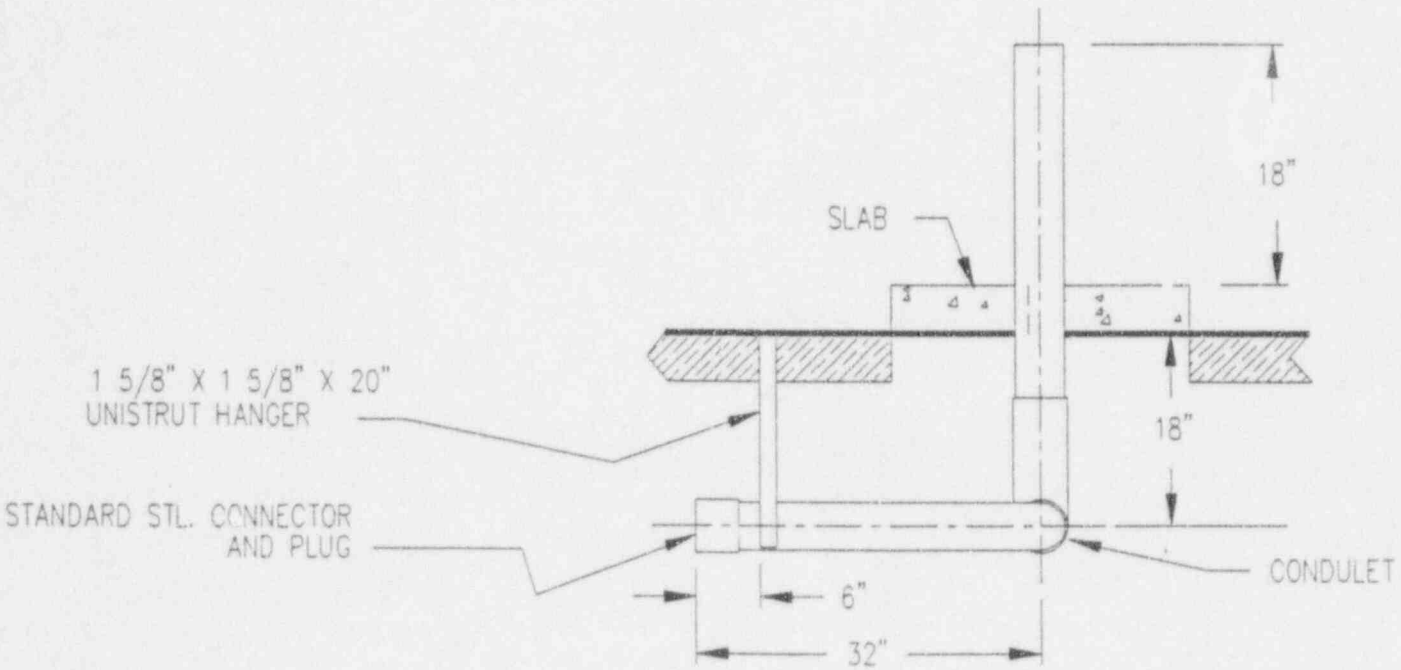


ELEVATION OF B & H

ITEM B DOES NOT INTERFACE W/CONCRETE



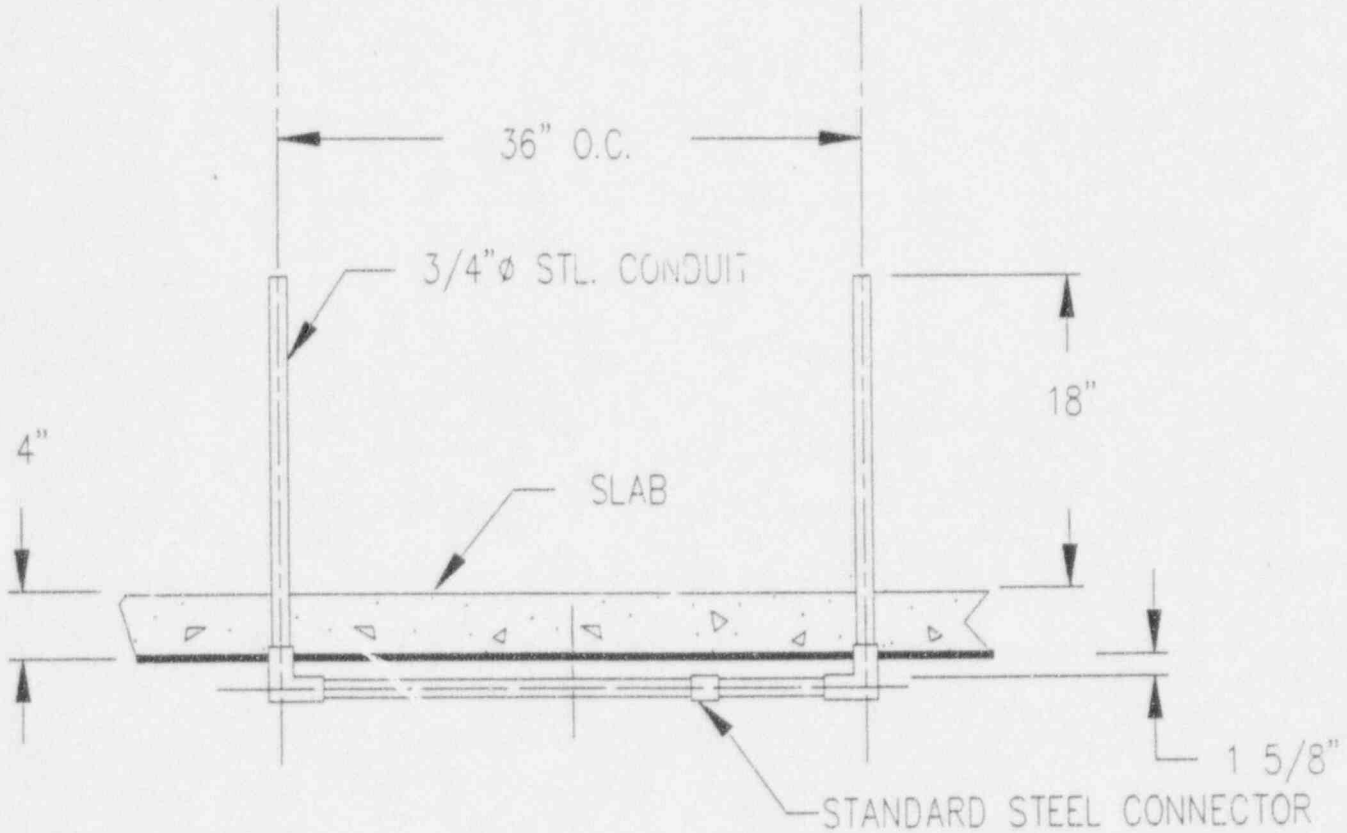
ELEVATION OF C & I



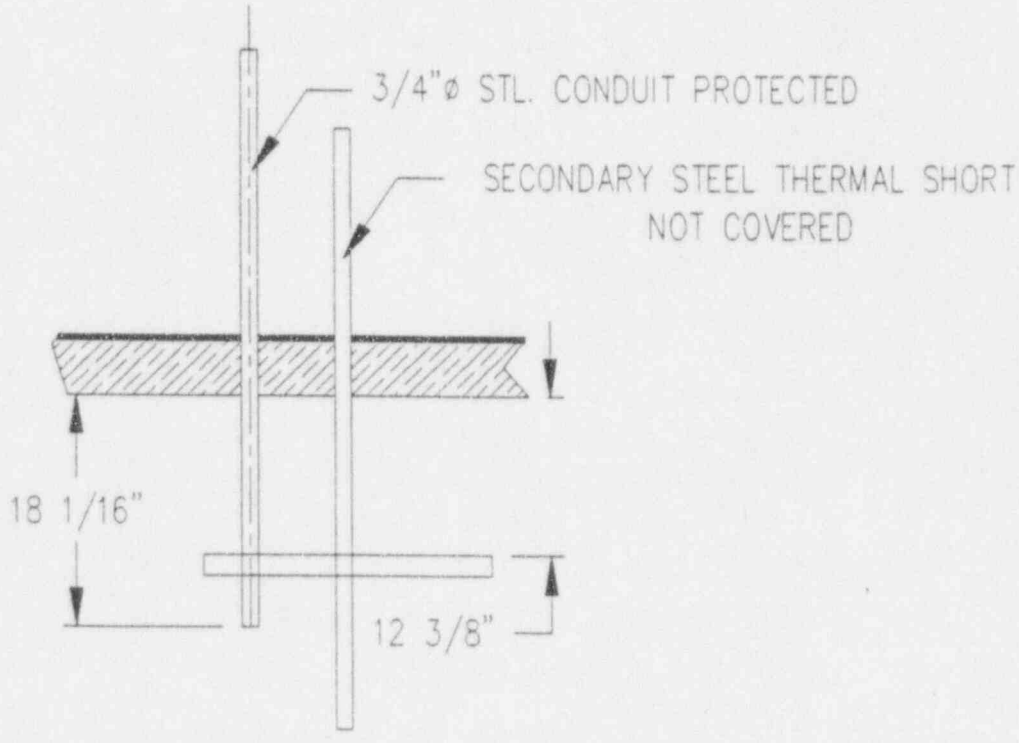
ELEVATION OF D & J

ITEM D DOES NOT INTERFACE W/CONCRETE

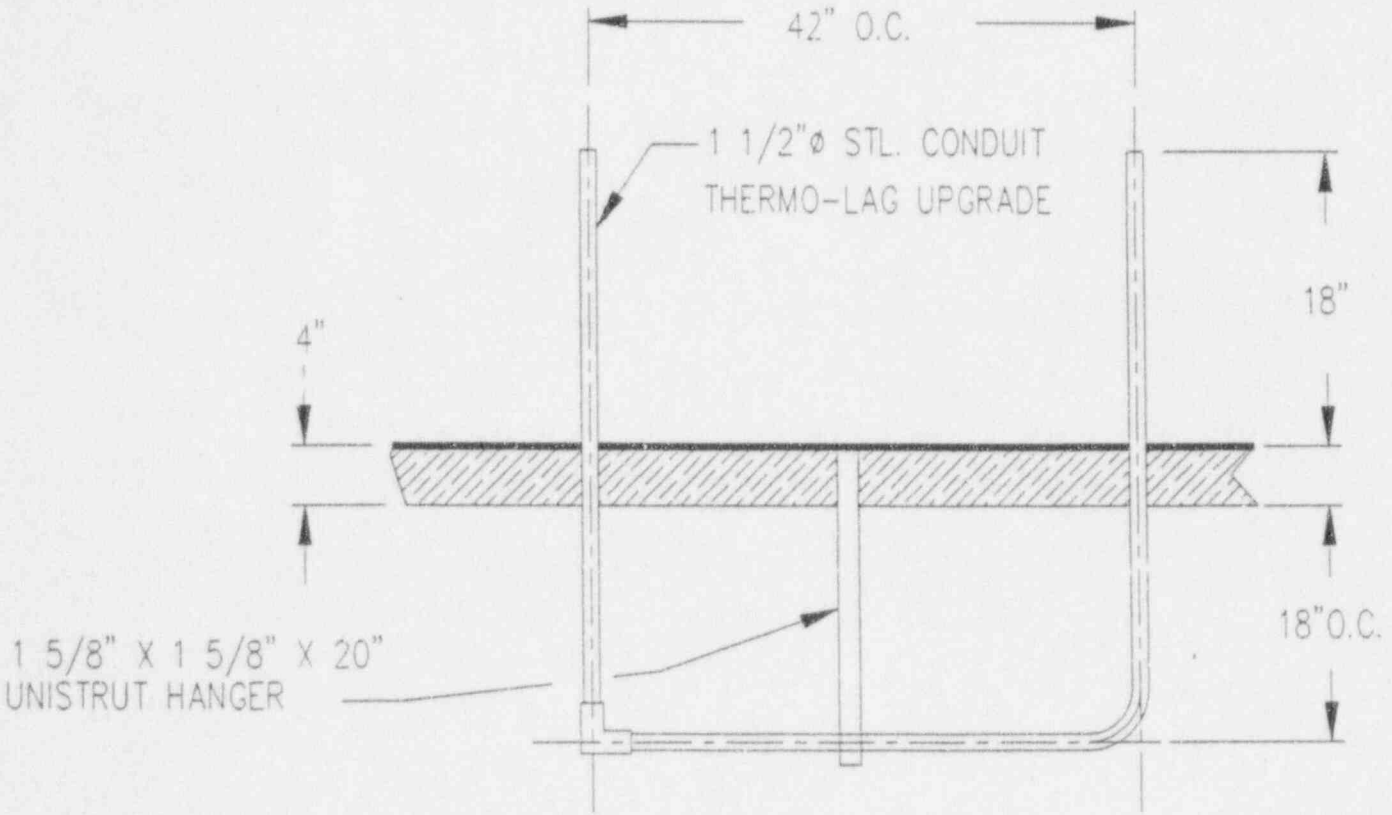
STANDARD 4"ø RIGID STEEL CONDUIT



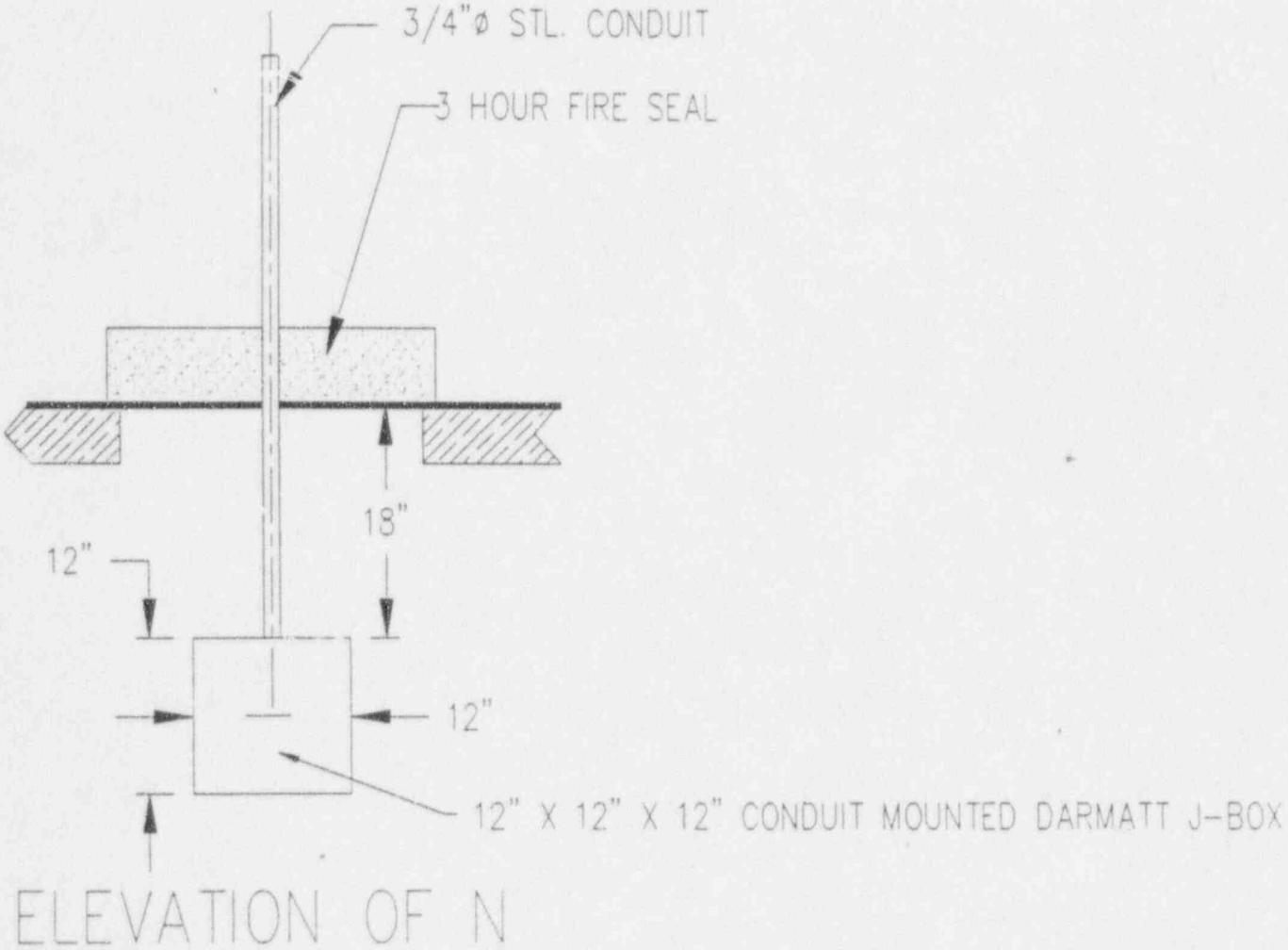
ELEVATION OF E & K



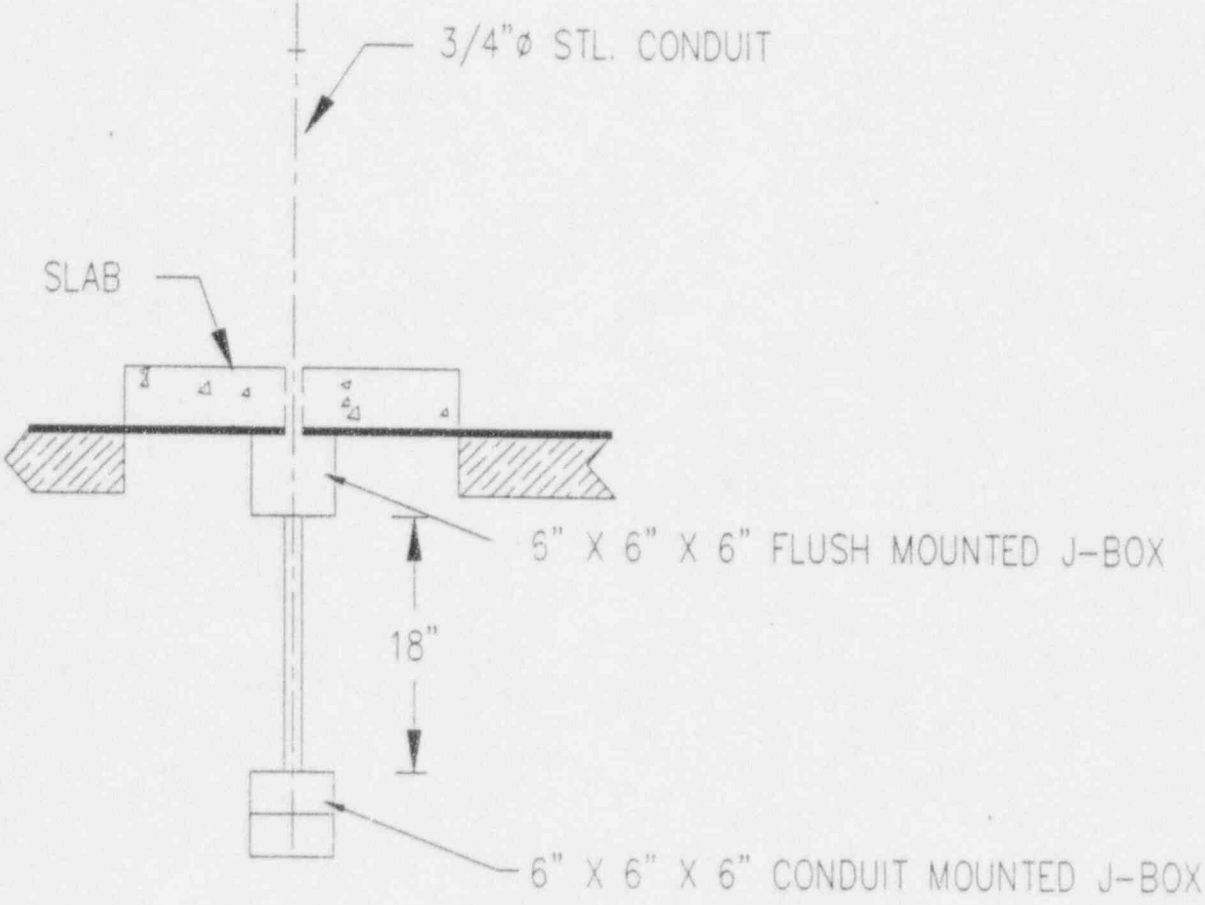
ELEVATION OF F & L



ELEVATION OF M

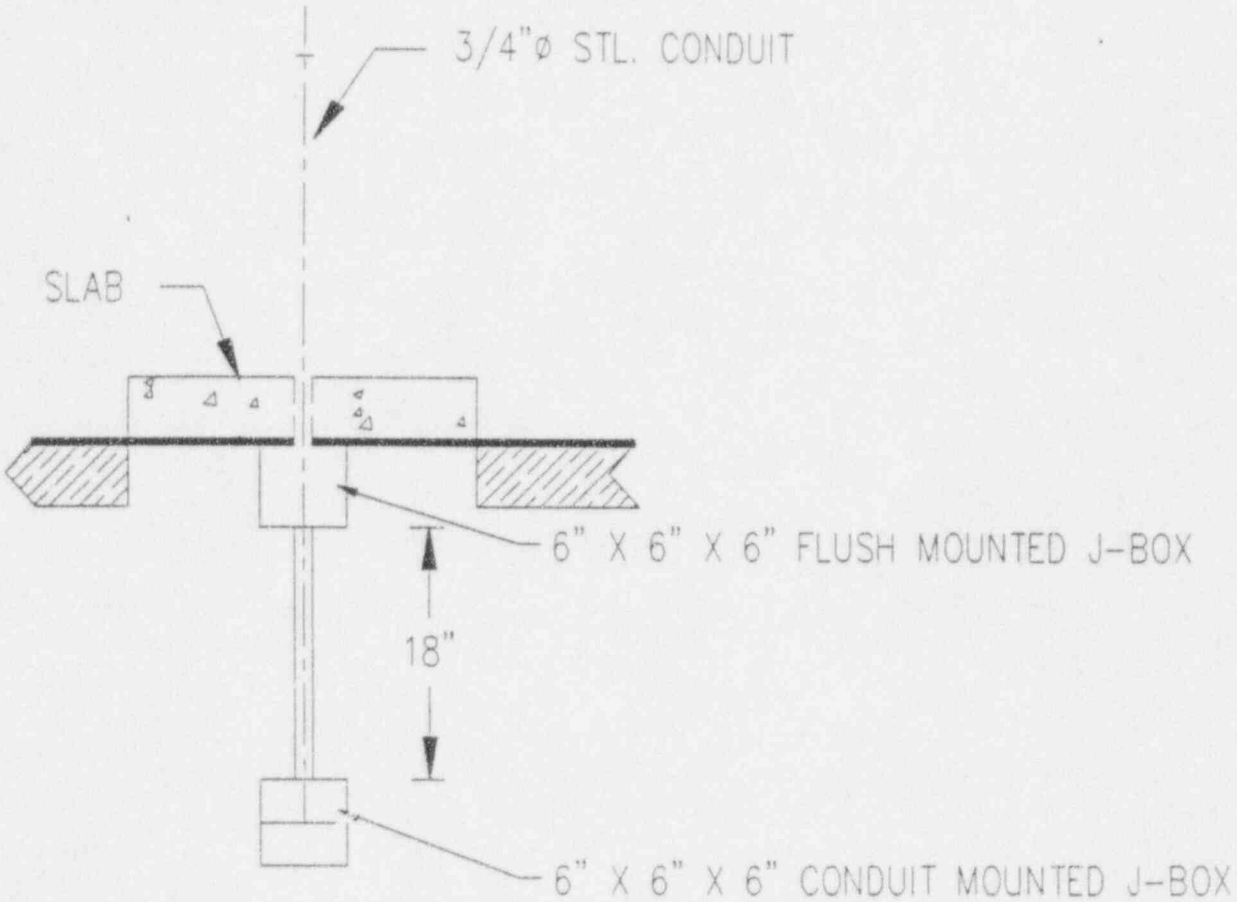


ELEVATION OF N



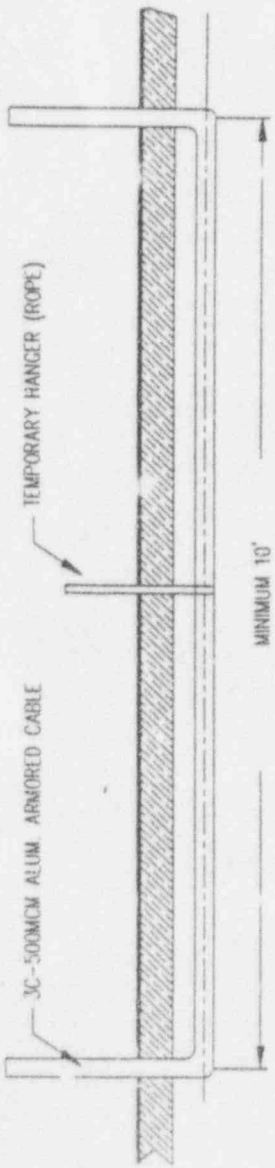
ELEVATION OF O

1 HOUR INSTALLATION



ELEVATION OF P

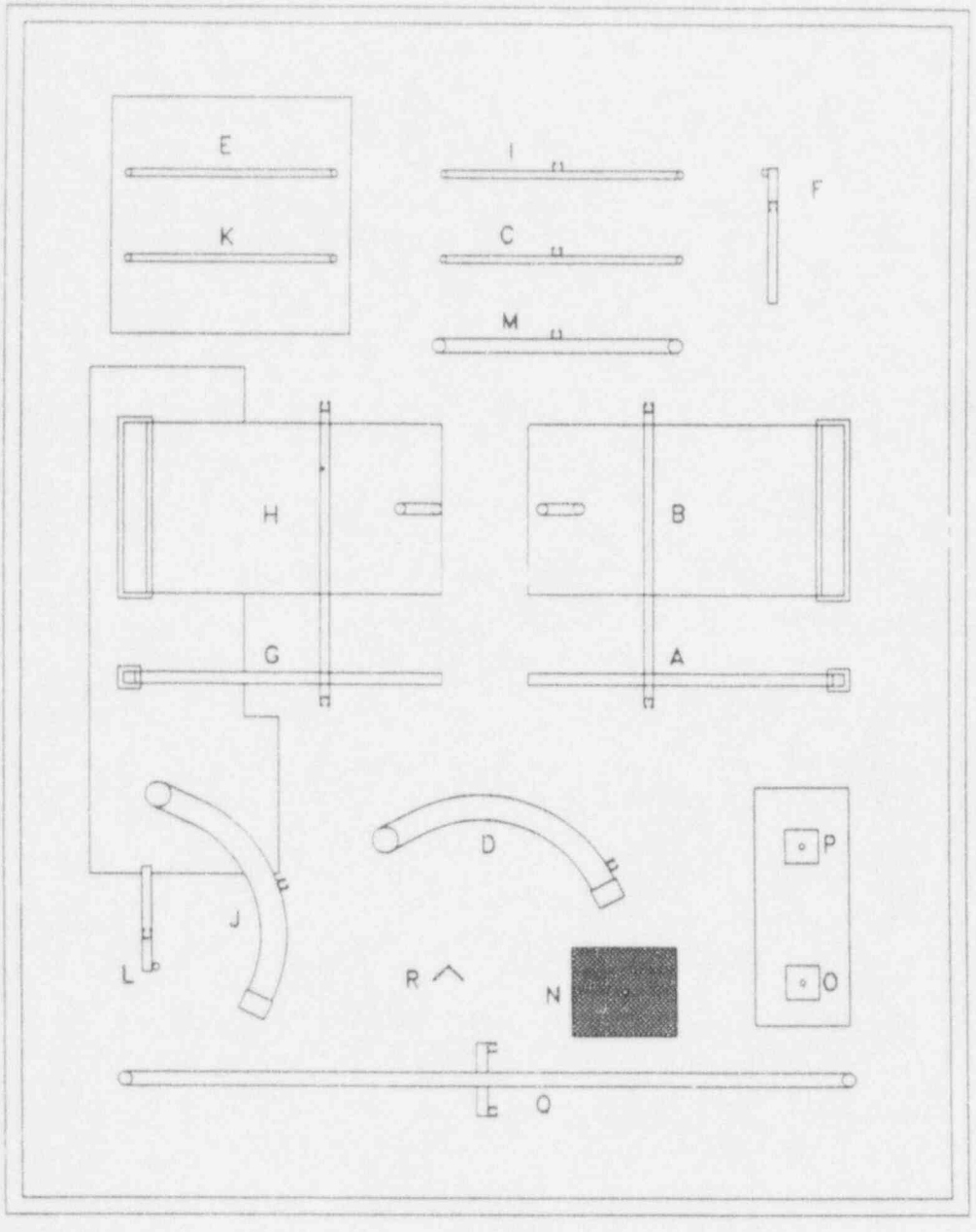
3 HOUR INSTALLATION



ELEVATION OF Q

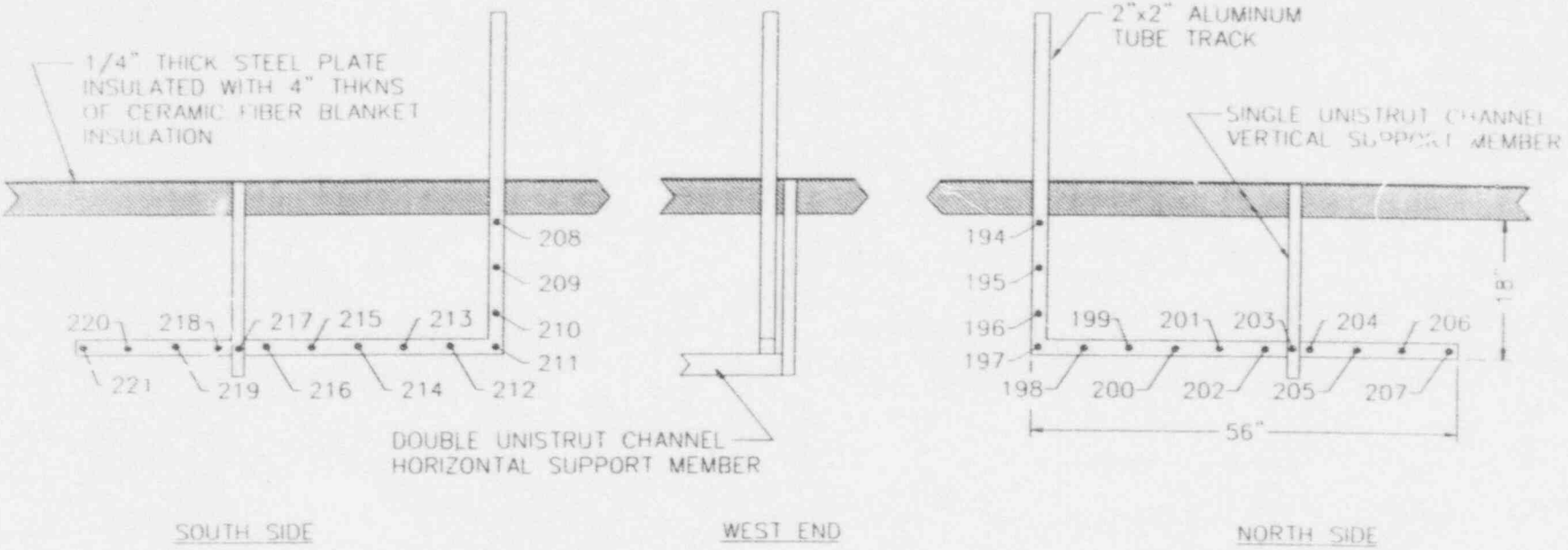
3C-500MCM ALUMINUM ARMORED CABLE FURNISHED BY NORTHERN STATES POWER TO BOUND PRAIRIE ISLAND SITE SPECIFIC INSTALLATION

NORTH



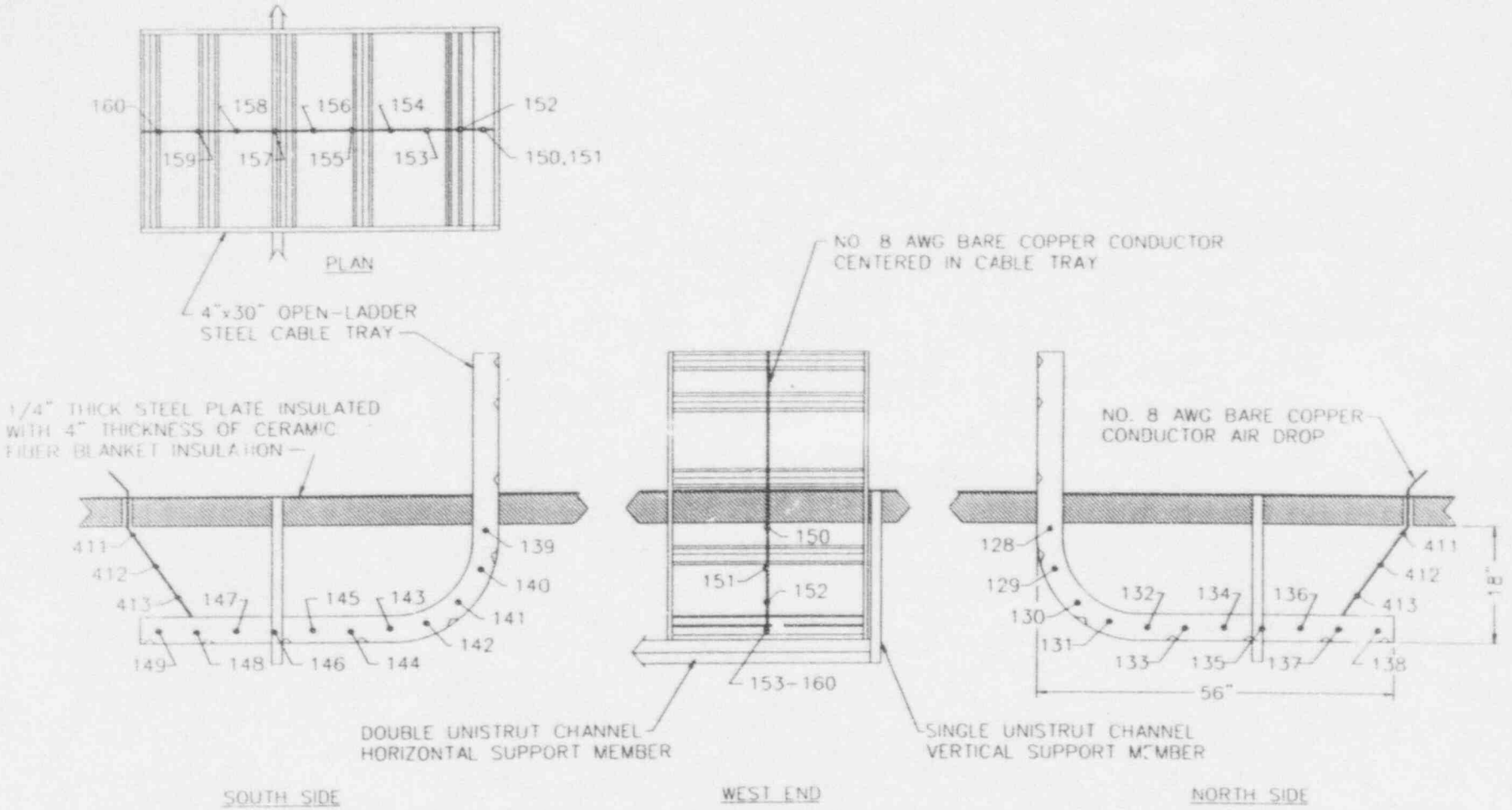
ARTICLE	TC NOS.	ARTICLE	TC NOS
A	194-234	J	324-349 & 426
B	128-160 & 411-413	K	112-127
C	39-67	L	377-384 & 427
D	350-376	M	68-95
E	96-111	N	407-410 & 417-420
F	1-8 & 428	O	299-323
G	235-273	P	274-298
H	161-193 & 414-416	Q	429-438
I	9-38	R	385-406

TEST ARTICLE LAYOUT &
THERMOCOUPLE LOCATIONS

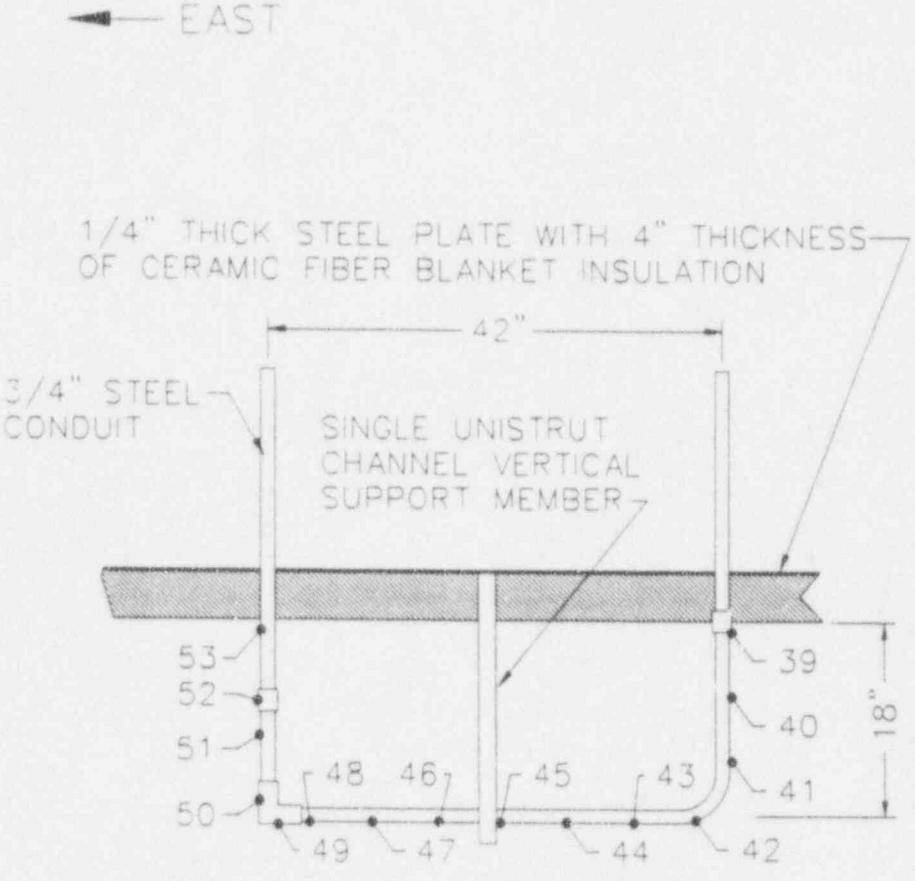


TC NOS. 222-234 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 222 COINCIDES WITH TC NOS. 194 AND 208 ON TUBE TRACK.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE A

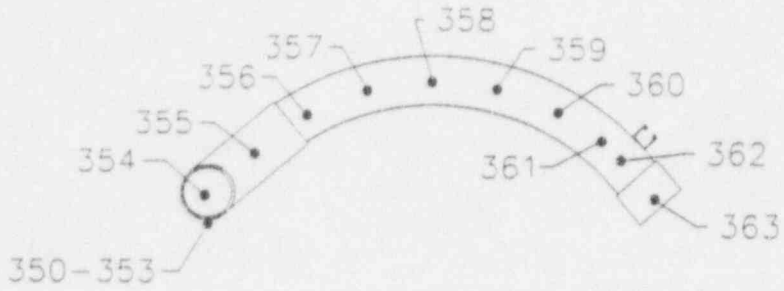


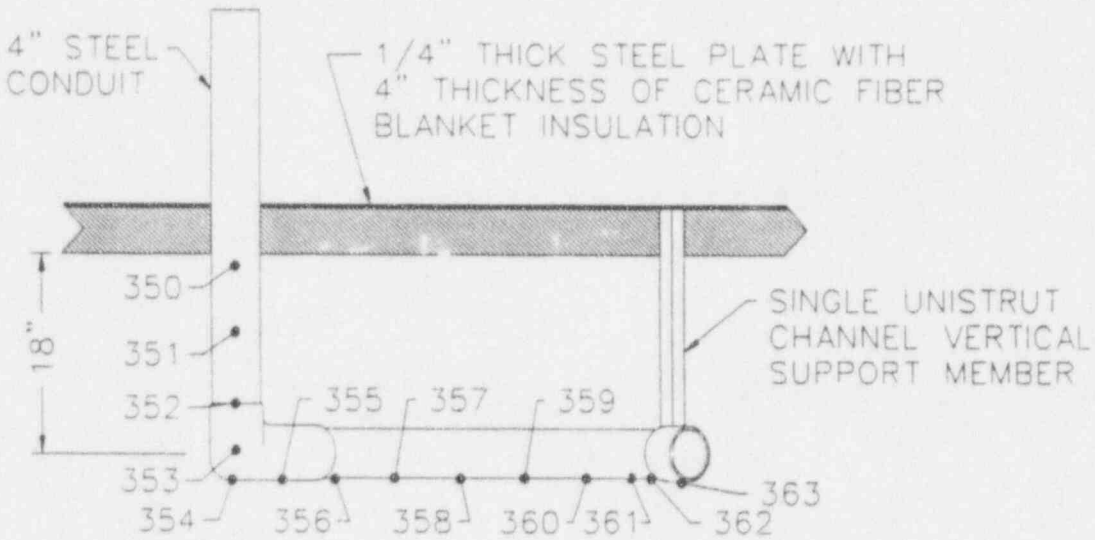
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE B



TC NOS. 54-67 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 54 COINCIDES WITH TC NO. 39.

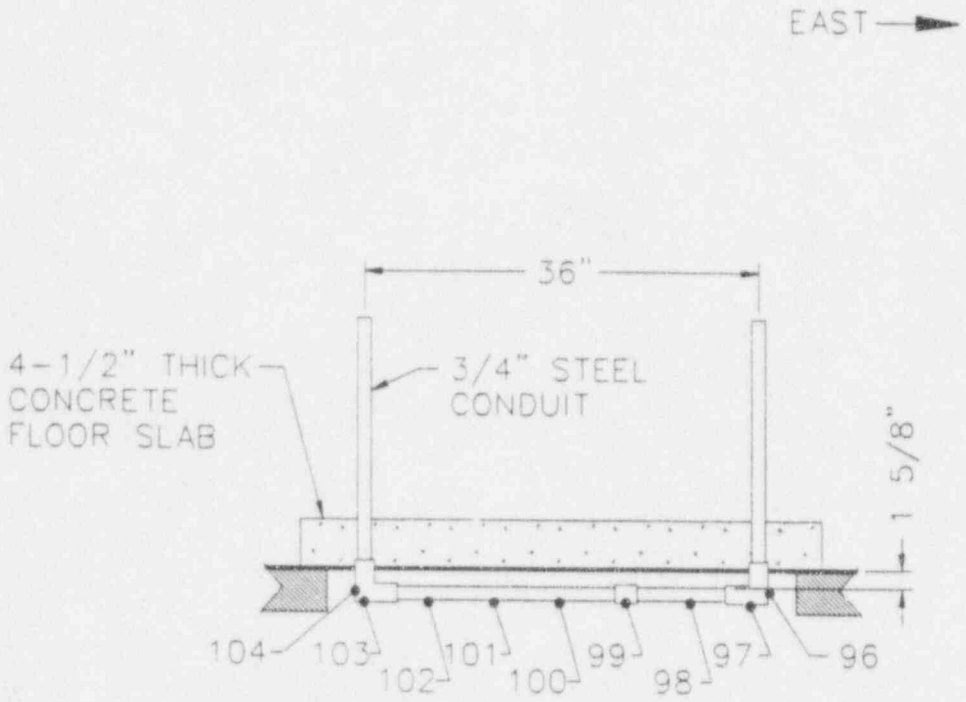
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE C





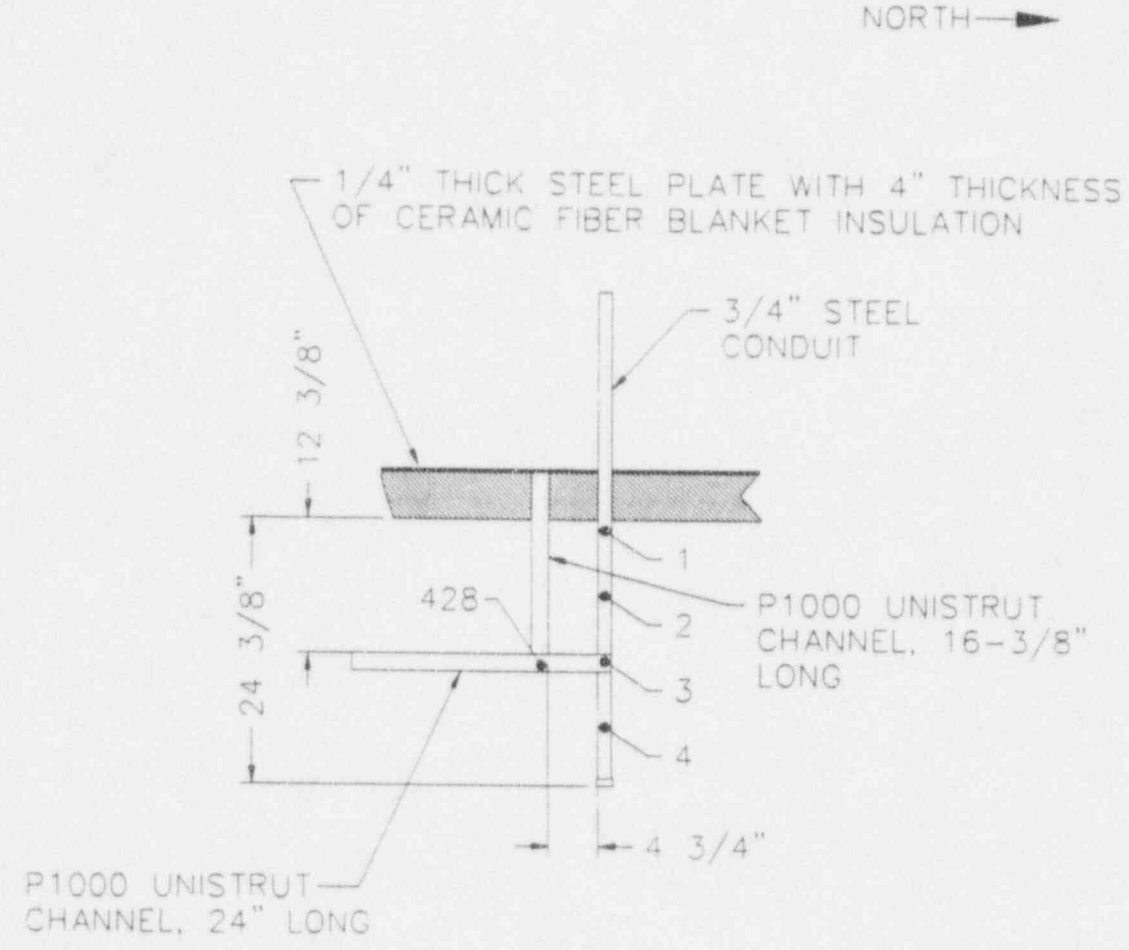
TC NOS. 364-376 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE D



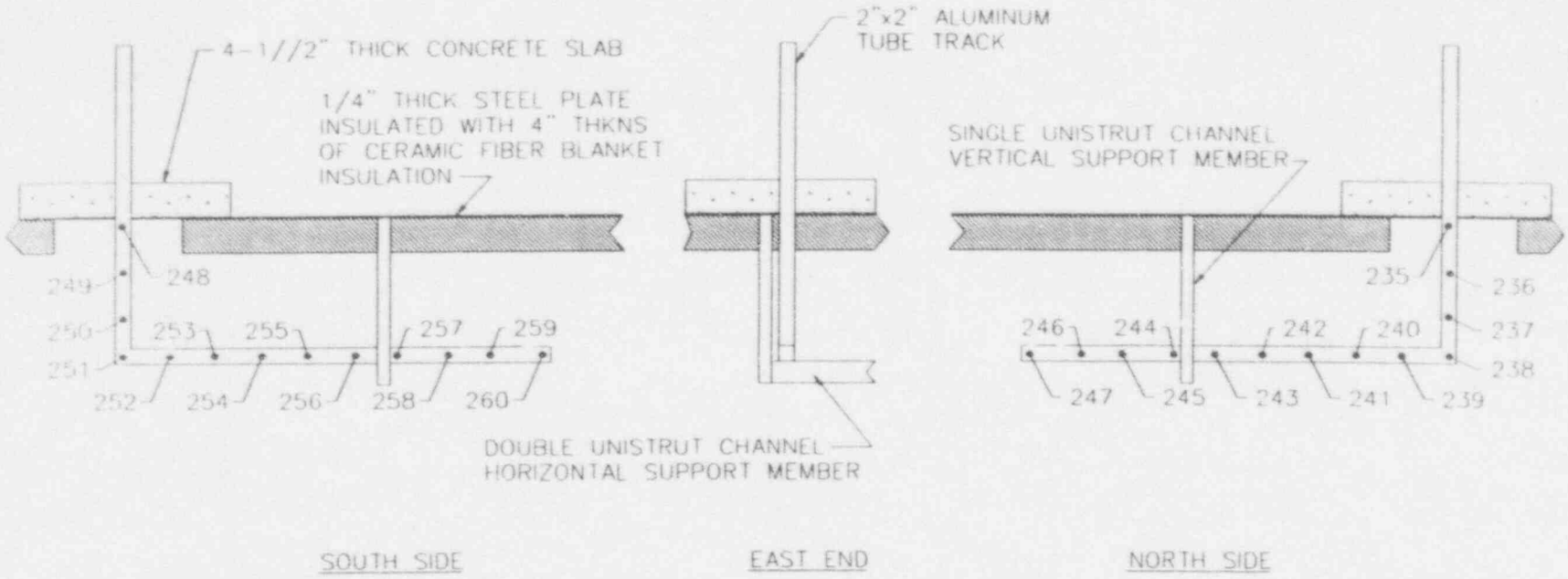
TC NOS. 105-111 (6" OC) ON NO. 8 AWG
BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 105 COINCIDES WITH TC NO. 96.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE E



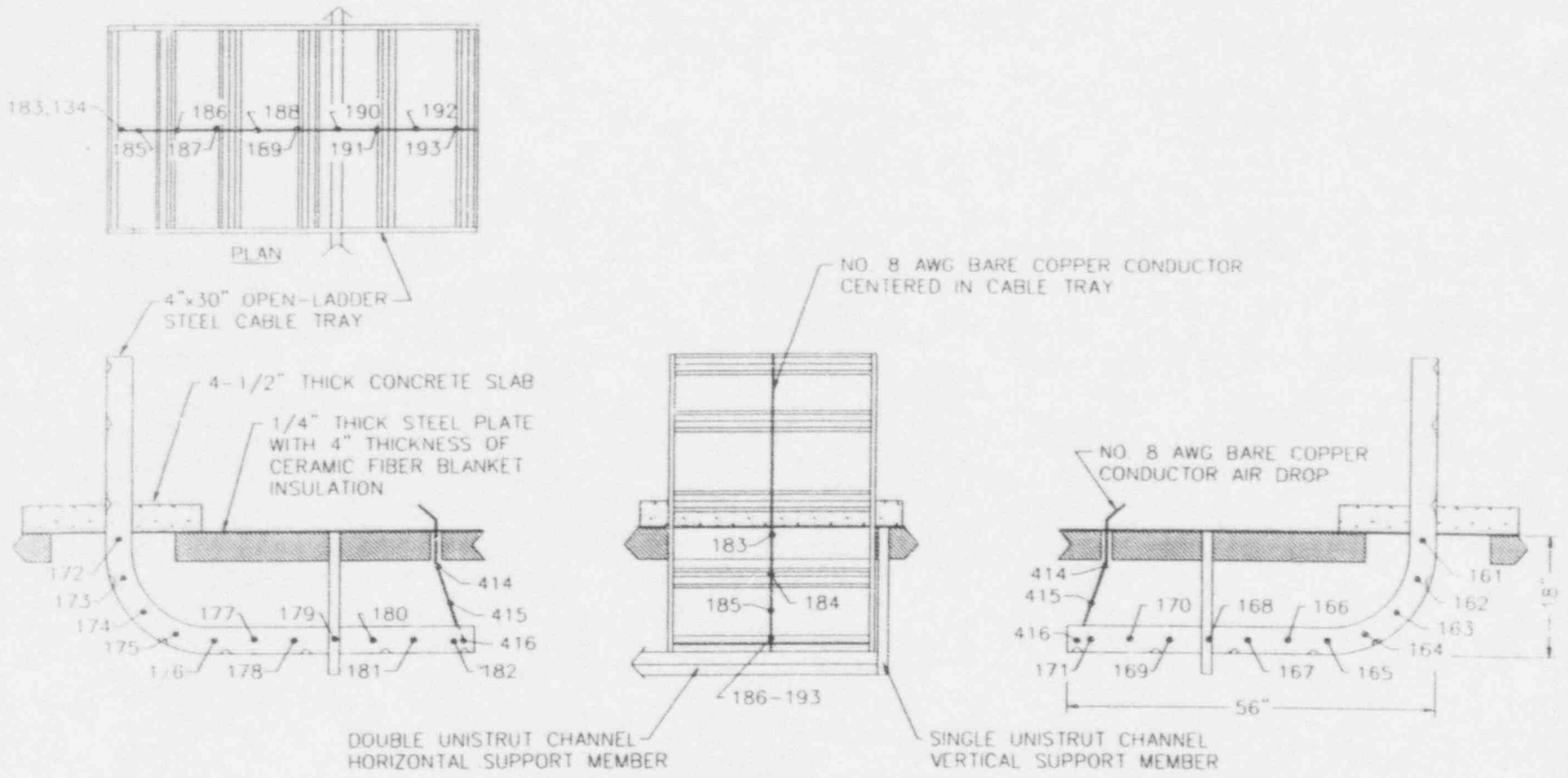
TC NOS. 1-4 ON WEST SIDE OF CONDUIT.
TC NOS. 5-8 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 5 COINCIDES WITH TC NO. 1.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE F

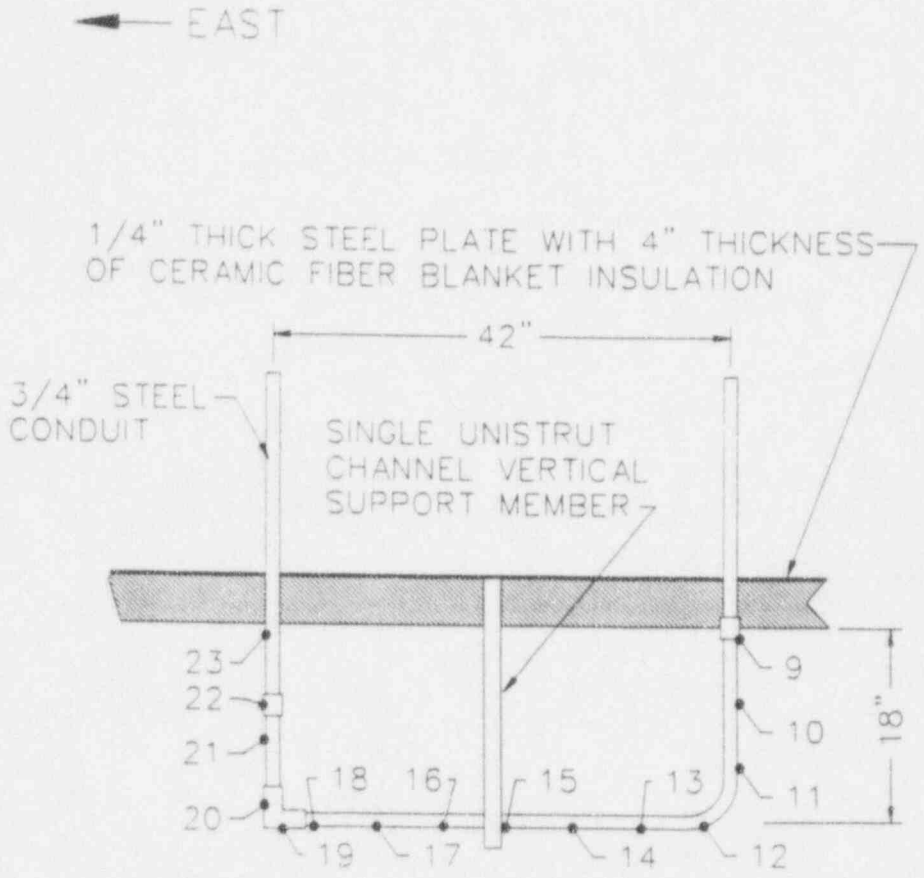


TC NOS. 261-273 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 261 COINCIDES WITH TC NOS. 235 AND 248 ON TUBE TRACK

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE G

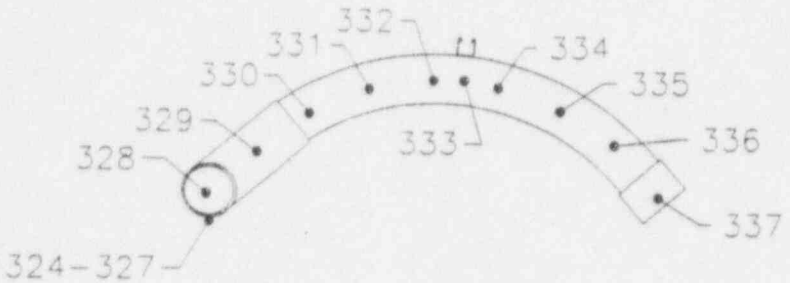


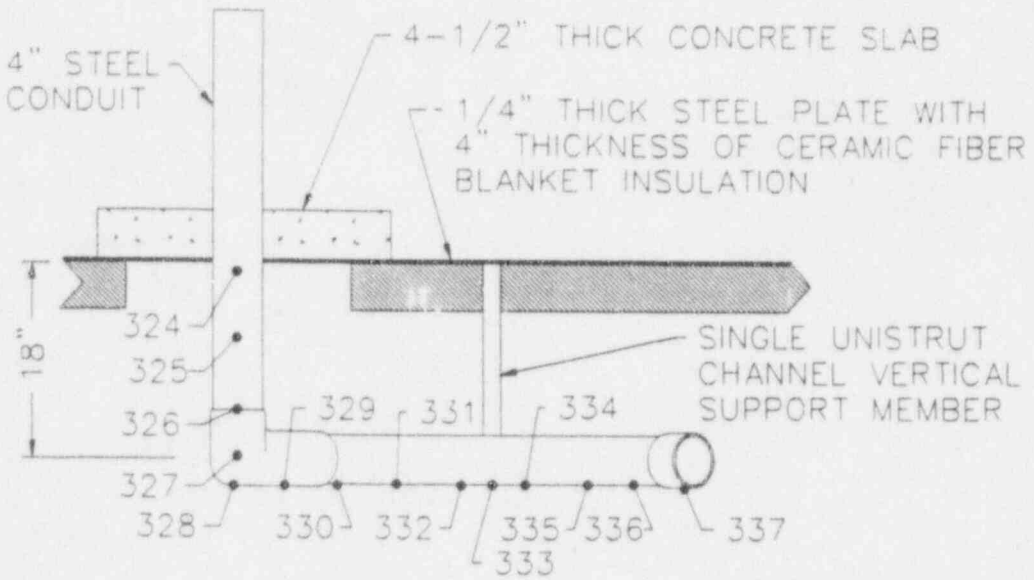
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE H



TC NOS. 25–38 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 25 COINCIDES WITH TC NO. 9.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS – ARTICLE I

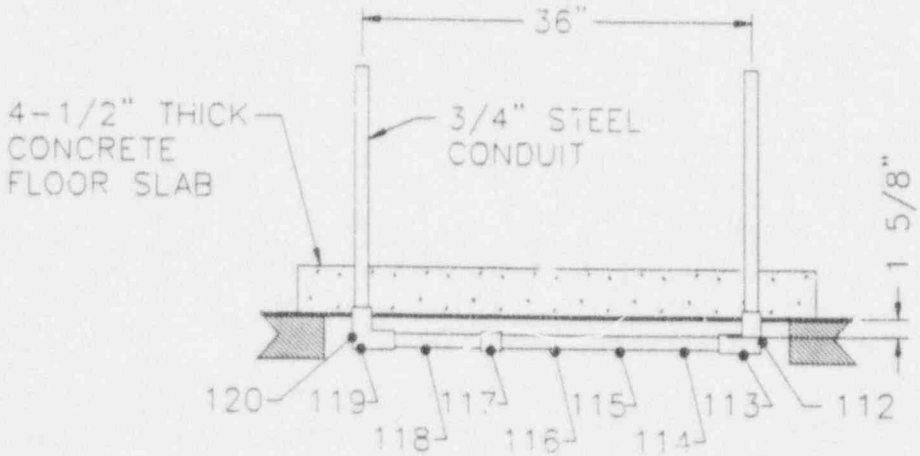




TC NOS. 338-349 & 426 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350. TC NO. 426 COINCIDES WITH TC NO. 337.

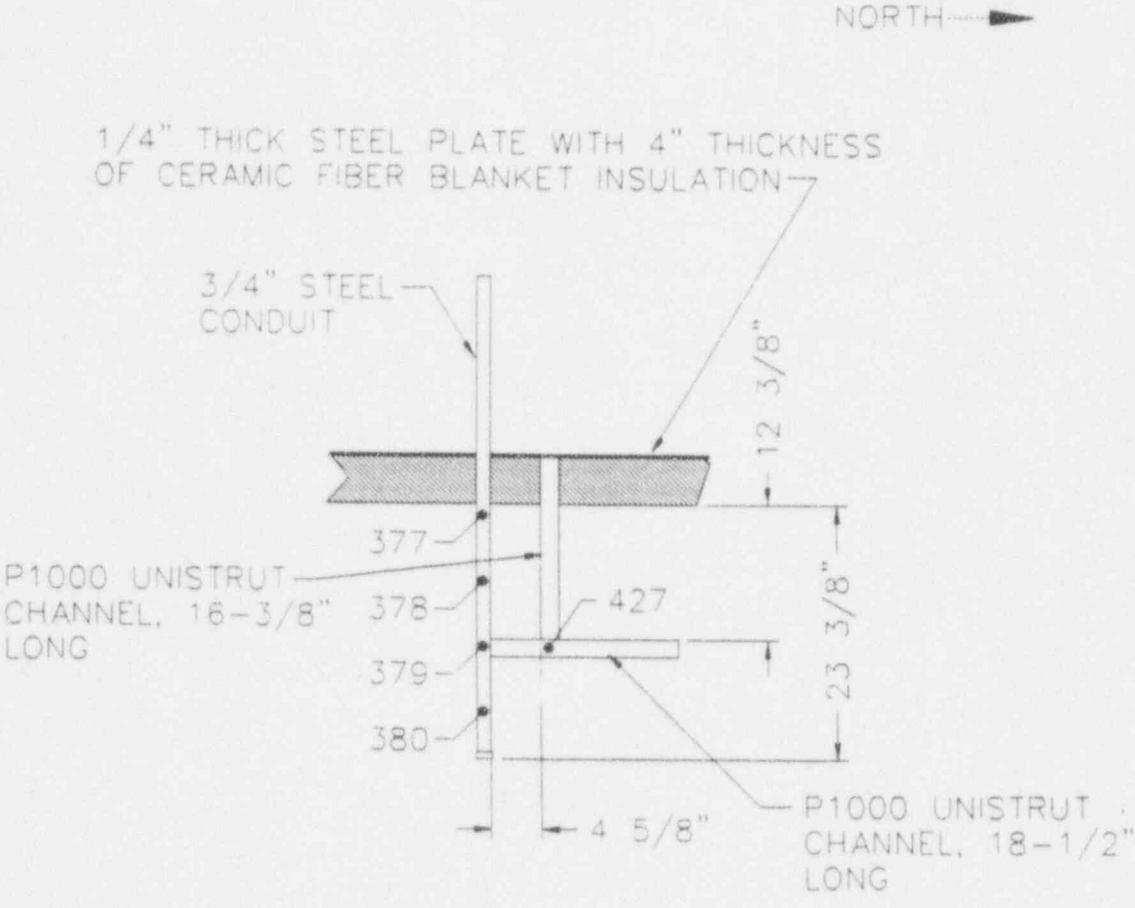
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS-ARTICLE J

EAST →



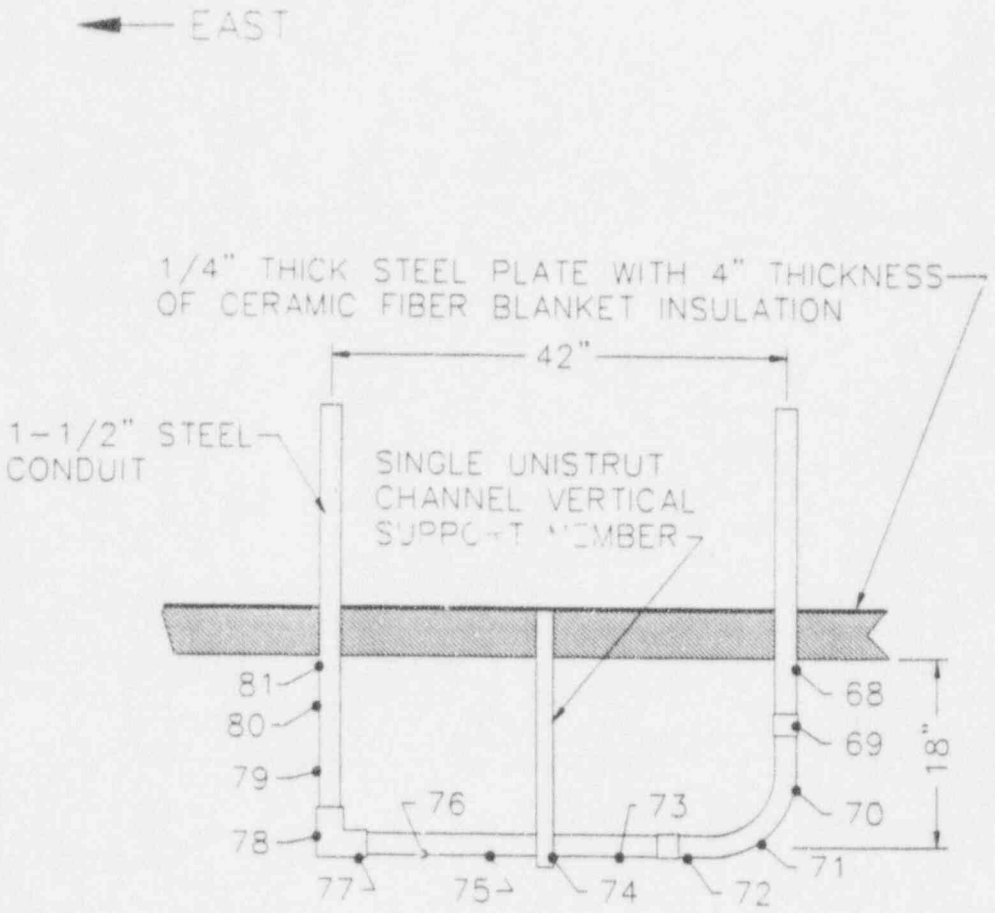
TC NOS. 121-127 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 121COINCIDES WITH TC NO. 112.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE K



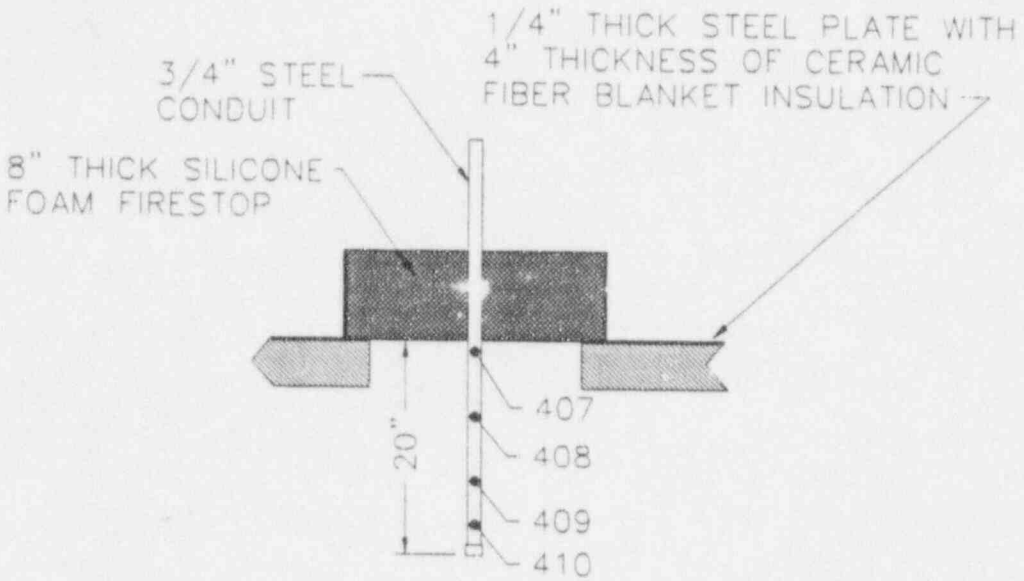
TC NOS. 377-380 ON EAST SIDE OF CONDUIT.
TC NOS. 381-384 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 381 COINCIDES WITH TC NO. 377.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE L



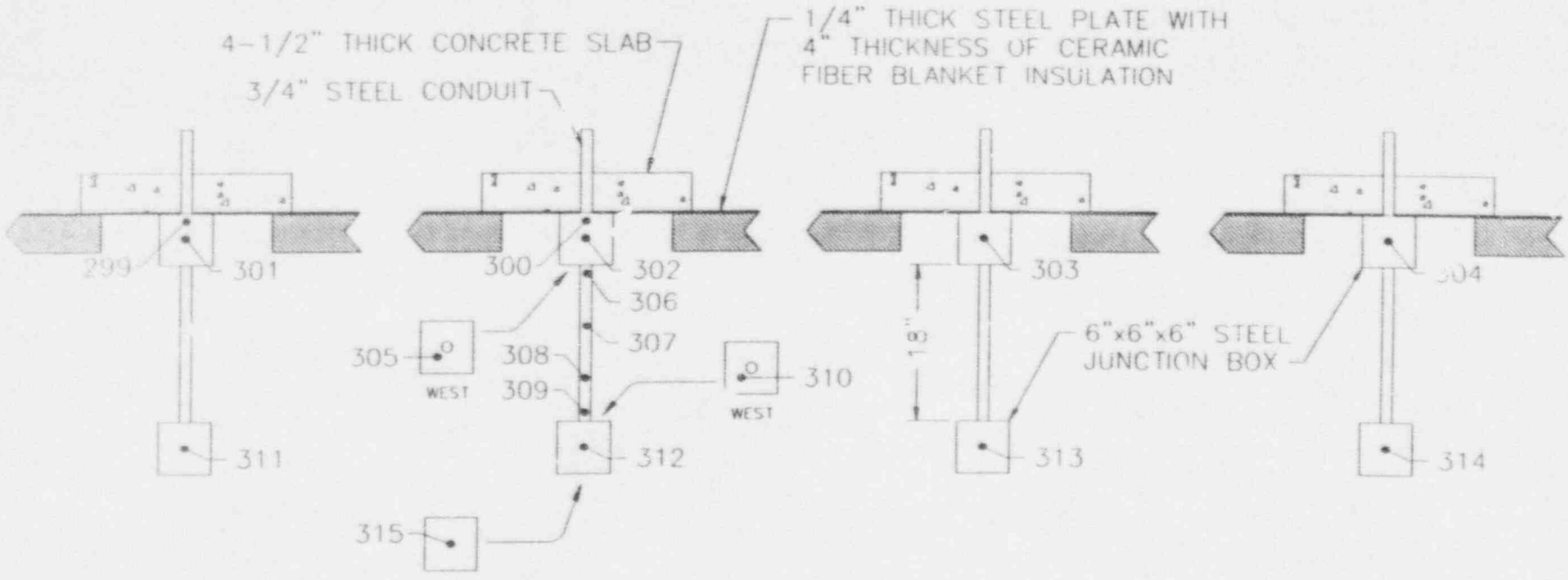
TC NOS. 82-95 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 82 COINCIDES WITH TC NO. 68.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE M



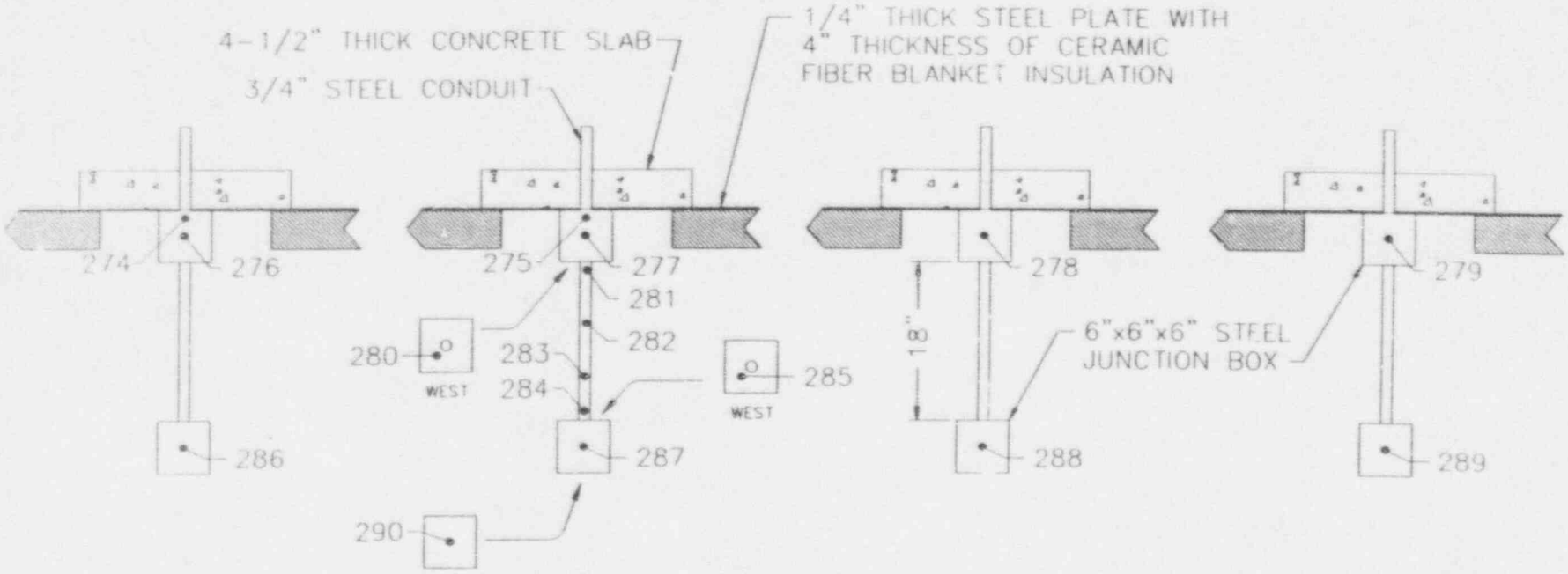
TC NOS. 417–420 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 417 COINCIDES WITH TC NO. 407.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE N



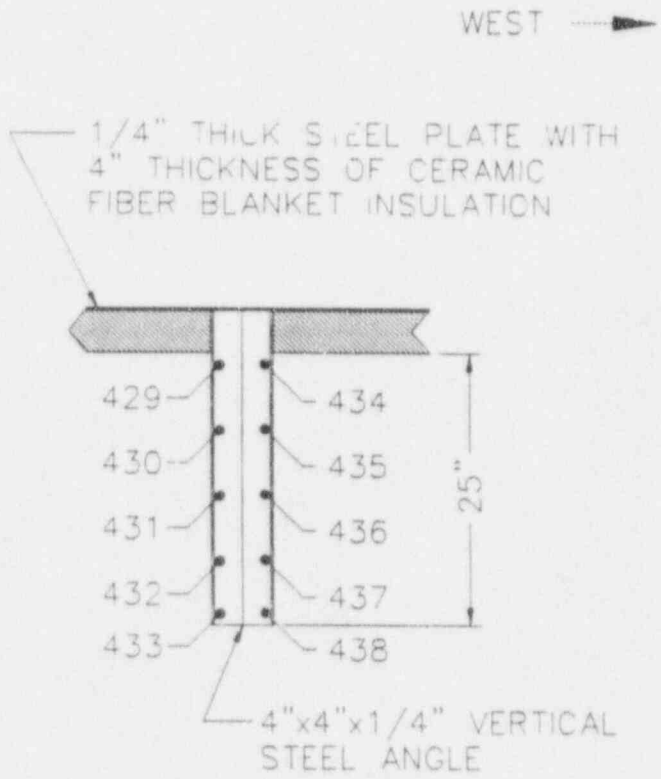
TC NOS. 316-323 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 316 COINCIDES WITH TC NOS. 299 & 300. TC NOS. 321-323 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE O

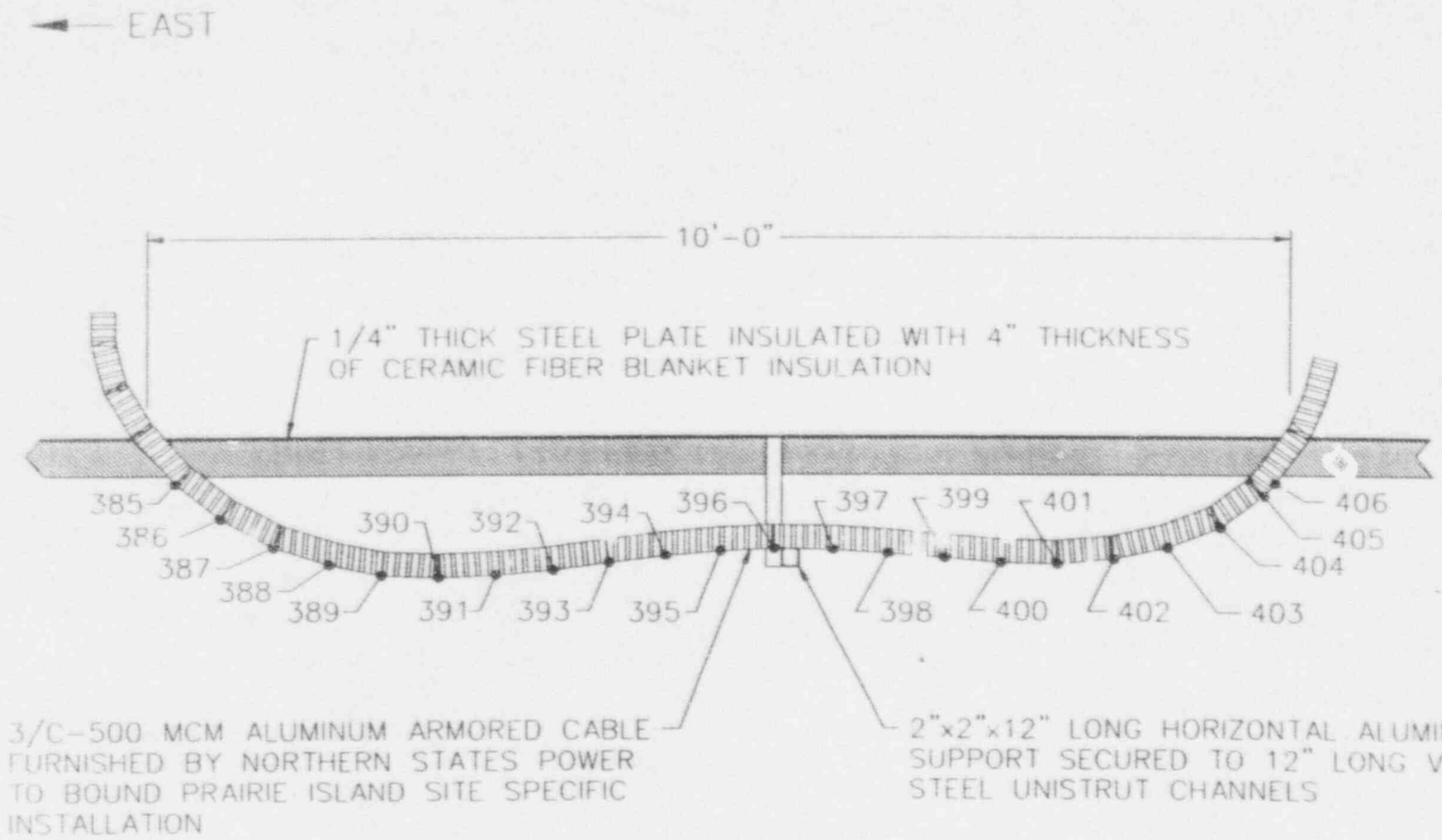


TC NOS. 291-298 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 291 COINCIDES WITH TC NOS. 274 & 275. TC NOS. 296-298 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE P



CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE R



CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE Q

NBK – FACSIMILE REQUEST FORM

ATTACHMENT 4

Underwriters Laboratories Inc.®

FAX NUMBERS
ME - (516) 271-8259
RTP - (919) 549-1842
SC - (408) 296-3256
CAM - (360) 817-6000
TW-FUS - 01-886-2-717-2405
TW-ES - 01-886-2-891-7644
HK - 01-852-895-8196

TO: ☑ 5A NBK COMMUNICATIONS CENTER
(5A Reception)

Date: 4-22-97

FAX No. (847) 272-2020 (If PROBLEMS (847) 272-8800 X 2021)
PLEASE TRANSMIT TO: (Circle or Check as Appropriate)

MEL SC CAM RTP HK TW (FUS) TW (ES) OTHER _____

TOTAL No. PAGES 3

NAME: Steven West

ORGANIZATION: USNRC

CITY, STATE, COUNTRY:

FAX NO.: 301 415 3577

SUBJECT: Transco

MESSAGE: Following are the test observation which you requested

Regards
Edward C. Johnson

SPECIAL INSTRUCTIONS:

REQUESTED BY: Johanson EMPLOYEE NO.: 17811

DEPARTMENT/SECTION: 4411 B EXT.: 42075

NUMBER OF ATTEMPTS: OPERATOR:

2000-3A
1/95

Record of Test Observations

File No.: R18500
Project No.: 97NK4087
Date: April 10, 1997

Client: Transco Inc.
Recorded By: M. Izydorek

Test Time Hr:Min:Sec	Exposed (E) or Unexposed (U) Surface	Article No.	Observation
0:0:5:00	E	All	All of the exposed material was charred and black in color.
0:0:6:15	E	N	The bottom piece of material (the cap) fell form the article.
0:08:22	E	B	Flames were issuing from the sample.
0:09:40	E	All	Flames issued from the exposed surfaces of the articles near the top of the exposed surface.
0:12:56	U	All	Smoke was issuing from the entire unexposed surface with the heaviest amount from Article H.
0:15:07	E	H	A crack, running in a North-South direction had developed at the West side of the article. the crack was 1/8 in. deep.
0:19:21	E	B,F,C,M	Flames continued to issue from the exposed surface of the articles.
0:20:03	E	All	The surfaces were becoming beige in color.
0:31:23	E	H	There were gaps present between the banding straps and the bottom surface of the protection material.
0:37:36	E	All	The surfaces were becoming white in color.
0:41:43	E	P	There was a slight separation in the material on the bottom surface of the protection material.
0:52:57	E	H	A Westerly view of the article shows a 1 in. separation near the West end on the bottom of the article.
1:10:26	E	J	On the South end of the article at the interface of the vertical and horizontal runs, there were two 1/4 in. wide openings in the protection material.
1:29:37	E	H	The area described at 0:15:07 had opened to a width of 2 in.
1:30:17	E	J	The openings described at 1:10:26 had closed.
1:33:28	E	G	A "flap" of protection material, 3 x 4 in., was hanging at the interface with the hanger.
1:35:18	E	Q	Heavy black smoke accompanied by flames was issuing from the article at the center and at both ends where it entered the furnace chamber. These flames were impinging on Article N.
1:49:24	E	B	Flames and black smoke issued from the top of

			the sample.
1:50:31	E	B	An area of flames issued from the bottom of the article at the interface with the support near the center of the article.
2:00:00	E	All	No significant changes observed.
2:16:00	E	A	the West half of the article fell to the furnace floor.
2:35:35	E	Q	The heavy black smoke ceased. Gray smoke issued from the center of the article at the bottom. The smoke was issuing from a crack.
2:40:00	E	All	Slight changes in color had occurred
2:41:03	E	Q	The crack described at 2:40:00 was 2 in. wide.
3:00:00	E & U	All	Fire test terminated.

with the exception of test article B, a 30-inch wide steel cable tray with a 1-hour Versawrap fire barrier, it appeared that at least the innermost layer of foil (the foil attached directly to the raceway) remained intact during the hose stream test. For test article B, the foil on the bottom surface of the tray was breached, apparently by the force of the solid hose stream. GL 86-10, S 1, states, in part, that the fire endurance qualification test for fire barrier materials are successful if "[t]he cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component (e.g., cables) is visible.

On April 11, 1997, I observed Transco disassemble the fire barriers that remained on test articles H and P after the fire and hose stream tests. For both of these proposed 3-hour fire barrier designs, the inner layers of foil, water filled mylar tubes, and fiber blankets remained largely intact. Many of these mylar tubes appeared to contain their original inventory of water and those that had leaked contained some water. In addition, the ordinary adhesive-backed strapping tape that was used to attach the tubes to the raceways was largely free of fire damage.

One interesting part of the test was a test of a 12-inch by 12-inch by 8-inch thick silicone foam penetration seal that was penetrated by a ¾-inch diameter steel conduit (test article N). In addition to the normal fire resistant damming board, the seal assembly included an outer layer of intumescent-coated fiberglass cloth (on the fire side). According to Mr. Hawks, Transco considered this a "throw away" or research and development scoping test and did not instrument the seal assembly with thermocouples to obtain unexposed side temperatures. After the 3-hour fire exposure and hose stream test, Transco disassembled the penetrations seal. The seal assembly was intact. About 2 to 3 inches of the silicone foam material was consumed during the fire exposure. A full 5 to 6 inches of unreacted silicone foam material remained.

UL will base its determinations on the thermal performance of the test articles on its observations during the fire endurance and hose stream tests, analyses of the electronically recorded thermocouple data, and consideration of both the maximum single point temperatures and the average unexposed side temperatures. Presumably, UL will also consider the effects of the problems with the thermocouples that were experienced during the test. Attachment 4 is UL's record of test observations.

Docket Nos.: 50-313, 50-282, and 50-306

Attachments: As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 9, 1997

MEMORANDUM TO: L.B. Marsh, Chief
Plant Systems Branch
Office of Nuclear Reactor Regulation

FROM: K. Steven West, Chief
Fire Protection Engineering Section
Plant Systems Branch
Office of Nuclear Reactor Regulation

SUBJECT: TRIP REPORT - TRIP TO UNDERWRITERS LABORATORIES, INCORPORATED TO OBSERVE THREE HOUR FIRE TEST OF ONE AND THREE HOUR VERSAWRAP RACEWAY FIRE BARRIER SYSTEMS (TAC M82809)

During April 10 and 11, 1997, I visited to Underwriters Laboratories, Incorporated (UL), Northbrook, Illinois, to observe a full-scale fire endurance test of 1- and 3-hour Versawrap fire barrier systems. Attachment 1 is a list of individuals that observed or participated in the test. I interacted mostly with the individuals marked with asterisks.

Transco Products, Incorporated (Transco) is developing Versawrap as a stand-alone fire barrier or as an upgrade for such existing raceway fire barriers as Thermo-Lag 330-1. In general, Versawrap barriers are installed (from the item to be protected outward) as individual layers of foil, water filled mylar tubes, fiber blankets, foil, and intumescent-coated fiberglass cloth. The numbers and arrangements of the individual barrier components are dependent on the type of item to be protected (e.g., raceway, cable, support, etc.) and the desired fire rating. (Attachment 1 to a memorandum of April 15, 1997, from K.S. West to L.B. Marsh describes the components of a typical Versawrap barrier and their general arrangements.) Entergy Operations, Incorporated, is considering installing 1- and 3-hour Versawrap fire barriers at Arkansas Nuclear One, Unit 1, and Northern States Power is considering installing a 1-hour Versawrap barrier at Prairie Island Nuclear Power Station.

Attachment 2 is Transco Test Procedure TR-228, "Three Hour Fire Test of One and Three Hour VERSAWRAP Raceway Fire Barrier Systems for Conduits and Cable Trays," Revision 2, February 7, 1997. The test was a single 3 hour fire exposure followed by a solid-stream hose stream test that was intended to demonstrate the ability of both 1- and 3-hour Versawrap fire barrier systems (in the same test) to meet the acceptance criteria of Generic Letter 86-10, Supplement 1 (GL 86-10, S 1).

CONTACT: K.S. West, NRR
301-415-1220

The test specimen had been constructed and installed on the test furnace before I arrived at UL. Therefore, I did not observe fire barrier installation or thermocouple placement. The overall test specimen consisted of a steel and concrete deck from which 18 individual 1- and 3-hour test articles were suspended into UL's large floor furnace. According to Kevin Hawks, Transco, (1) Transco personnel installed the Versawrap fire barriers on the test articles in accordance with Transco instructions and procedures, (2) the test articles were instrumented in accordance with GL 86-10, S 1 (3) Transco quality control witnessed and documented test specimen construction, (4) UL quality control also independently witnessed and documented test specimen construction, (5) UL will prepare the fire test report. The test articles and the conditions which they were intended to bound are described in Attachment 2. I made pen and ink changes to Attachment 2 to reflect changes that Transco had made to the test articles after it issued the test procedure. Attachment 3 shows the test article layout, construction details, and thermocouple locations. The test articles, which did not contain cable fill, were instrumented with 438 thermocouples.

On the basis of my observations, it appeared that UL exposed the test specimen in accordance with the ASTM E-119 standard time-temperature curve for 3 hours. UL programmed its data acquisition computers to electronically record the test article thermocouple temperatures every two minutes. UL also printed the thermocouple temperatures about every five minutes. UL will use the electronically recorded temperature data to judge the fire endurance performance of the individual test articles. The printed temperatures were provided for contemporaneous information during the test. About midway through the fire exposure, Transco noticed some apparently anomalous thermocouple readings. For example, closely-spaced thermocouples were reporting vastly different temperatures. Upon examination, Transco found that the insulation had melted off of some thermocouple wires that were running on top of and in direct contact with the steel test deck. Apparently, at these points the thermocouples were measuring the temperature of the test deck rather than the temperatures of the test articles. After UL and Transco placed insulating blankets between the affected thermocouple wires and the steel test deck, the printed temperatures returned (dropped) to what appeared to be a more normal range. Transco indicated that UL would assess the impact of this event on the overall test results in its fire test report.

Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 61 minutes, it appeared that test articles A, B, C, D, L, O, and R met the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 1-hour fire rating while test articles E and Q did not. Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 2 hours and 55 minutes (the temperatures at 3 hours were not printed), it also appeared that test articles F, G, H, and I may meet the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 3-hour fire rating, but test articles J, K, M, N, and P will not.

Following the 3 hour fire exposure, UL subjected the test specimen to a solid hose stream test for 2-1/2 minutes. With the exception of test article P, most of the outer layers of intumescent-coated fiberglass cloth, foil, and fiber blankets were knocked off of the bottom and side surfaces of the test article fire barriers by the force of the hose stream. The barrier on test article P remained intact and may not have been hit by the hose stream. In addition,

ATTACHMENT 1

List of Observers and Participants
Fire Endurance Test of Versawrap Fire Barrier
Underwriters Laboratories, Inc., Northbrook, Illinois
April 10, 1997

K. Steven West	U.S. Nuclear Regulatory Commission
Robert Goss*	Transco Products, Inc.
Kevin Hawks*	Transco Products, Inc.
Greg Jaroz*	Transco Products, Inc.
Sandra Bradford*	Transco Products, Inc.
John Kmetz	Transco Products, Inc.
Jeff Deminski	Transco Products, Inc.
Gary Sharisky	Transco Products, Inc.
Ed Johanson*	Underwriters Laboratories, Inc.
Chris Johnson	Underwriters Laboratories, Inc.
Michael Allen Boomgarden	Underwriters Laboratories, Inc.
Bill Joy	Underwriters Laboratories, Inc.
Mark Pastor	Underwriters Laboratories, Inc.
Herb Muller	Underwriters Laboratories, Inc.
Mark Izydorek	Underwriters Laboratories, Inc.
Sam Oolie	No Fire Technologies
Ron Rispoli*	Entergy Operations, Inc.
Woody Walker*	Entergy Operations, Inc.
Tom Lillehei	Northern States Power
Dan Langel	Sargent and Lundy

ATTACHMENT 2

TRANSCO PRODUCTS INC.

Transco Products Inc.
Test Procedure #TR-228

for
Three Hour Fire Test of
One and Three Hour *VERSAWRAP* Raceway Fire Barrier Systems
for Conduits and Cable Trays

(TRANSCO PRODUCTS INC. PROJECT #AR-256)

Rev.:	Description:	By:	Date:	Ck:	Date:	App.:	Date:
0	For Review and Test Specimen Fabrication	G.J. Jarosz	02/07/97	K.Hawks	02/07/97	R. Goss	02/07/97
1	For Review and Test Specimen Fabrication	G.J. Jarosz	03/01/97	K.Hawks	03/01/97	B.C. Mach-chhar	03/01/97
2	For Review and Test Specimen Fabrication	G.J. Jarosz	03/16/97	[signature]	03/17/97	[signature]	3/17/97

TABLE OF CONTENTS:

SECTION 1.0
SYNOPSIS:

Transco Fire Test #TR-228 will be a single fire test conducted in accordance with the performance requirements of NRC GL 86-10, Supplement 1 and the ASTM E-119 time/temperature curve. The purpose of this test is to demonstrate the ability of both one and three hour *VERSAWRAP* raceway fire barrier systems (in the same test) to protect a variety of raceway conditions that are representative of those commonly found in nuclear power plants. Even though some of the barrier systems to be tested are only intended for one hour applications, they will be subjected to the full three hour fire test. In these cases, the one hour barrier specimens will be considered to be successful thermally if they meet the raceway temperature pass/fail criteria of GL 86-10 for the first hour of the fire test. After the conclusion of the three hour fire test, both one and three hour specimens will be subjected to a hose stream test in accordance with Section 7.0 of this procedure. Testing will be performed at Underwriters Laboratories (Northbrook, Illinois).

The overall test specimen will consist of a metal and concrete deck from which a number of simulated conduit and cable tray raceways will be suspended. The sizes and shapes of these raceways are intended to represent conditions that bound equivalent or less severe raceway configurations in the field. These bounding conditions to be qualified by this test are described below. The metal/concrete deck with its individual raceway specimens will be placed on top of a large floor furnace where the raceways will be subjected to the three hour fire endurance test. Immediately after the conclusion of the fire test, the deck and raceway specimens are lifted as a single unit from the furnace and will then be exposed to the hose stream test.

The raceway items to be tested and conditions they are intended to bound are as follows:

ITEM: DESCRIPTION:

"A" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track - This item is intended to bound one hour *VERSAWRAP* installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled steel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum raceways. Because this is a one hour wrap, it is only required to meet the thermal pass/fail requirements of GL 86-10 Supplement 1 for one hour whereas the hose stream test for this specimen will be performed immediately after the three hour fire test. This specimen will demonstrate both horizontal and vertical raceway sections, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper cable and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading.

"B" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound one hour *VERSAWRAP* systems installed on 30" x 4" (and all smaller sizes) of both aluminum and/or steel cable trays (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "A" above*) as well as bundled conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a

"Unistrut" hanger thermal short interface. This tray will be empty except for a single #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum raceways up to this size for hose stream test qualifications of *VERSAWRAP*. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap.

"C" ¾" Diameter Rigid Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit and will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"D" 4" Diameter Rigid Steel Conduit - This item is intended to demonstrate one hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway specimen will fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"E" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass) located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will use condulets at each end of the specimen on the exposed side of the deck. A conduit connector will also be installed on the conduit. (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"F" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~one~~ three hour *VERSAWRAP* systems installed on ¾" diameter conduit (as the most severe thermal mass) connected to a "Unistrut" hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped with *VERSAWRAP* as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"G" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track -This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled sateel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum trays. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. This item will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for small raceways.

"H" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound three hour *VERSAWRAP* systems installed on 30" x 4" and all smaller sizes of both aluminum and steel cable tray (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "G" above*) and bundled steel or aluminum conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum trays up to this size for hose stream test qualifications. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for both large tray and/or box wraps.

"I" ¾" Diameter Rigid Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"J" 4" Diameter Rigid Steel Conduit -This item is intended to demonstrate three hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway assembly will be fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for large and small conduit wraps.

"K" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit (the most severe thermal mass) found in the field that is located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize condulets at each end of the specimen. A conduit connector will also be installed on the conduit (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered as a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a single #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"L" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~three~~ one hour *VERSAWRAP* systems installed on a ¾" diameter rigid steel conduit as the smallest size of conduit found in the field (the most severe thermal mass) connected to a hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"M" 1-½' Diameter Steel Conduit ~~and TSI "Thermo-Lag"~~ Raceway Covered with Modified VERSAWRAP - This item is intended to bound "modified" one hour *VERSAWRAP* systems installed on 1-½" (and larger) diameter conduits in the field. The test raceway assembly will be fabricated from standard 1-½" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. ~~The one hour Thermo-Lag material will be installed with "dry joints" (no trowel-grade Thermo-Lag will be used).~~ A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on these raceway types. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed

according to Section 5.0 of this procedure.

"N" 12" x 12" x 12" x 16 Gauge Steel Box Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* conduit systems ~~that interface with a one hour "Darmatt KM1" raceway barrier system~~ installed on the box. The conduit will pass through a penetration seal to show wrap terminations as such. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1.

"O" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

"P" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

aluminum hanger

"Q" 3C-500MCM Aluminum Armored Cable - This item is intended to bound one hour *VERSAWRAP* systems installed on a 3C-500MCM aluminum armored cable as supplied by Northern States Power for their Prairie Island Nuclear Power Station. The 10' (minimum) span of cable will be temporarily supported by a ~~rope~~ about mid-span. During the test, the ~~rope~~ will ~~burn~~ melt and will allow the wrapped cable to be unsupported for the remainder of the fire test. The intent here is to show that the wrap will still be effective even if the cable suddenly becomes unsupported between hanger points (maximum distance as tested herein) in the field. (In the field, the cable is located in an aluminum tray suspended on steel hangers. The utility wishes to evaluate the possibility of wrapping only the cable instead of the entire tray. It is felt that if the aluminum tray is not wrapped, it will melt or be consumed during a fire thus leaving the cable unsupported except at points where the tray was suspended on steel hangers.)

aluminum unistrut trapeze-style hanger

"R" 3" x 3" angle - structural steel

SECTION 2.0
TEST FURNACE:

The furnace to be used is Underwriters Laboratories' standard large floor furnace. The furnace shall be operated in accordance with the requirements of ASTM E-119 for the three hour fire test

SECTION 3.0
ITEMS TO BE PROTECTED:

The following is a description of the items to be used as raceway elements for the fire test:

> *(See Section 1.0, Synopsis for a general description of these items. Note: all steel trays and boxes will be manufactured from 16 gauge steel while all conduit will be standard, rigid conduit. All "free-cable air drops" will consist of single pieces of stranded 8 AWG bare copper wire according to GL 86-10, Supplement 1 requirements. All hangers will be fabricated from standard "Unistrut" type material [hangers may be welded to the raceways for the test in lieu of using clips, straps, etc].)*

An accurate description of specimen fabrication shall be included in the final test report (as verified by Transco Products Inc. Quality Control). Hardware substitutions are permitted provided substitute material (etc.) does not increase the heat mass of the specimen and are documented by Transco QC and UL.

SECTION 4.0
FIRE BARRIER MATERIAL INSTALLATION:

The *VERSAWRAP* and Transco Products Inc. TCO-001 materials shall be installed by Transco Products Inc. personnel in accordance with the manufacturer's instruction and/or procedures. If written instructions are not available at the time of installation, then Transco Products Inc. QC personnel shall document/verify step-by-step methods used for installation. Test installation records will be included as an appendix to the final test report.

Materials used for this test shall be purchased, received, and installed in accordance with latest approved revision of Transco Products Inc.'s Quality Assurance Program and applicable procedures. All fire barrier envelope installation will be witnessed by Transco Products Inc. Quality Control personnel. Material components (except for tie wire and ceramic blanket) will be identified with the responsible QC's initials as each layer is installed.

Note: This test will be performed as a "Safety Related" quality program in accordance with the latest approved revision of Transco Products Inc.'s Quality Assurance Manual (10CFR, Part 21 applies) with the exception that all materials will be provided as "Q-Class" with Certificates of Conformances.

SECTION 5.0
THERMOCOUPLES:

A.) Fire Barrier Envelope:

The fire barrier envelope is considered all areas of the specimen on the exposed side of the test slab. For these areas, thermocouples shall be mounted to the specimen to gather temperature data for the duration of the fire test. At a minimum, temperatures shall be documented at nominal two minute intervals for the duration of the test. Thermocouple placement for the fire barrier envelope (quantity and locations) shall be as specified in NRC GL 86-10 and Supplement 1 as follows:

"**.... Cable Trays** - The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray shall be measured by placing the thermocouples every 152 mm (6 - inches) on the exterior surface of each tray side rails between the cable tray side rail and the fire barrier material.

Internal raceway temperatures shall be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm (6- inches) along the length of the copper conductor. Thermocouples shall be placed immediately adjacent to all structural members, supports, and barrier penetrations. ..."(1)

"**.... Conduits** - The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite of the test deck and closest to the furnace fire source. The internal raceway temperatures should be measured by a stranded AWG 8 bare copper

conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations...."(1)

Free-Cable Air Drops: Thermocouples will be installed on the stranded 8 AWG wire used for demonstrating the "free-cable air drop" every 152 mm [6 inches] in accordance with the same requirements for monitoring internal conduit/cable tray temperatures.

(Note: *In accordance with NRC GL 86-10, Supplement 1 requirements, "for the thermocouples installed on conduits, cable tray side rails, and bare copper conductors, a ± 13 mm (±1/2 inch) installation tolerance is acceptable". Hence, this tolerance shall be considered acceptable for use in this test. The tolerance is considered to be from the point of individual thermocouple placement and not compounded from one thermocouple to the next (i.e., all thermocouples can not be 6 1/2" from each other but rather must be ±1/2" from the measured 6" [minimum] mark on the item being monitored.)*

Junction box thermocouples will be installed in accordance with the requirements of Generic Letter 86-10, Supplement 1.

B.) Penetration Seal:

Thermocouple placement for the unexposed penetration seal surface (test item "N") will comply with the typical requirements of ASTM E814. As an optional method for protecting thermocouple tips, the thermojunctions of each thermocouple may be embedded into the seal surface or seal surface/penetrating member interface approximately ⅛ -¼" below the seal surface (because of the nature of the seal material, this placement can be performed at any time after the installation of the seal material). For this alternate method, insulation pads for covering the thermocouple tips will not be used.

All specimen temperatures shall be monitored using thermocouples (with special limits of error equal or less than 1.1°C). Thermojunctions of all specimen thermocouples shall be electrically welded. All thermocouple wire shall be supplied with certifications of purity, accuracy, and calibration.

Furnace atmosphere thermocouples shall be placed 12" below the furnace deck/slab as well as 12" away from representative elements of the test specimen accordance with ASTM E-119-88 requirements (not less than nine [9] thermocouples will be used to monitor furnace atmosphere temperatures). Additional furnace atmosphere thermocouples be employed around the specimen as it protrudes into the furnace. These will be placed at the laboratories discretion to supplement data acquisition in areas where furnace atmosphere thermocouples can not be mounted to satisfy ASTM E-119 requirements because of the specimen's configuration, et cetera.

The installation and location of each uniquely identified thermocouple (for both the specimen and furnace) shall

be mapped and verified (measured) by Transco Products Inc. Quality Control. Verification may be performed as hand written notes and shall become part of the permanent records of the test. Also, all thermocouple certifications shall also become a permanent record of the test.

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[1] Generic Letter 86-10 and Supplement 1

SECTION 6.0
FIRE TEST:

The fire test shall be conducted in accordance with the ASTM E-119 time/temperature curve (and temperature tolerance) for a minimum of three (3) hours. As a minimum, temperature data provided by both furnace and specimen thermocouples should be monitored and documented at nominal two (2) minute intervals. The laboratory shall verify and document visual specimen performance and occurrences (*i.e.*, smoke, et cetera) for the duration of the test.

It is intent of the test to demonstrate as many different raceway configurations as possible. As such, several raceway test specimens exhibit multiple features (*i.e.*, the 3 hour large tray demonstrates the tray wrap, a "free- air" cable and interface, a wrap-to-concrete interface, *etc.*). If one of these features fails thermally or during the hose stream test, it is the intent of the test to then exclude that feature from the configuration being qualified. In the case of the large tray for example, if the "free-air" cable or wrap-to-concrete interface fails for any reason, it is does not cause the tray to fail provided the rest of the tray specimen meets the acceptance criteria of Generic Letter 86-10, Supplement 1. Any failed portion of a specimen will then not be qualified by this test.

SECTION 7.0
HOSE STREAM TEST:

After the conclusion of the three hour fire test, the fire barrier envelope specimen (along with the surrounding penetration seal) shall be subjected to a minimum of one of the following hose stream tests (as identified in NRC GL 86-10, Supplement 1):

(a.) "The stream applied at random to all exposed surfaces of the test specimen through a 3.8 cm (1-1/2-inch) fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 1pm (75gpm) with the tip of the nozzle at a maximum of 1.5 meters (5 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3 -hour barriers); or[2]

(b.) "The stream applied at random to all exposed surfaces of the test specimen through a 6.4 cm (2 ½-inch) national standard playpipe with a 2.9 cm (1-1/8 -inch) orifice at a pressure of 207 kPa (30psi) at a distance of 6.1 meters (20 feet) from the specimen, (Duration of the hose stream application - 1 minute for a 1-hour barrier and 2 ½ minutes for a 3-hour barrier); or"[2]

(c.) "The stream applied at random to all exposed surfaces of the test specimen through 3.8 cm (1 ½-inch) fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa (75psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 3 meters (10 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3-hour barriers)."[2]

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2. Generic Letter 86-10 and Supplement 1

The responsible QC shall verify and document the type of hose stream, distance, time et cetera employed in each hose stream test.

SECTION 8.0
TEST REPORT:

The laboratory performing the test shall provide a written report which accurately describes the following minimum elements of the test:

1.) Verification of specimen materials and dimensions used;

2.) Verification of fire barrier envelope materials, dimensions, and installation techniques (procedures) used;

3.) Verification of general furnace construction/dimensions and locations of burner, thermocouples, et cetera;

4.) Verification of specimen thermocouple locations (along with copies of thermocouple material certifications);

5.) Verification of standards used for conducting fire test along with record of both furnace atmosphere and specimen temperature data acquired during test;

6.) Record of furnace pressure during fire test;

7.) Record of visual occurrences/observations of fire and hose stream tests;

8.) Record of hose stream test(s);

9.) Photographic records of specimen before fire barrier envelope installation, after fire barrier installation, and post fire/hose stream tests;

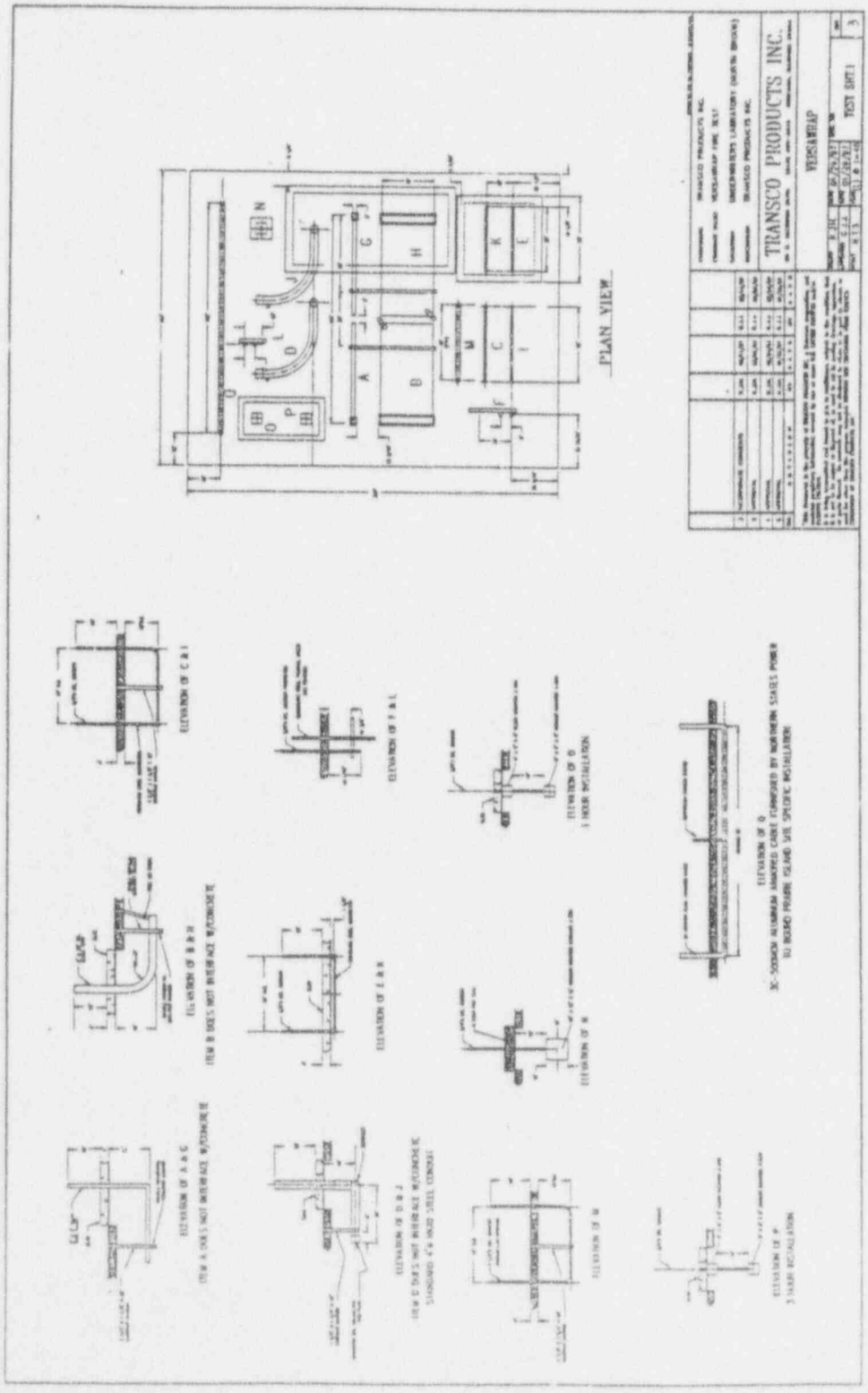
10.) Post test observations including measurements of material loss/degradation, et cetera;

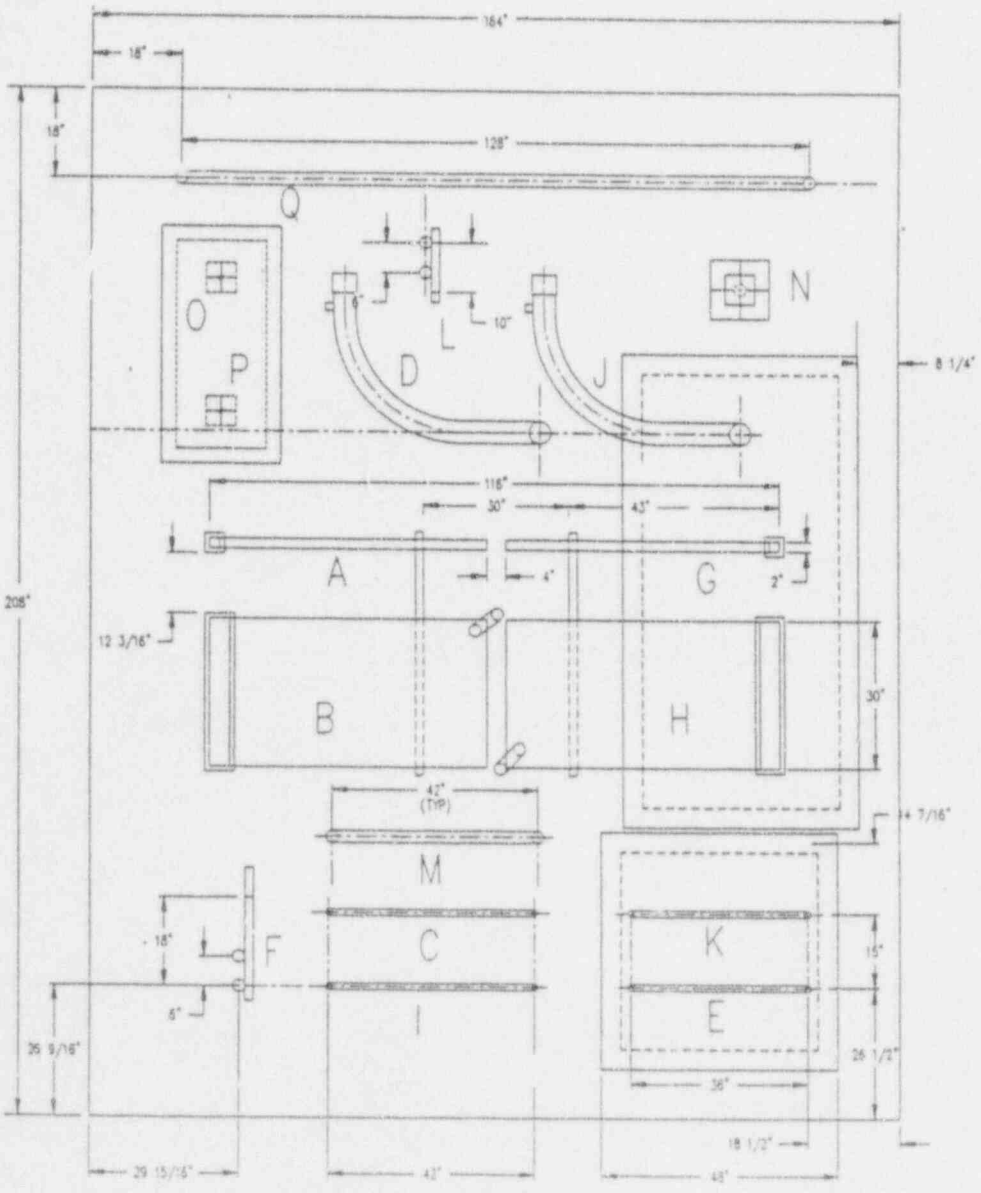
11.) Certification of the report by the agency performing test; and,

12.) QC records and notes from installation and test as an appendix to the report.

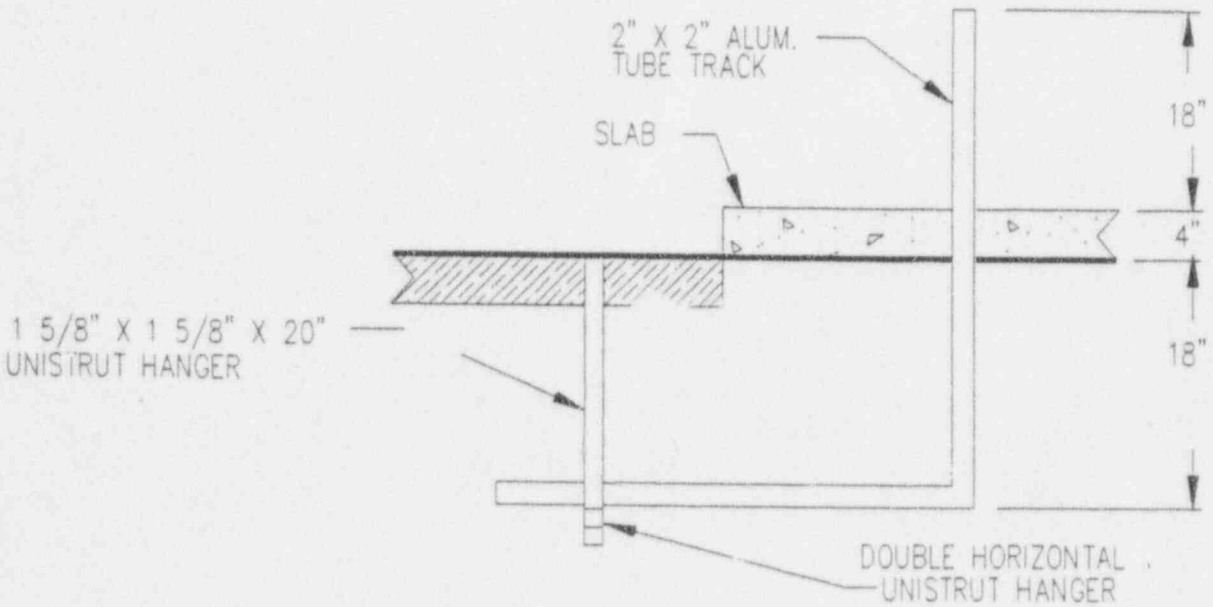
13.) Record of test items thermocouple temperature readings.

ALL TEST RECORDS, NOTES, CERTIFICATIONS, REQUIRED BY THIS TEST WILL BE LEGIBLE AND SUITABLE FOR REPRODUCTION.


PLAN VIEW
TRANSCO PRODUCTS INC.
VERSAWRAP
TEST SPEC 1

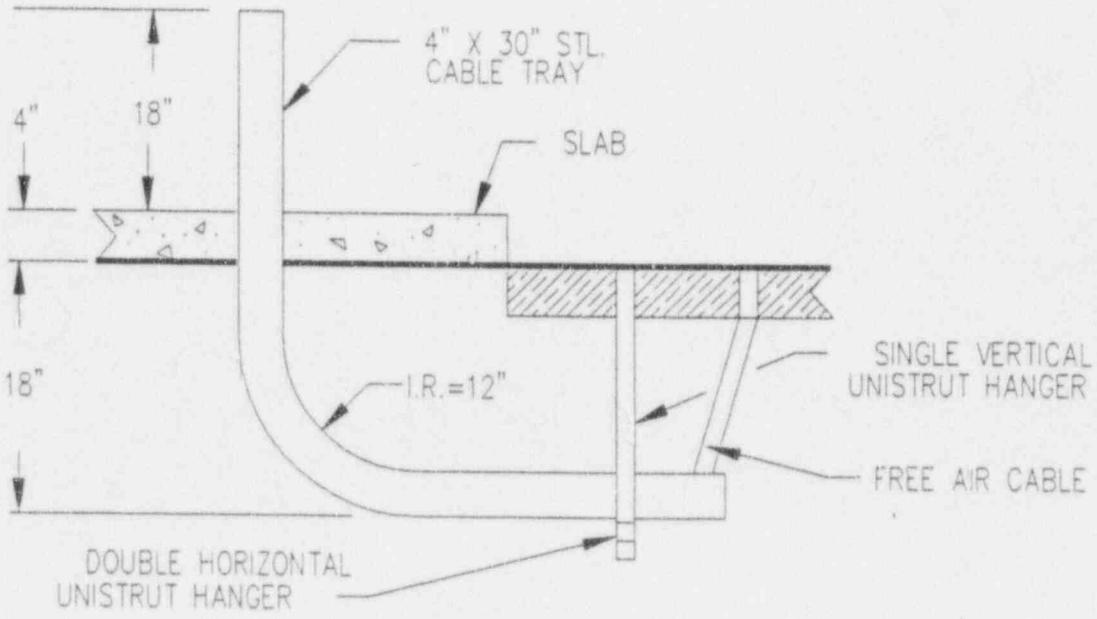

164"
18"
18"
128"
Q
O
P
L
10"
D
J
N
8 1/4"
118"
30"
43"
A
4"
G
2"
208"
12 3/16"
B
H
30"
42"
(TYP)
14 7/16"
M
C
K
18"
F
6"
I
E
15"
35 9/16"
26 1/2"
36"
18 1/2"
29 15/16"
42"
48"

PLAN VIEW



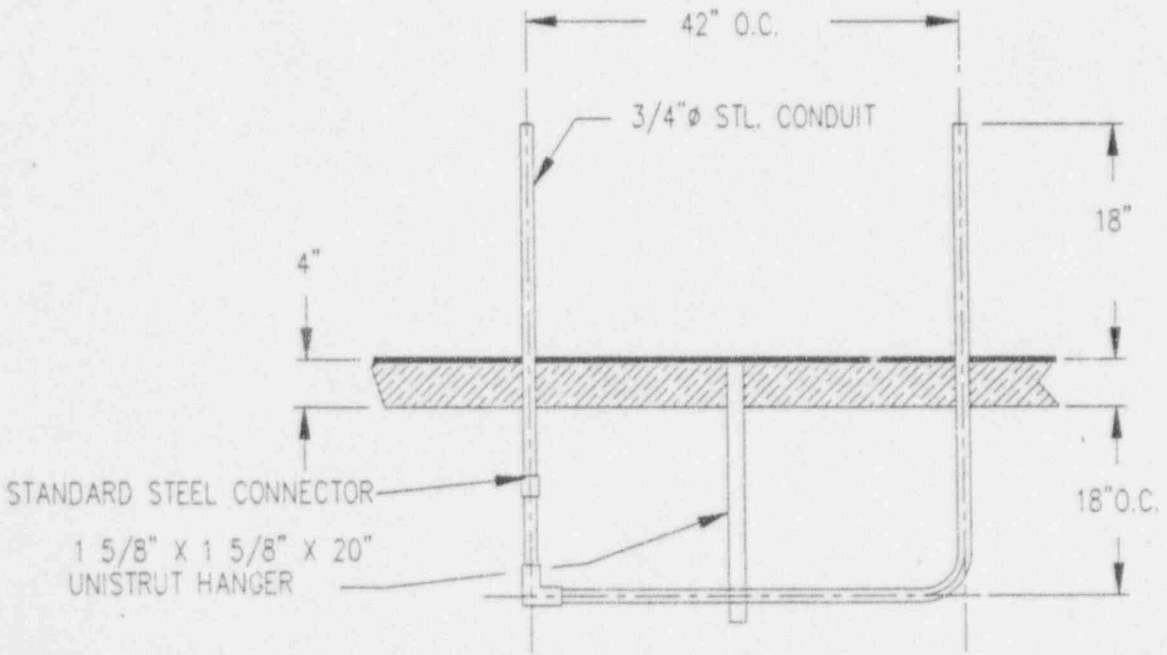
ELEVATION OF A & G

ITEM A DOES NOT INTERFACE W/CONCRETE

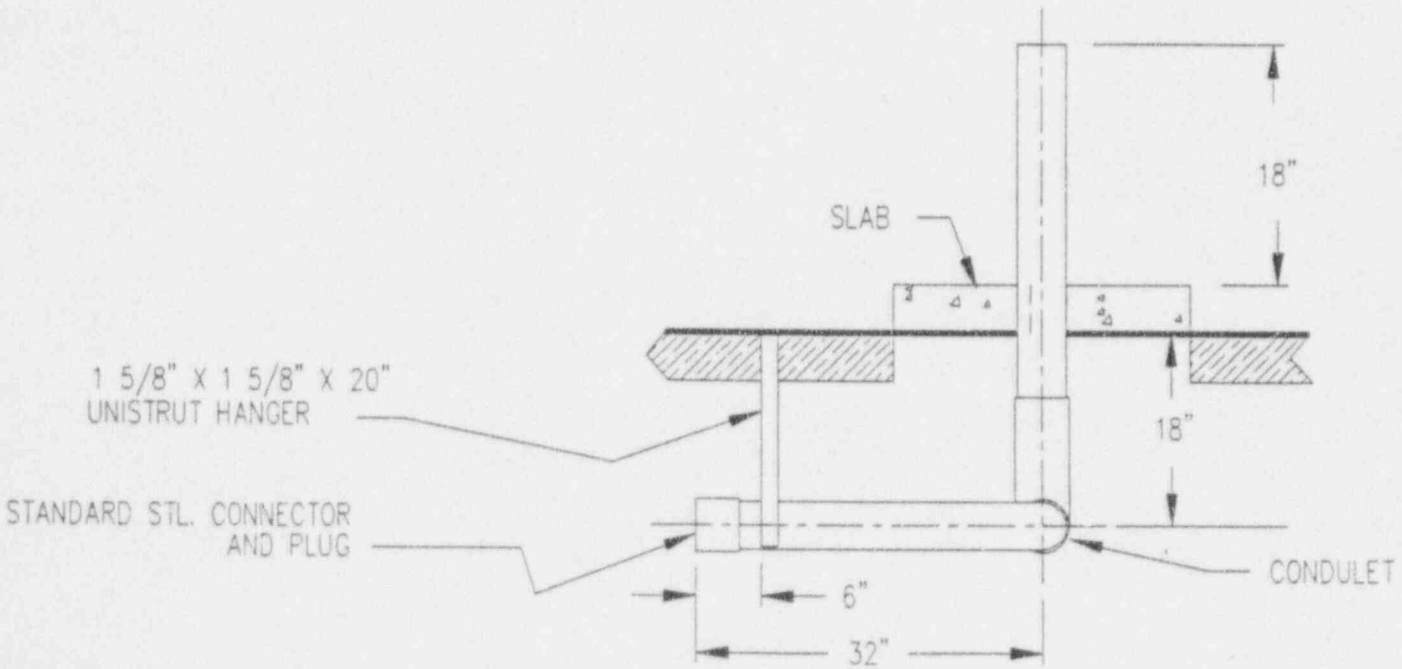


ELEVATION OF B & H

ITEM B DOES NOT INTERFACE W/CONCRETE



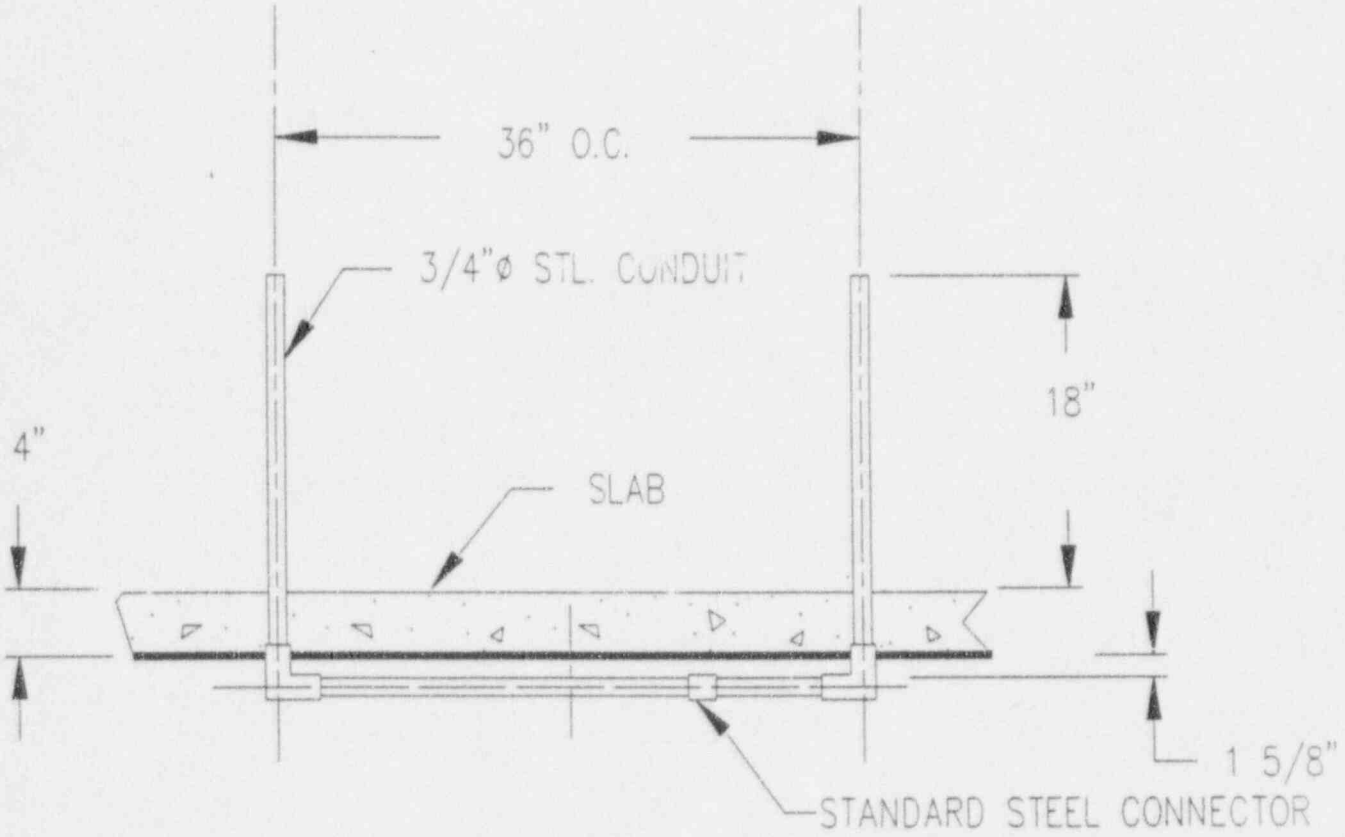
ELEVATION OF C & I



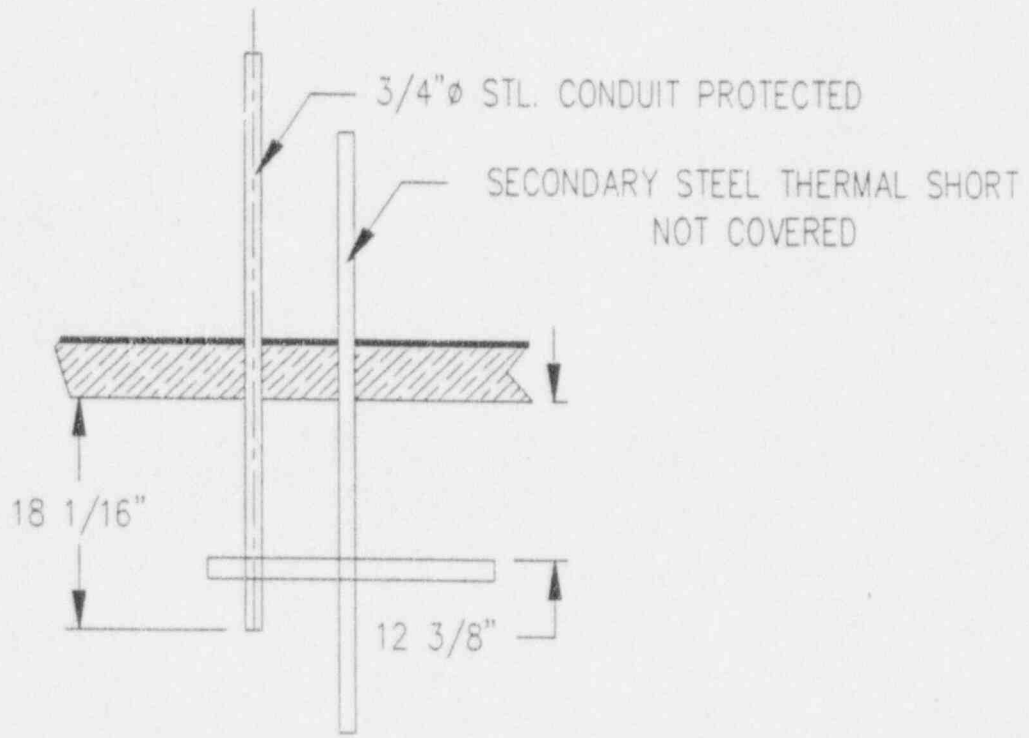
ELEVATION OF D & J

ITEM D DOES NOT INTERFACE W/CONCRETE

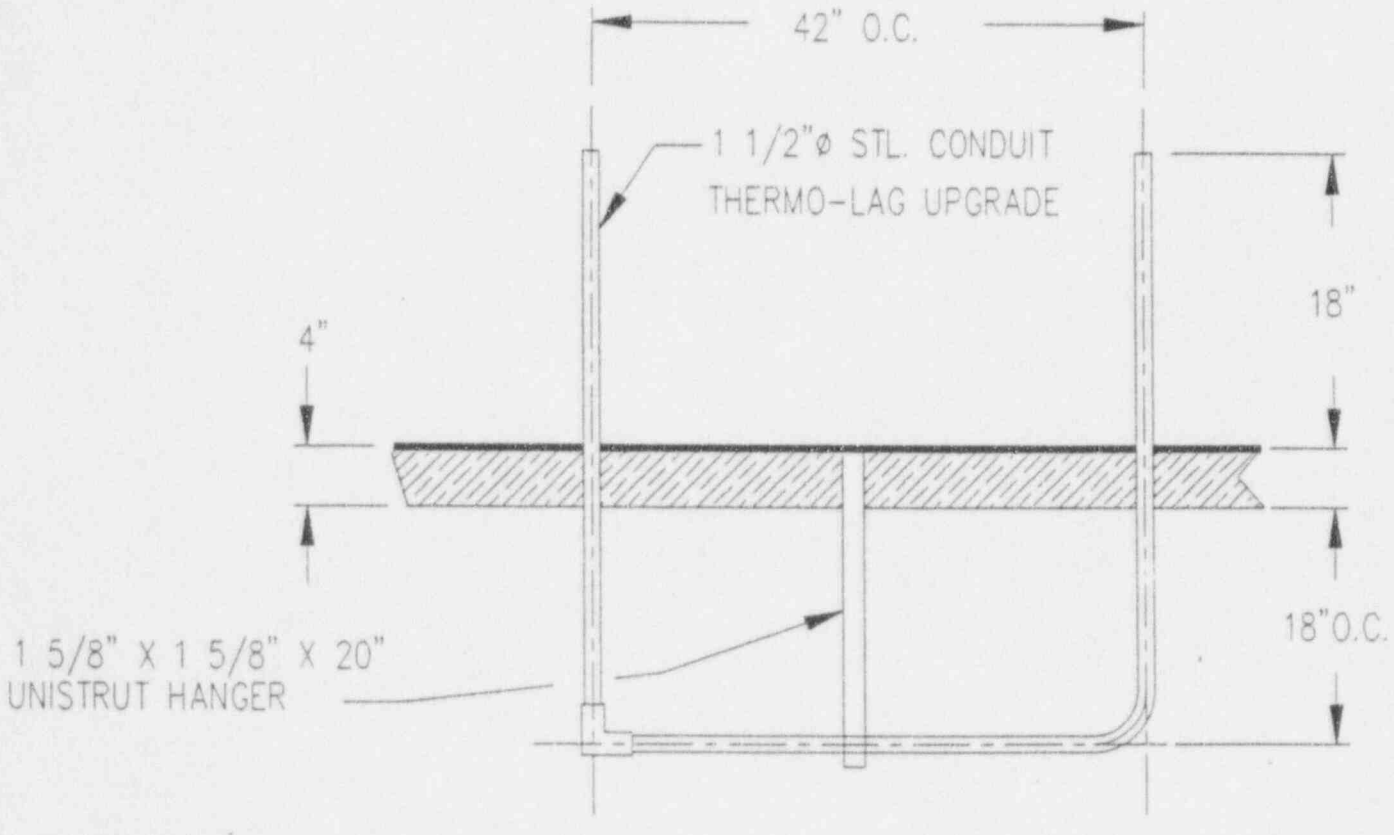
STANDARD 4"ø RIGID STEEL CONDUIT



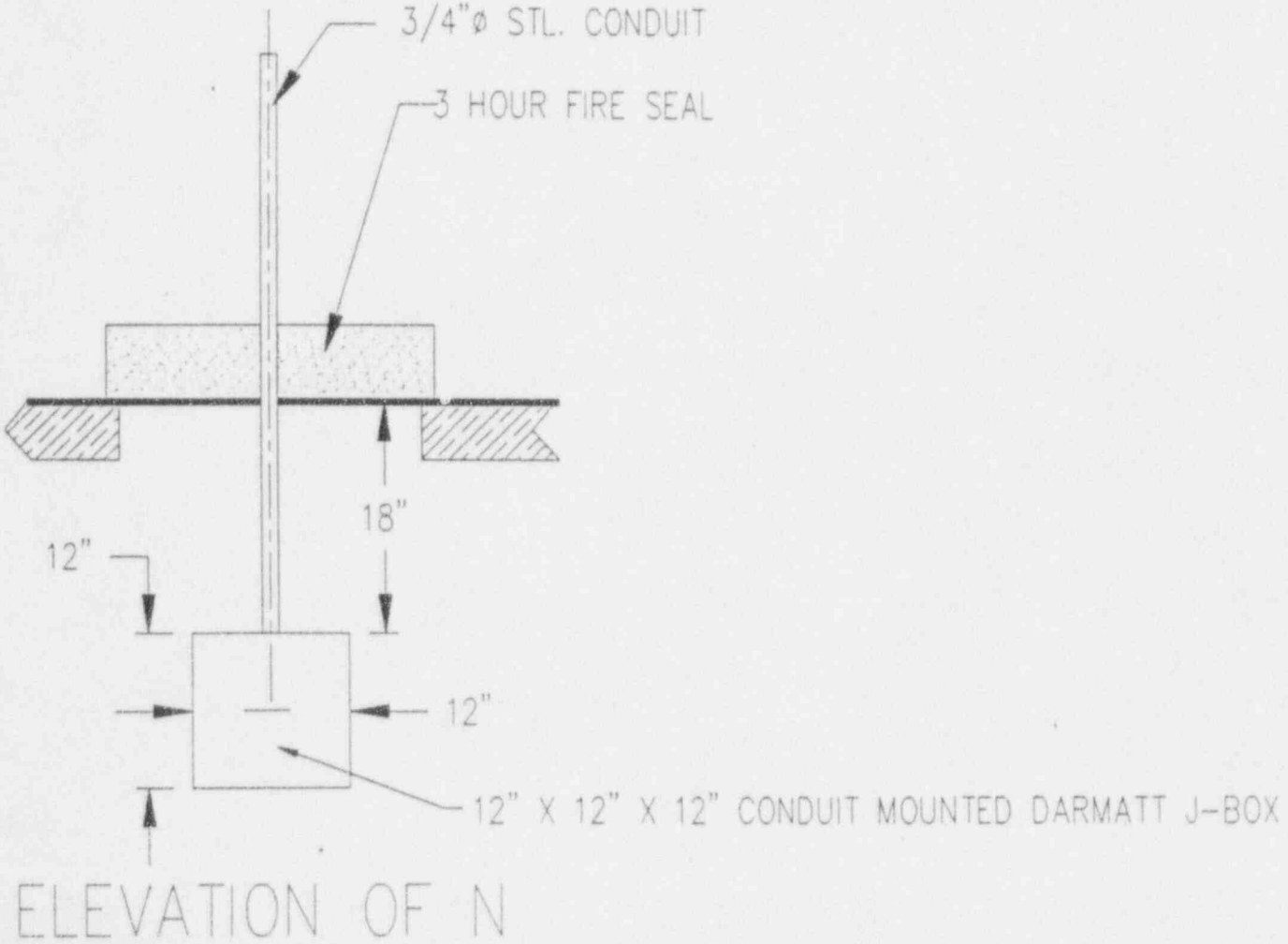
ELEVATION OF E & K



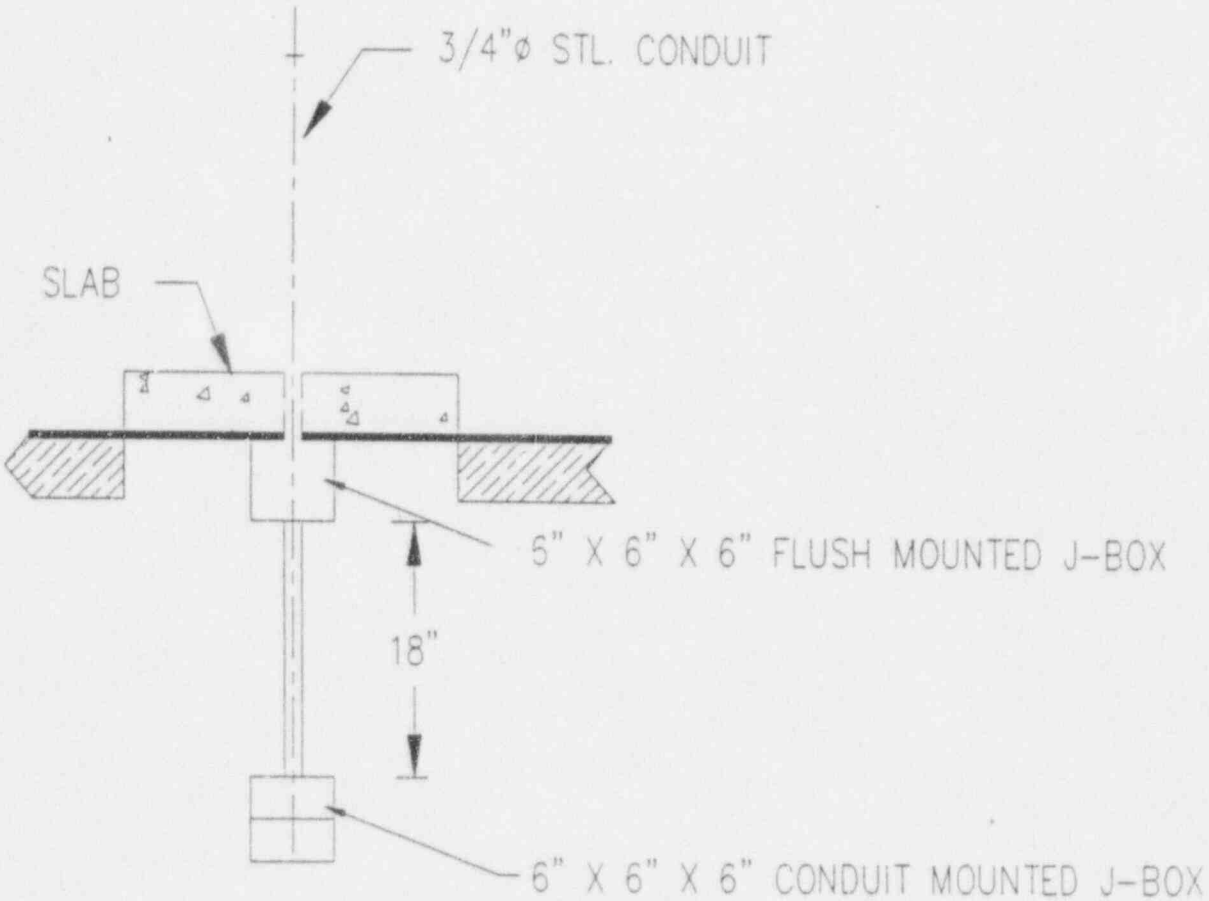
ELEVATION OF F & L



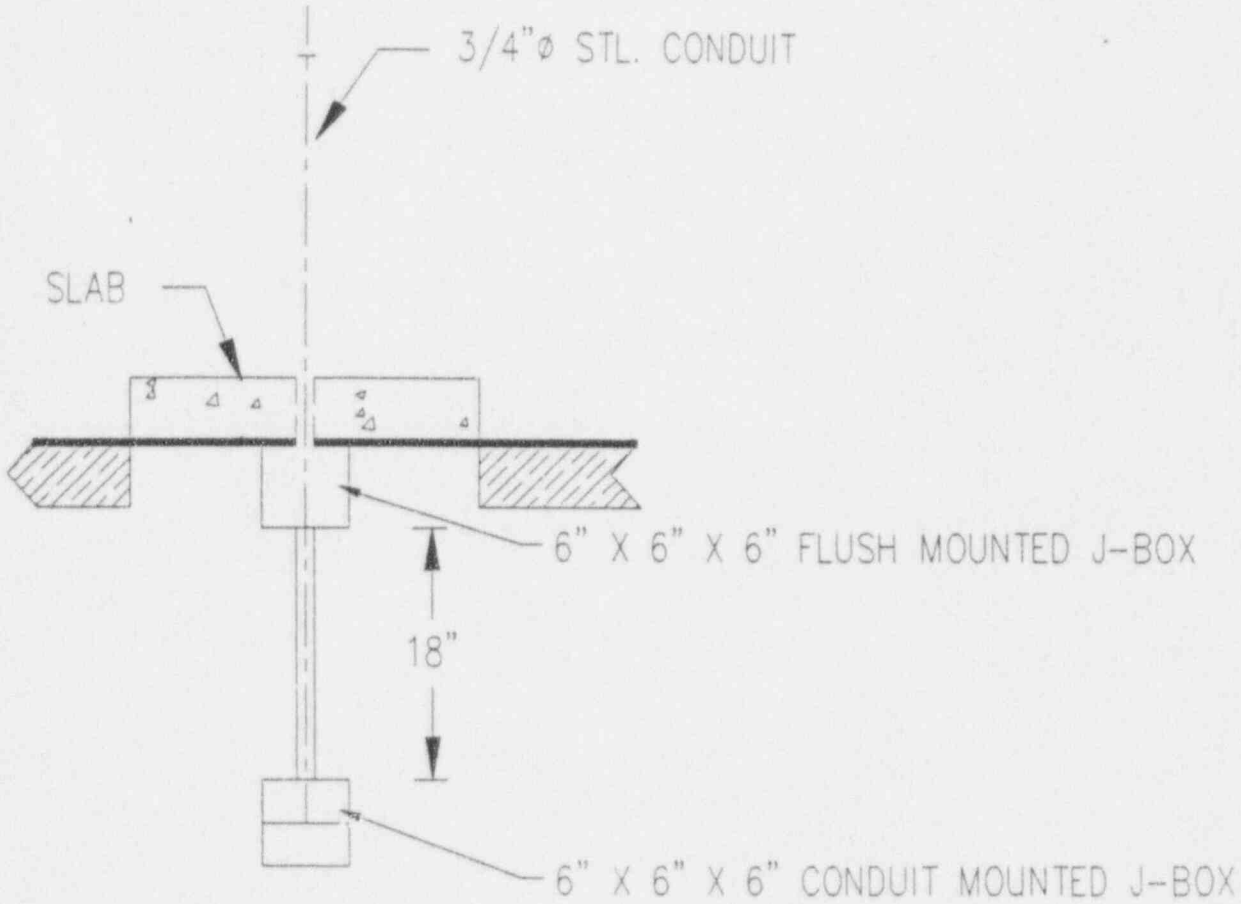
ELEVATION OF M



ELEVATION OF N

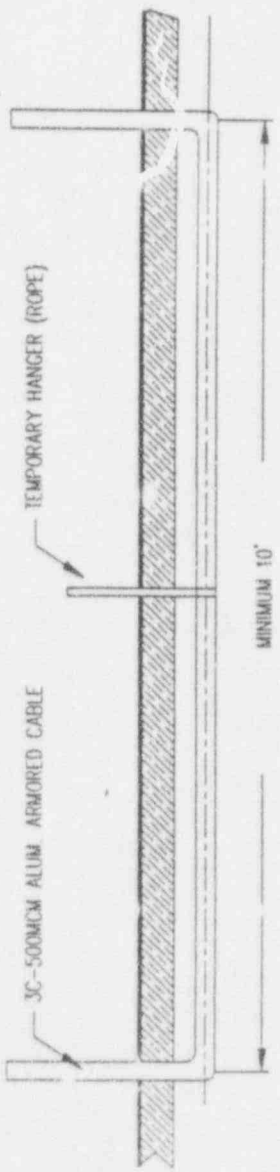


ELEVATION OF O
1 HOUR INSTALLATION



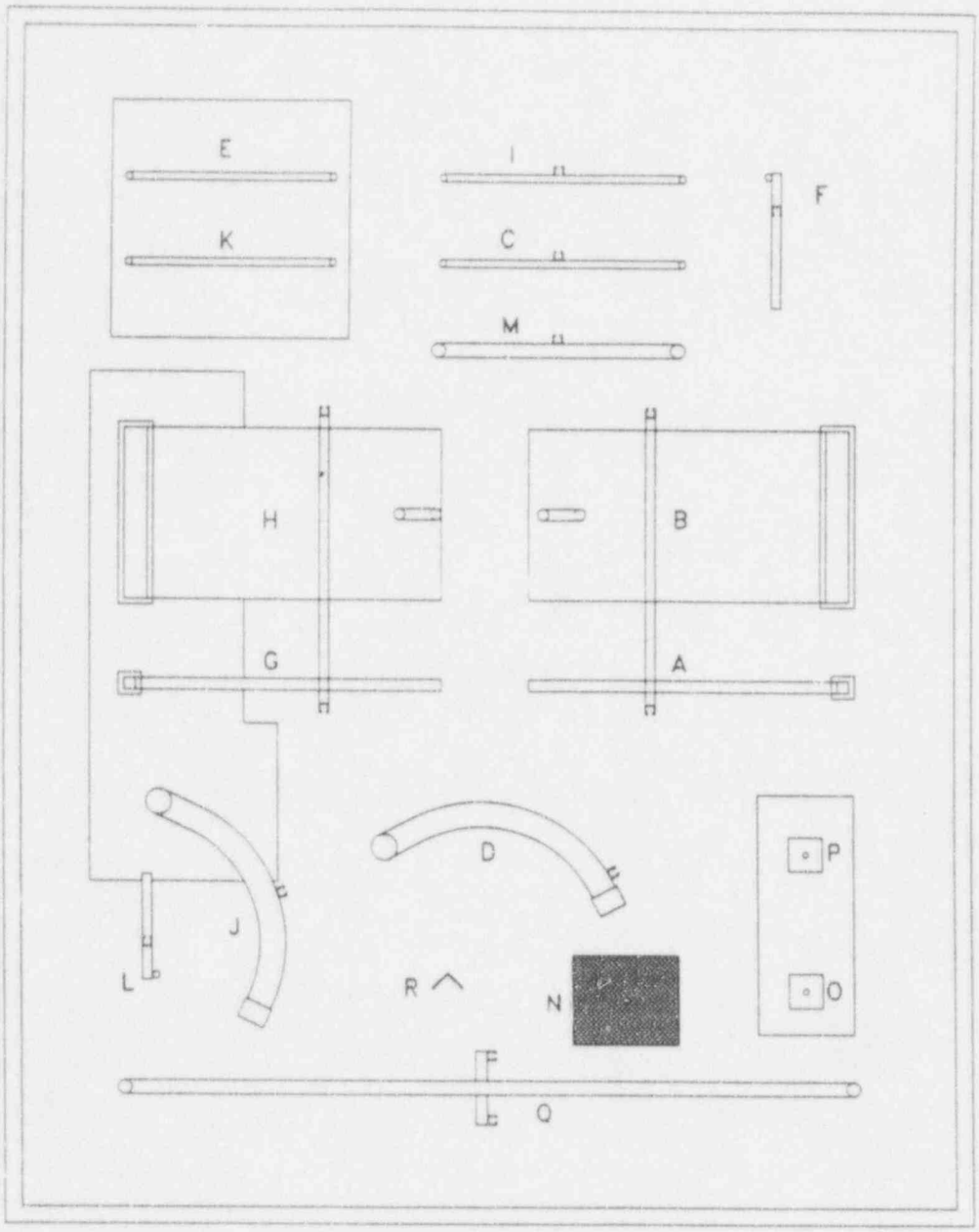
ELEVATION OF P

3 HOUR INSTALLATION



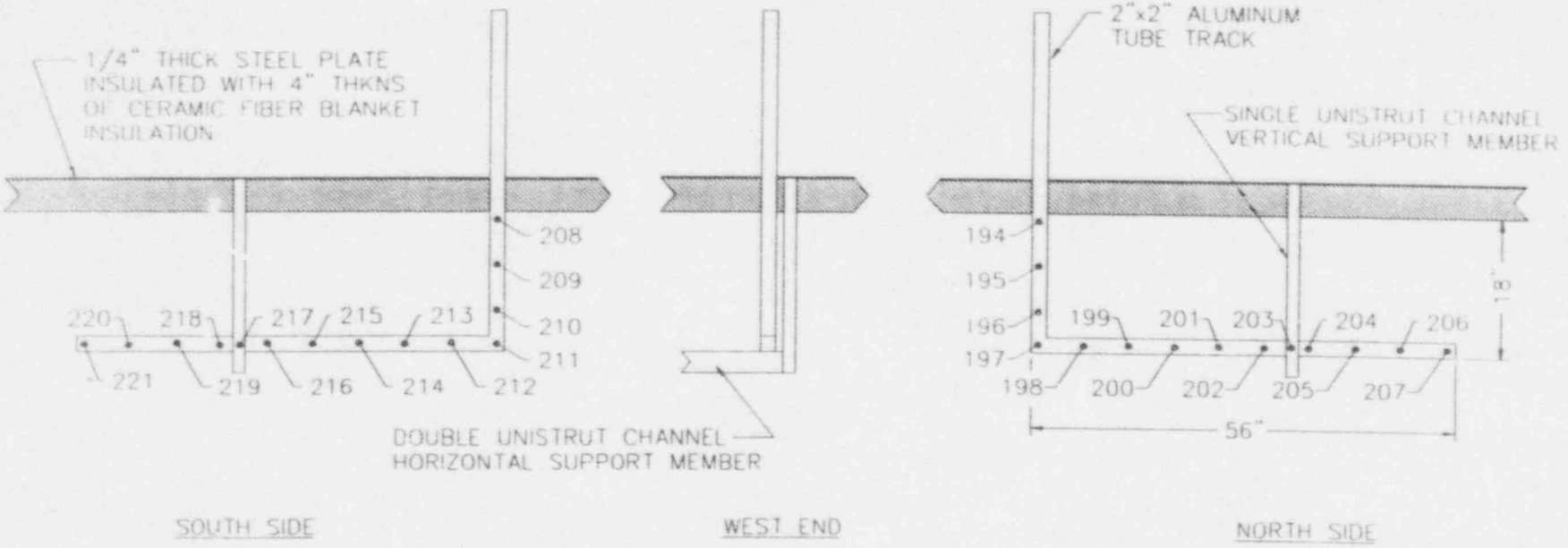
ELEVATION OF Q
3C-500MCM ALUMINUM ARMORED CABLE FURNISHED BY NORTHERN STATES POWER
TO BOUND PRAIRIE ISLAND SITE SPECIFIC INSTALLATION

NORTH



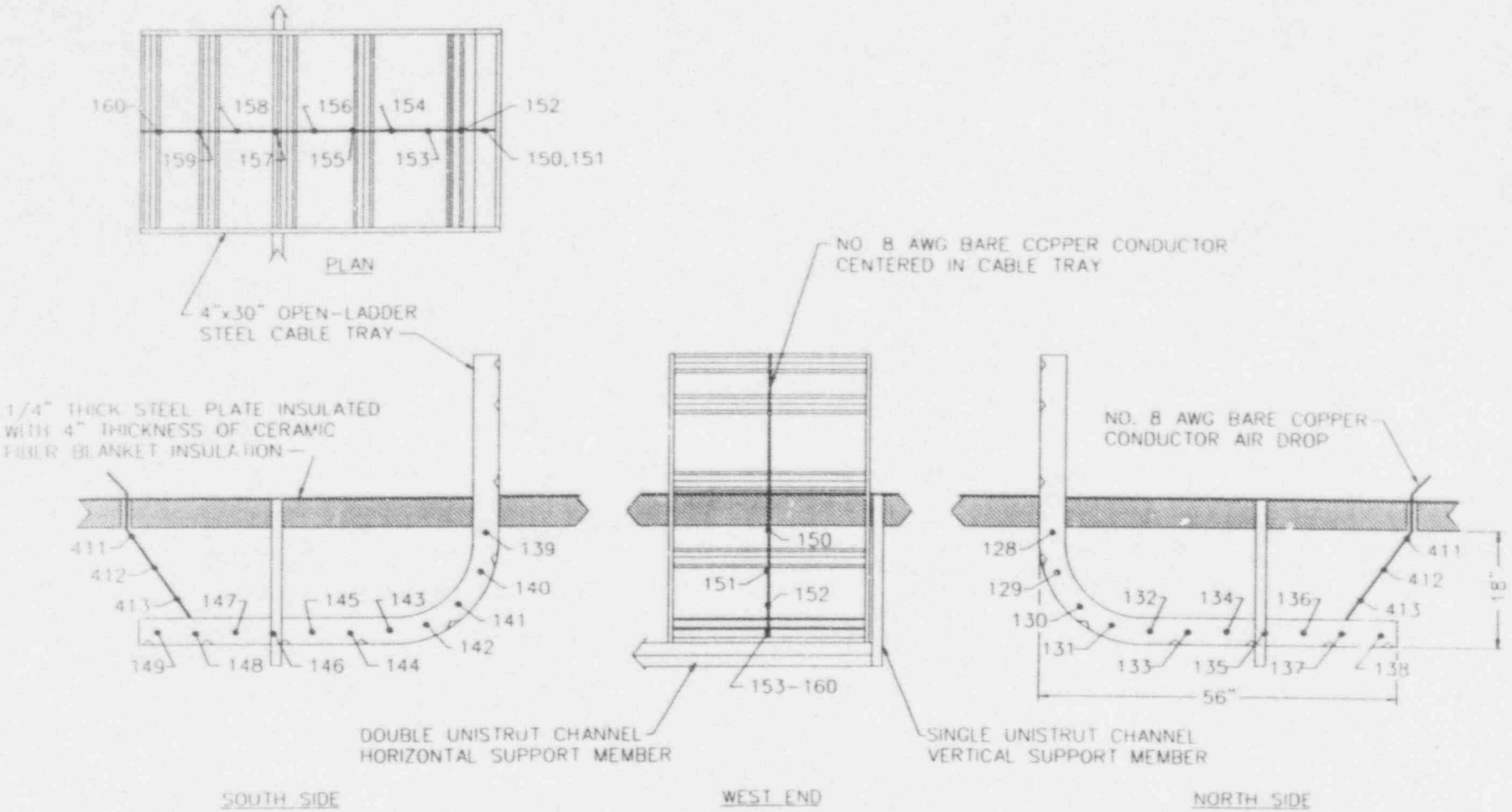
ARTICLE	TC NOS.	ARTICLE	TC NOS
A	194-234	J	324-349 & 426
B	128-160 & 411-413	K	112-127
C	39-67	L	377-384 & 427
D	350-376	M	68-95
E	96-111	N	407-410 & 417-420
F	1-8 & 428	O	299-323
G	235-273	P	274-298
H	161-193 & 414-416	Q	429-438
I	9-38	R	385-406

TEST ARTICLE LAYOUT &
THERMOCOUPLE LOCATIONS

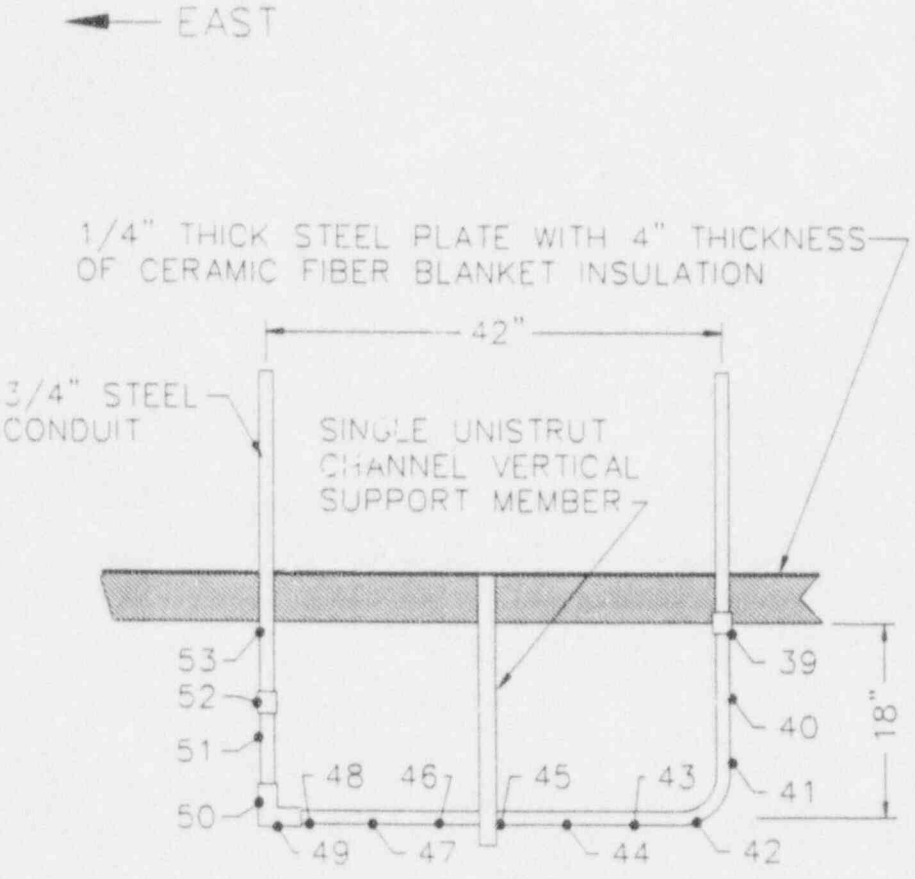


TC NOS. 222-234 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 222 COINCIDES WITH TC NOS. 194 AND 208 ON TUBE TRACK.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE A

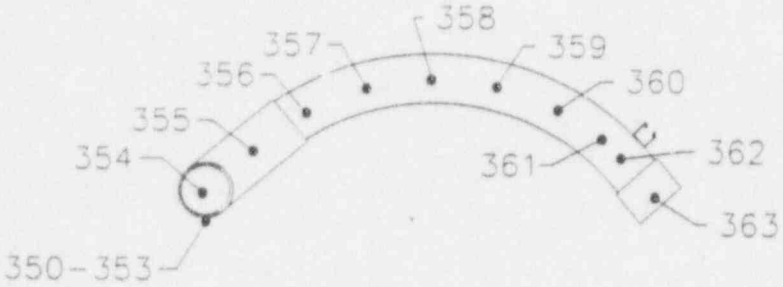


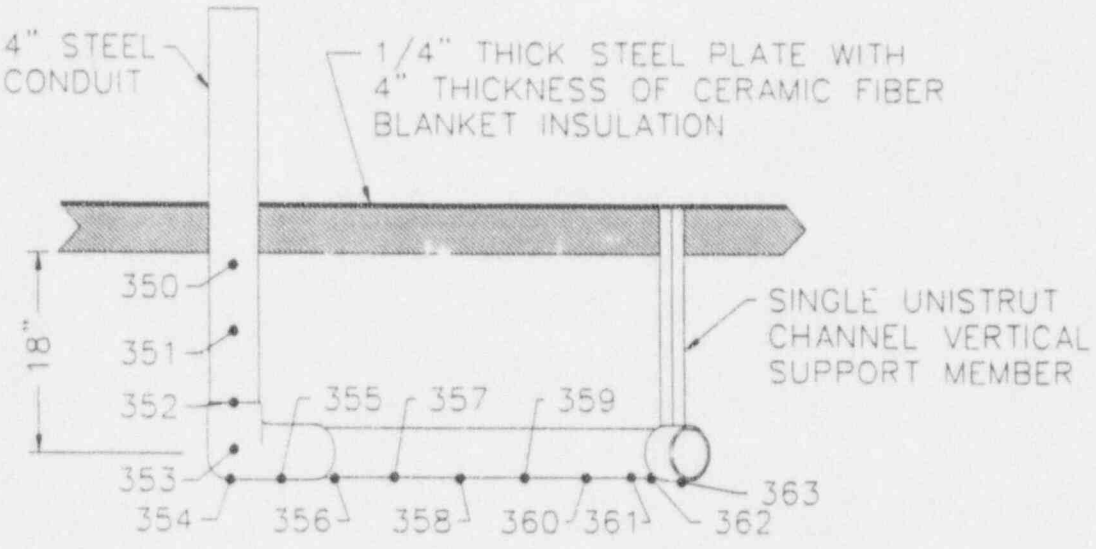
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE B



TC NOS. 54–67 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 54 COINCIDES WITH TC NO. 39.

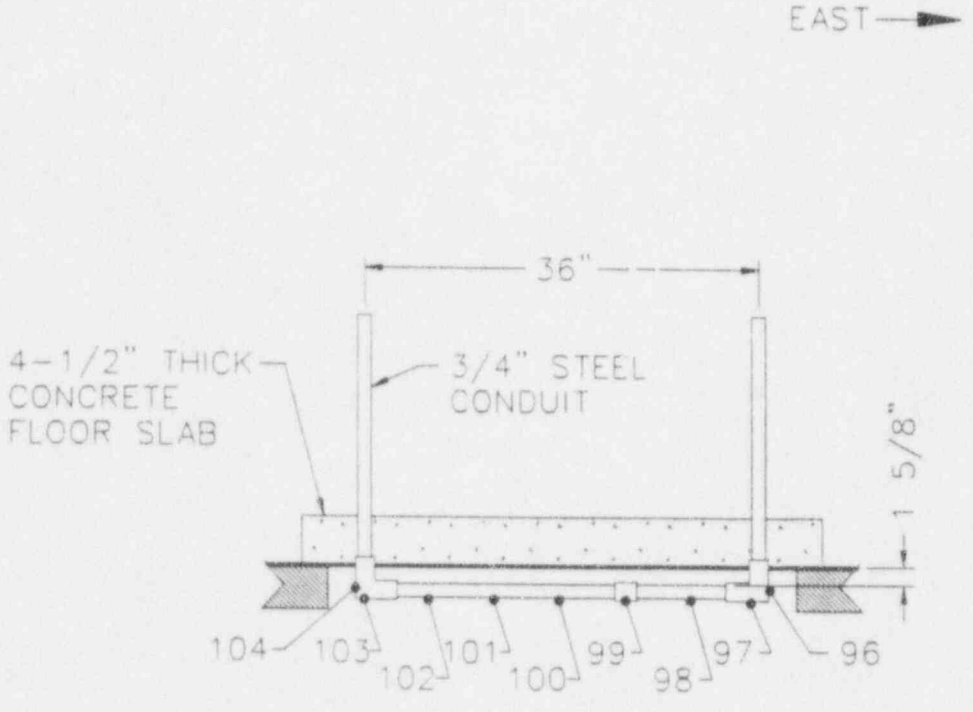
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE C





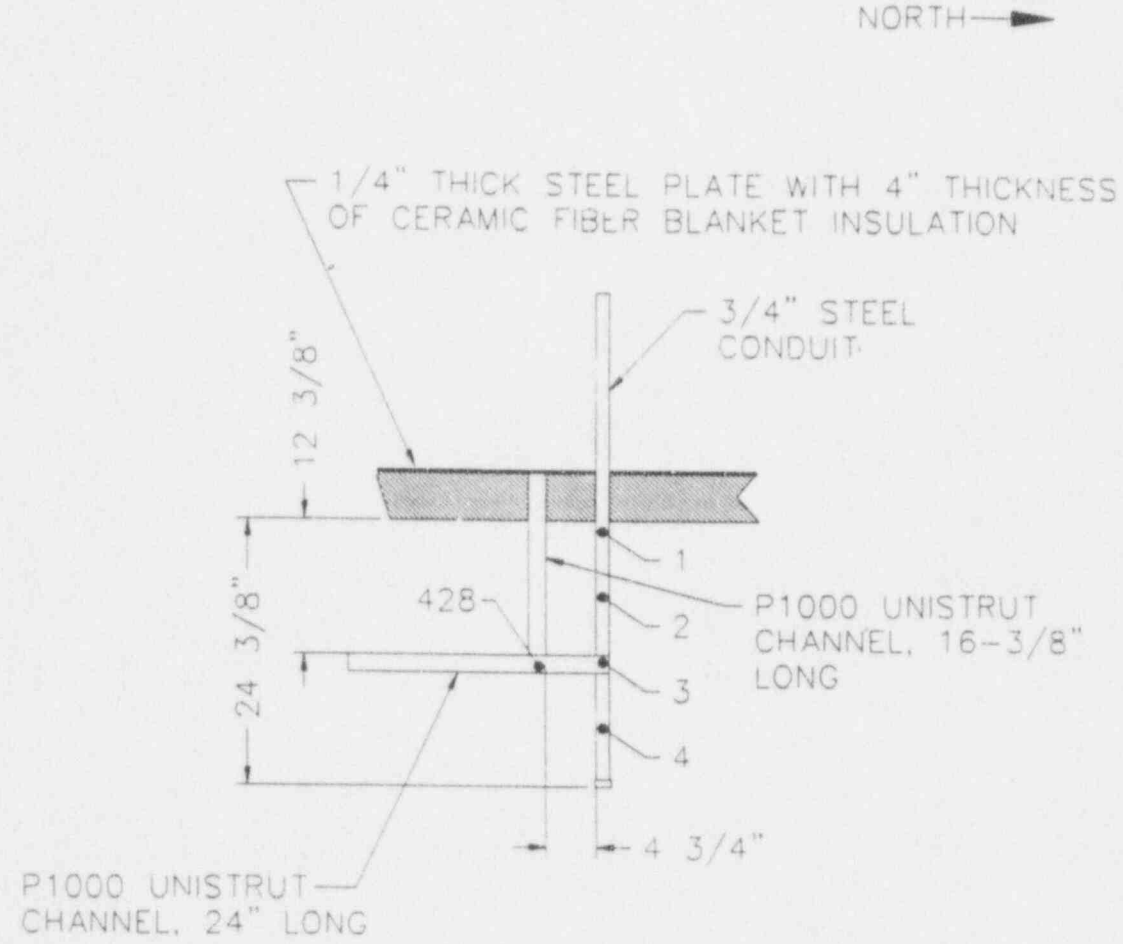
TC NOS. 364-376 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE D



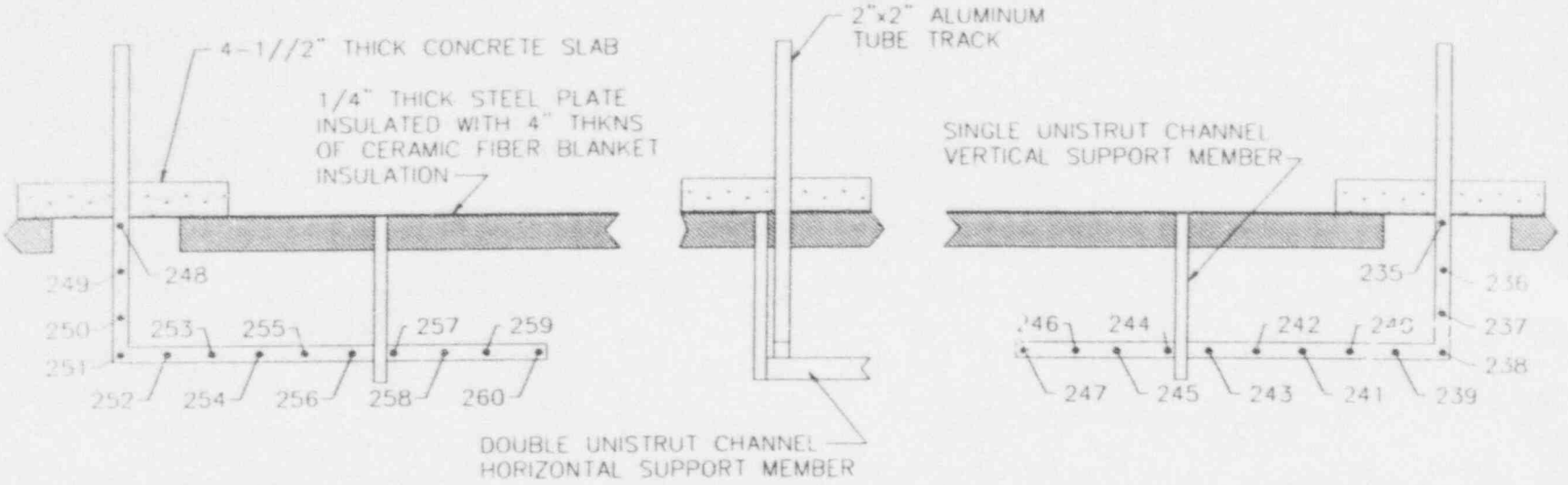
TC NOS. 105-111 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 105 COINCIDES WITH TC NO. 96.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE E



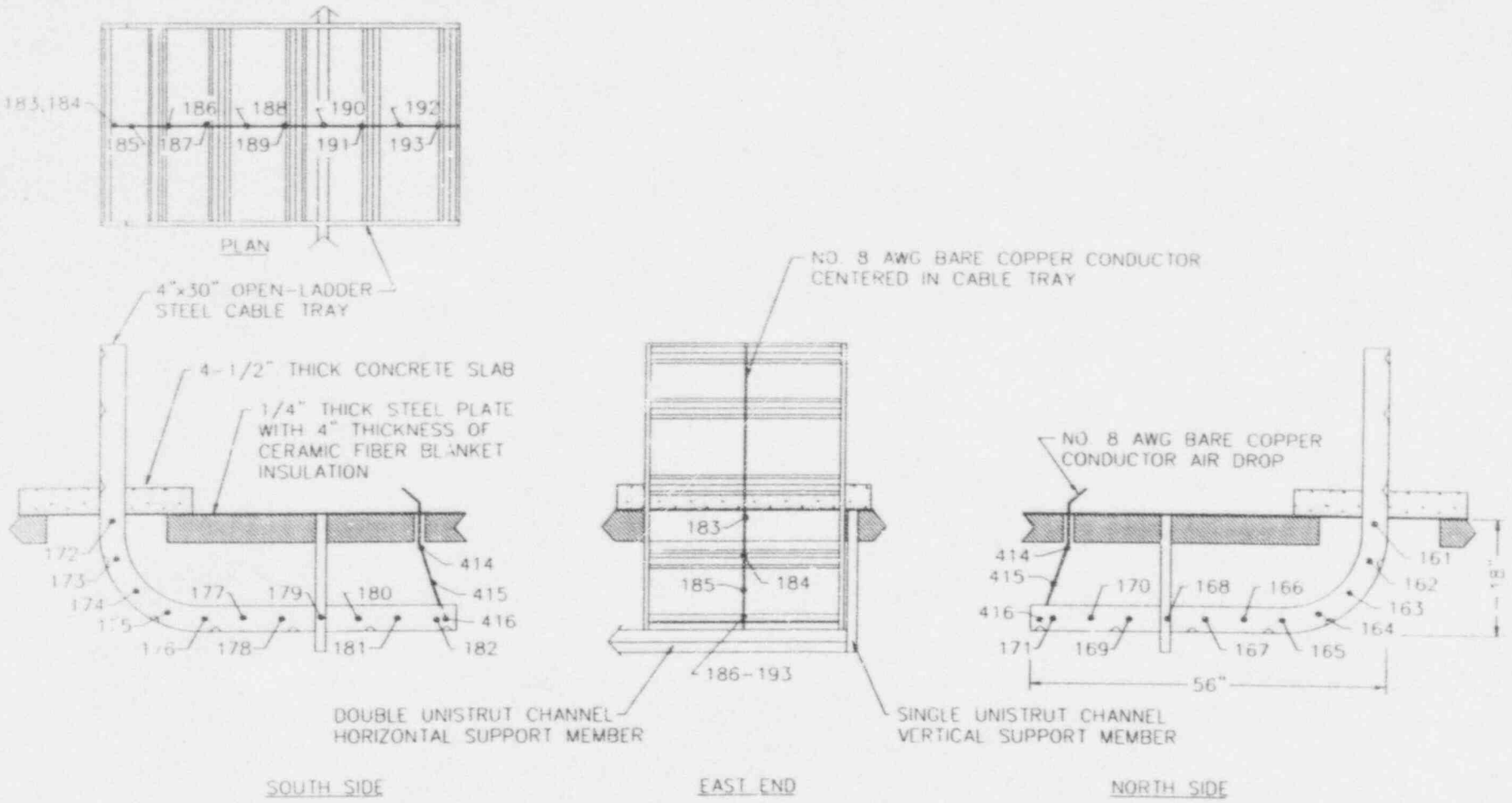
TC NOS. 1-4 ON WEST SIDE OF CONDUIT.
TC NOS. 5-8 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 5 COINCIDES WITH TC NO. 1.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE F

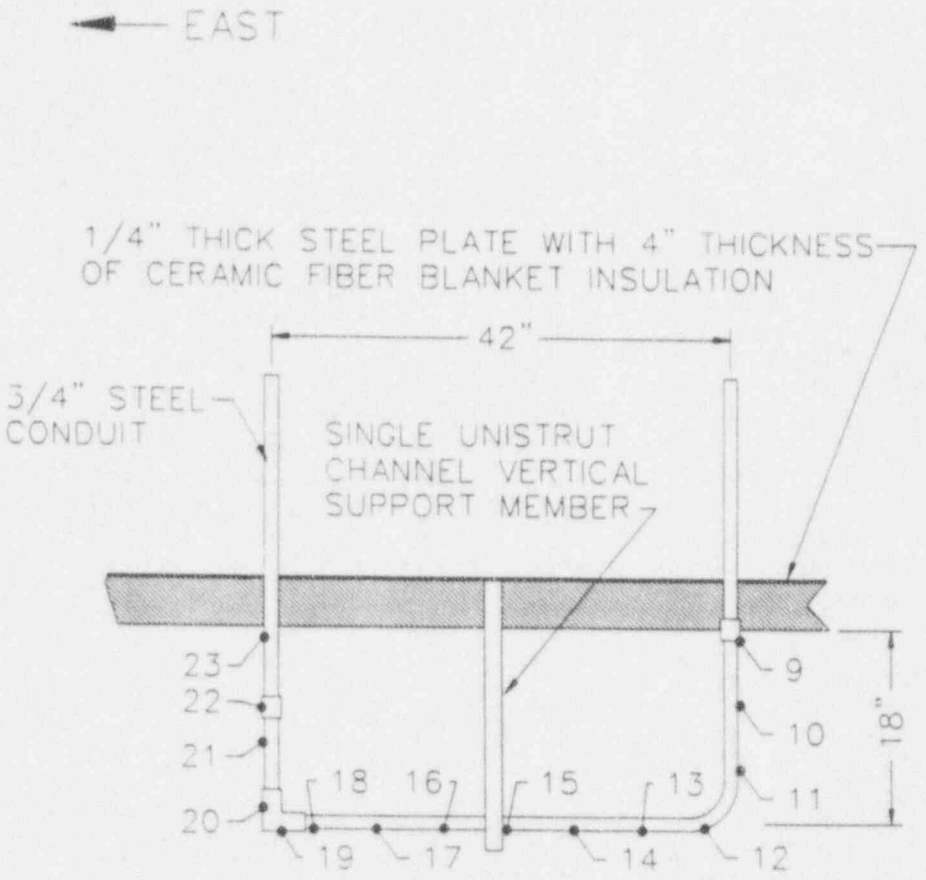


TC NOS. 261-273 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 261 COINCIDES WITH TC NOS. 235 AND 248 ON TUBE TRACK

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE G

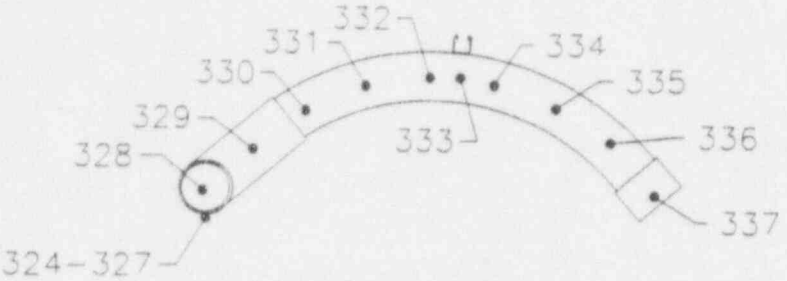


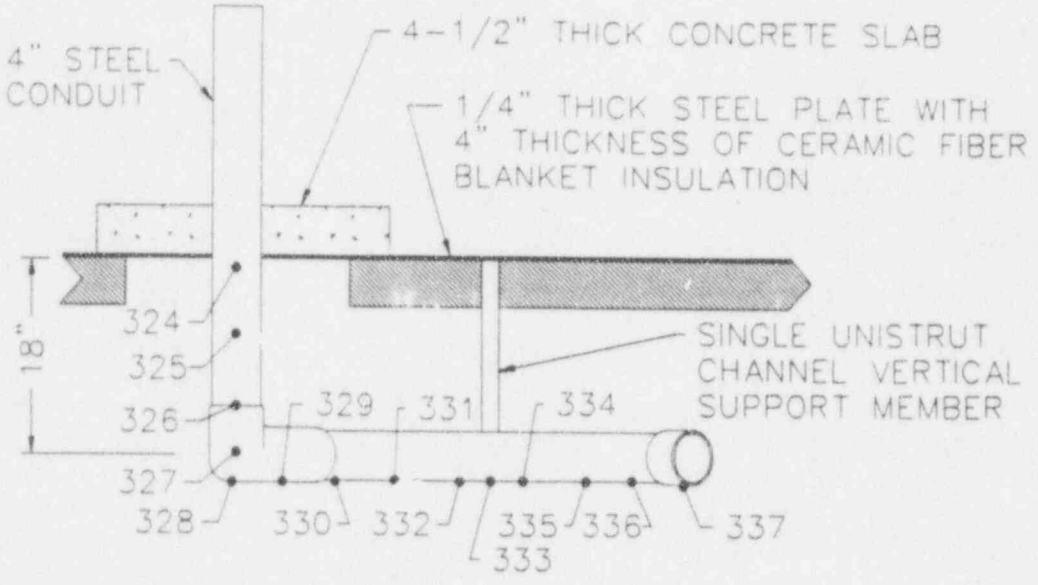
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE H



TC NOS. 25–38 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 25 COINCIDES WITH TC NO. 9.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE I

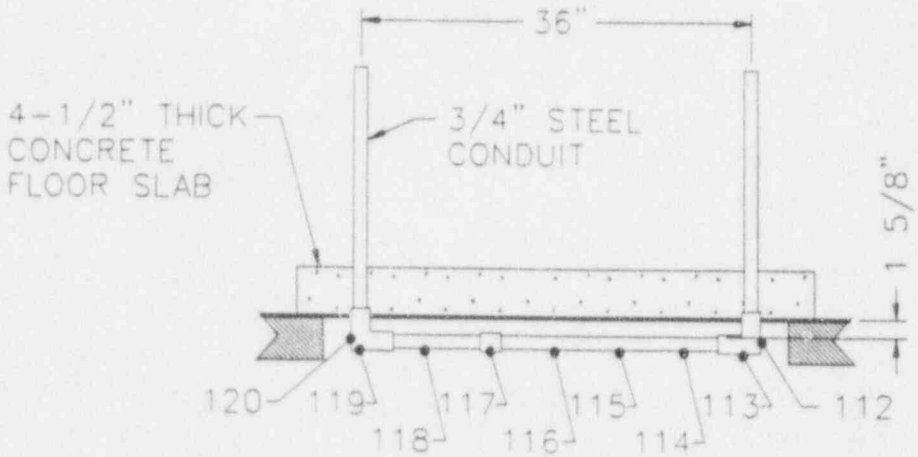




TC NOS. 338-349 & 426 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350. TC NO. 426 COINCIDES WITH TC NO. 337.

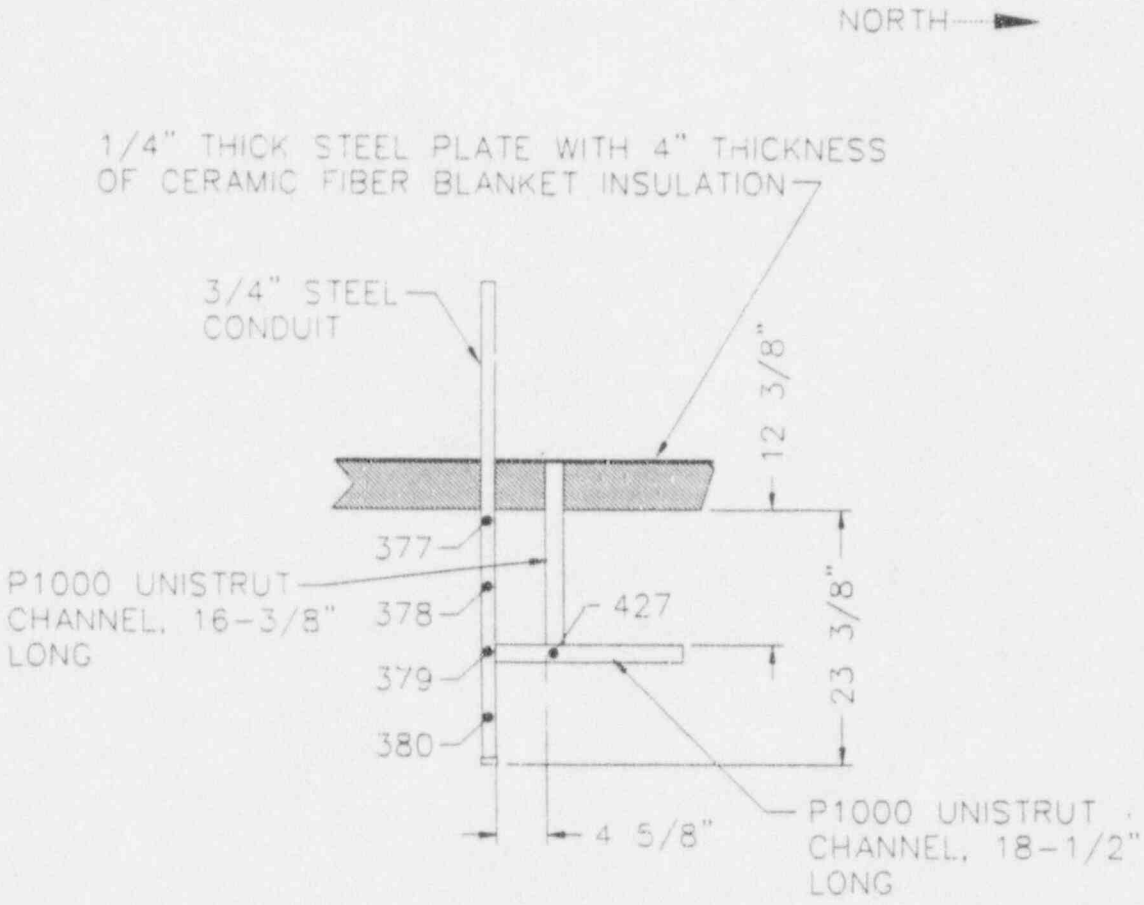
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS-ARTICLE J

EAST →



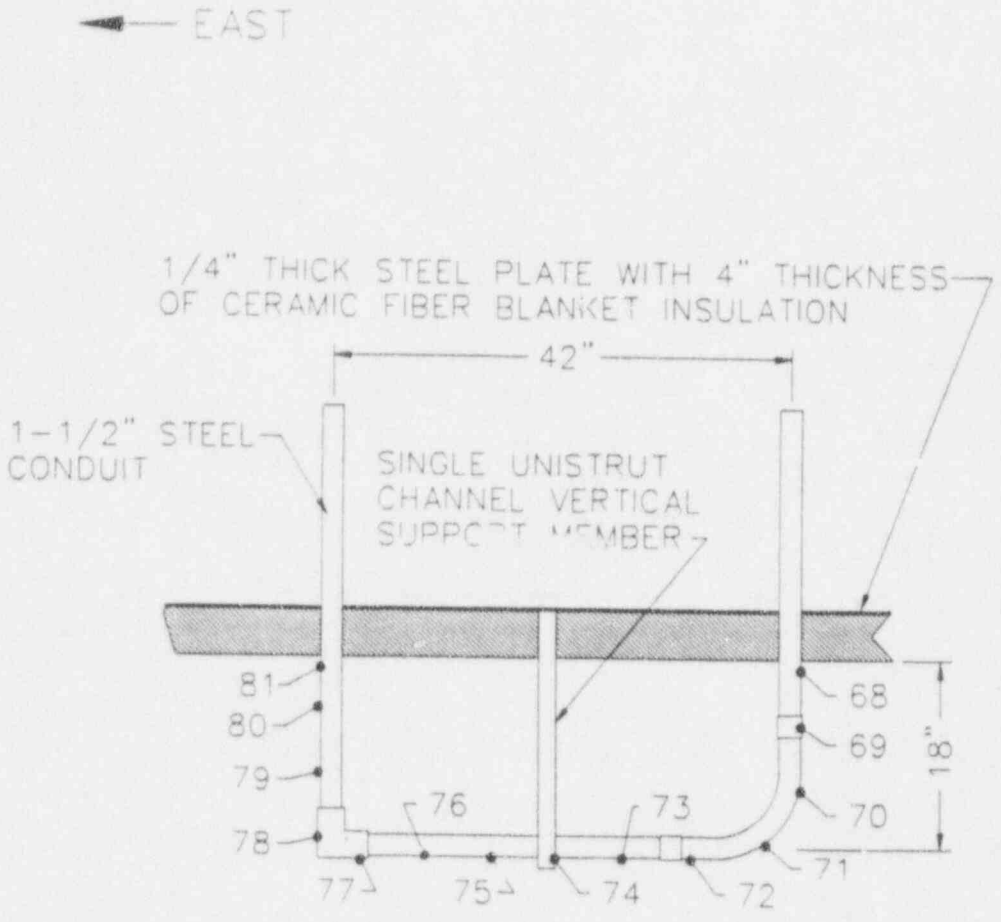
TC NOS. 121-127 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 121COINCIDES WITH TC NO. 112.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE K



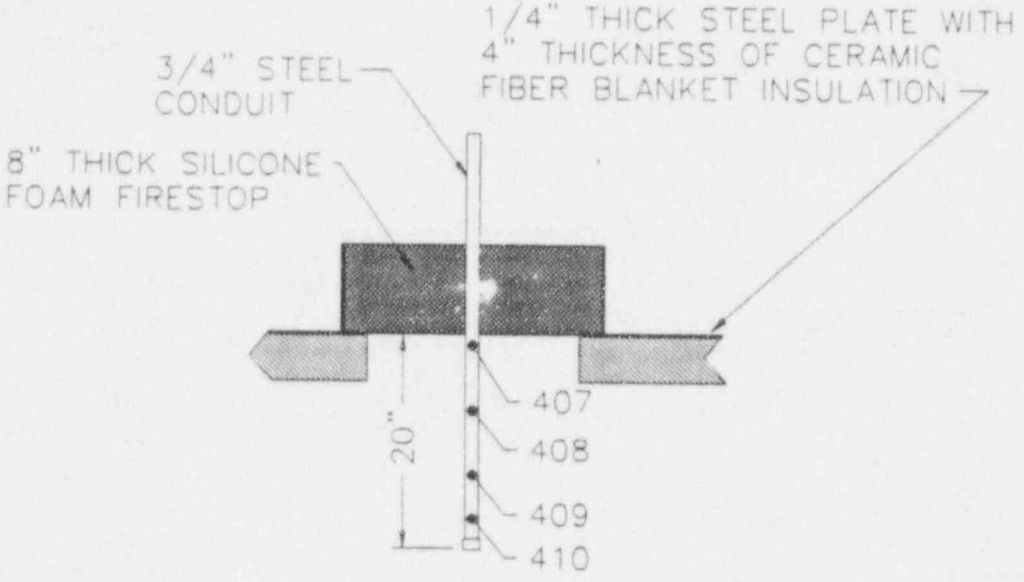
TC NOS. 377-380 ON EAST SIDE OF CONDUIT.
TC NOS. 381-384 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 381 COINCIDES WITH TC NO. 377.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE L



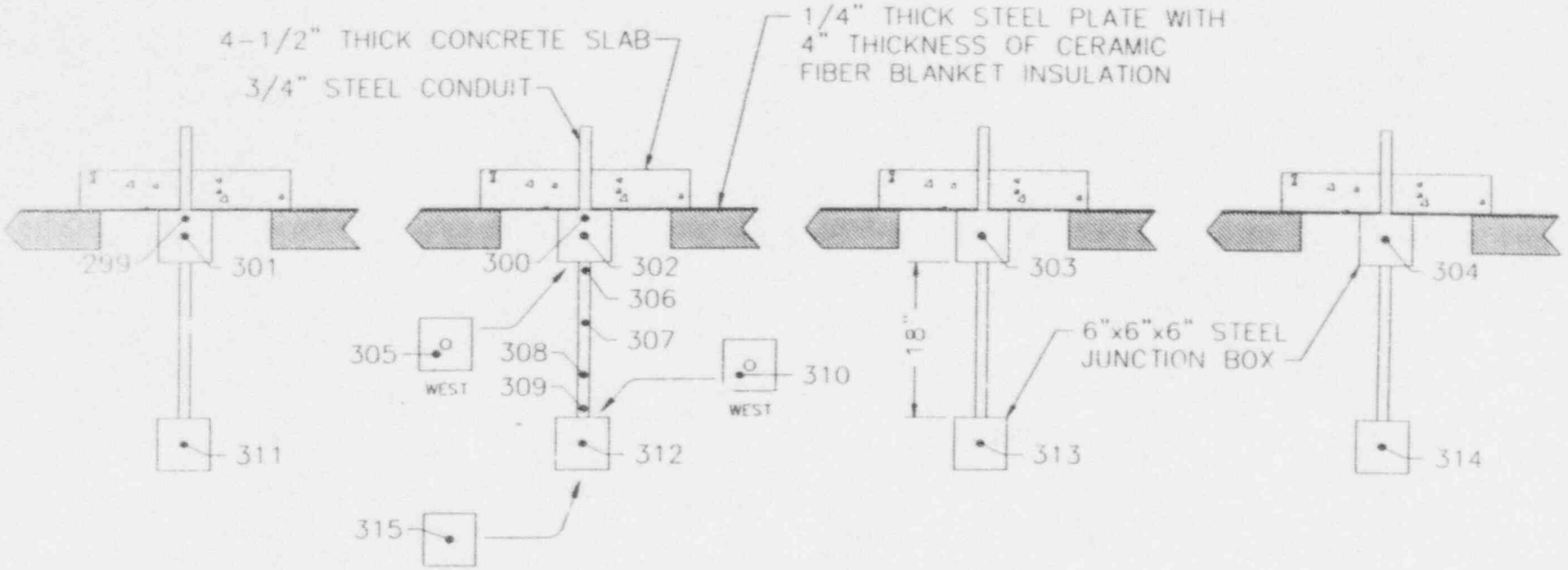
TC NOS. 82-95 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 82 COINCIDES WITH TC NO. 68.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE M



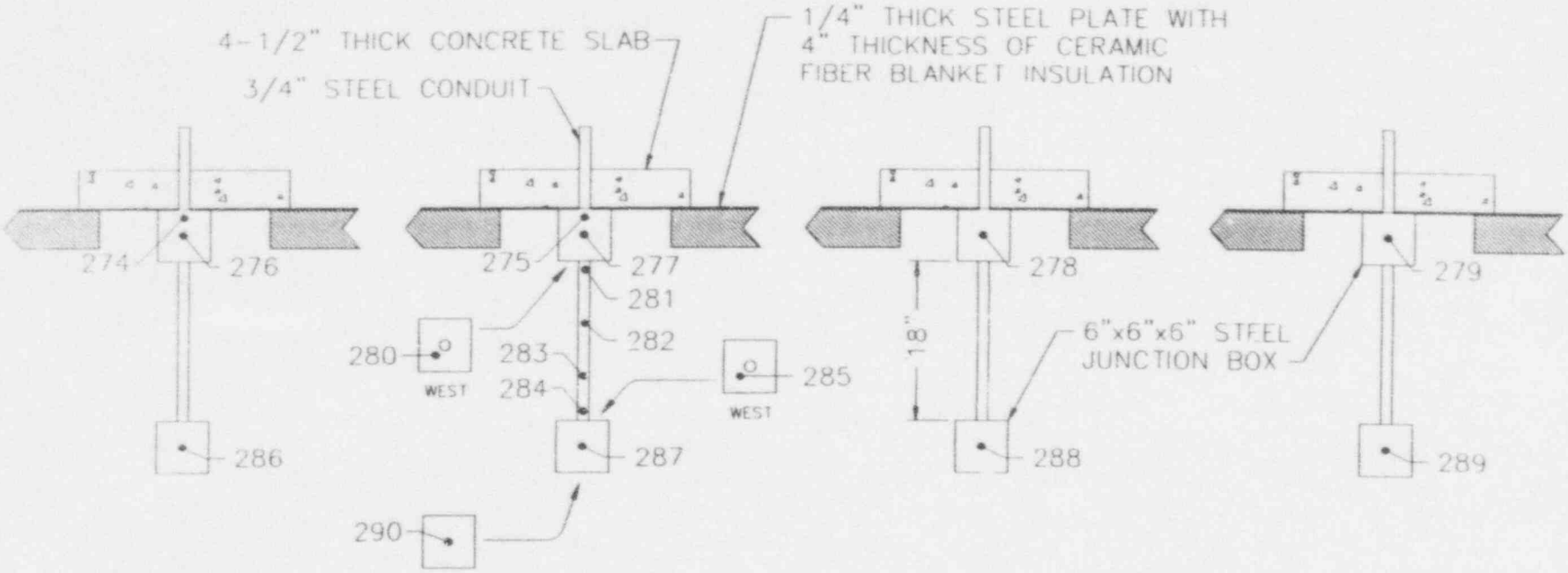
TC NOS. 417–420 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 417 COINCIDES WITH TC NO. 407.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE N



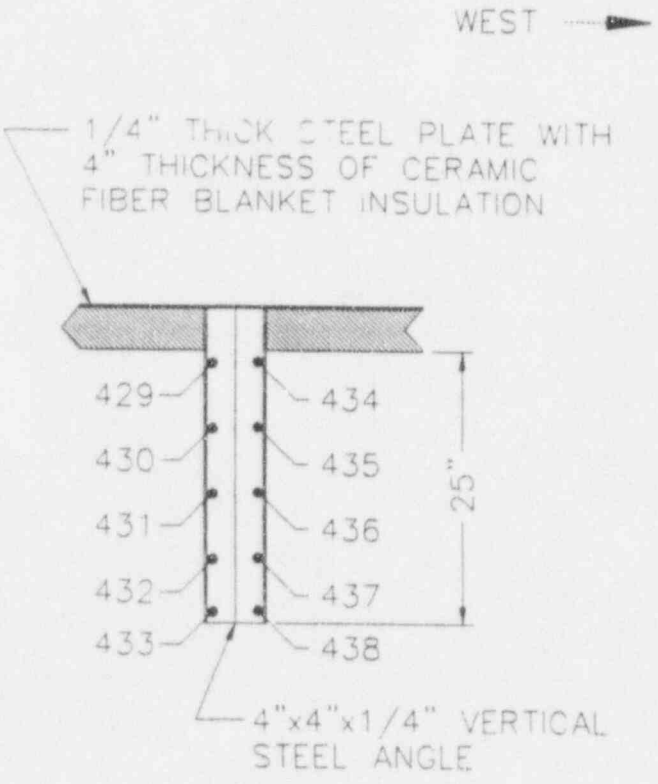
TC NOS. 316-323 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 316 COINCIDES WITH TC NOS. 299 & 300. TC NOS. 321-323 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE 0

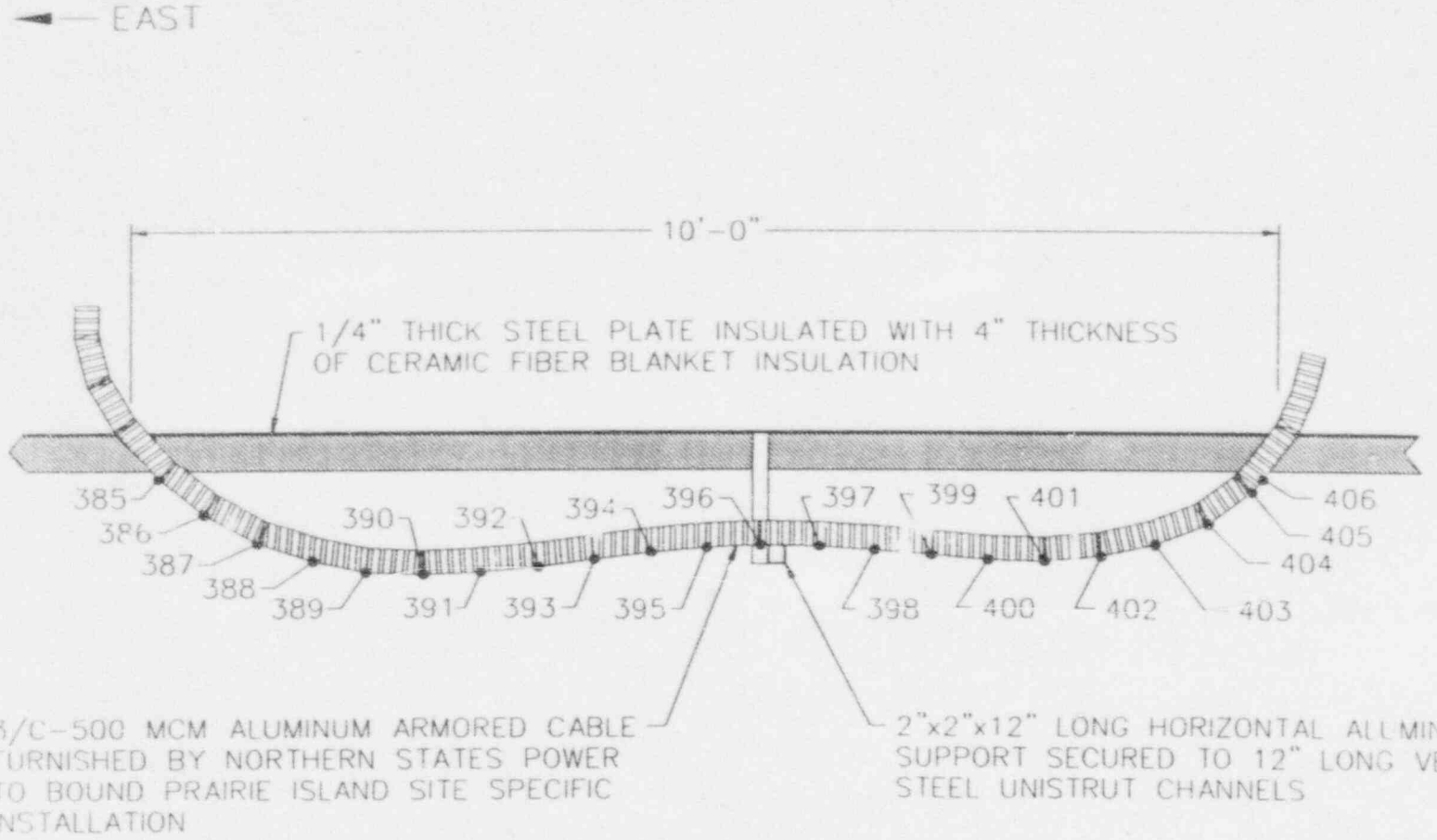


TC NOS. 291-298 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 291 COINCIDES WITH TC NOS. 274 & 275. TC NOS. 296-298 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE P



CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE R



CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE Q

NBK – FACSIMILE REQUEST FORM ATTACHMENT 4

Underwriters Laboratories Inc.®

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NAME: Steven Wiest

ORGANIZATION: USNRC

CITY, STATE, COUNTRY:

FAX NO.: 301 415 3577

SUBJECT: Transco

MESSAGE: Following are the test observation which you requested

Regards
Edward A. Johnson

SPECIAL INSTRUCTIONS:

REQUESTED BY: Johanson EMPLOYEE NO.: 17811

DEPARTMENT/SECTION: 4411 B EXT.: 42075

NUMBER OF ATTEMPTS: OPERATOR:

2000-3A
1/96

"SENDER WILL BE NOTIFIED IF TRANSMISSION DELAYED MORE THAN TWO HOURS"

Record of Test Observations

File No.: R18500
Project No.: 97NK4087
Date: April 10, 1997

Client: Transco Inc.
Recorded By: M. Izydorek

Test Time Hr:Min:Sec	Exposed (E) or Unexposed (U) Surface	Article No.	Observation
0:0:5:00	E	All	All of the exposed material was charred and black in color.
0:0:6:15	E	N	The bottom piece of material (the cap) fell form the article.
0:08:22	E	B	Flames were issuing from the sample.
0:09:40	E	All	Flames issued from the exposed surfaces of the articles near the top of the exposed surface.
0:12:56	U	All	Smoke was issuing from the entire unexposed surface with the heaviest amount from Article H.
0:15:07	E	H	A crack, running in a North-South direction had developed at the West side of the article. the crack was 1/8 in. deep.
0:19:21	E	B,F,C,M	Flames continued to issue from the exposed surface of the articles.
0:20:03	E	All	The surfaces were becoming beige in color.
0:31:23	E	H	There were gaps present between the banding straps and the bottom surface of the protection material.
0:37:36	E	All	The surfaces were becoming white in color.
0:41:43	E	P	There was a slight separation in the material on the bottom surface of the protection material.
0:52:57	E	H	A Westerly view of the article shows a 1 in. separation near the West end on the bottom of the article.
1:10:26	E	J	On the South end of the article at the interface of the vertical and horizontal runs, there were two 1/4 in. wide openings in the protection material.
1:29:37	E	H	The area described at 0:15:07 had opened to a width of 2 in.
1:30:17	E	J	The openings described at 1:10:26 had closed.
1:33:28	E	G	A "flap" of protection material, 3 x 4 in., was hanging at the interface with the hanger.
1:35:18	E	Q	Heavy black smoke accompanied by flames was issuing from the article at the center and at both ends where it entered the furnace chamber. These flames were impinging on Article N.
1:49:24	E	B	Flames and black smoke issued from the top of

			the sample.
1:50:31	E	B	An area of flames issued from the bottom of the article at the interface with the support near the center of the article.
2:00:00	E	All	No significant changes observed.
2:16:00	E	A	The West half of the article fell to the furnace floor.
2:35:35	E	Q	The heavy black smoke ceased. Gray smoke issued from the center of the article at the bottom. The smoke was issuing from a crack.
2:40:00	E	All	Slight changes in color had occurred
2:41:03	E	Q	The crack described at 2:40:00 was 2 in. wide.
3:00:00	E & U	All	Fire test terminated.

with the exception of test article B, a 30-inch wide steel cable tray with a 1-hour Versawrap fire barrier, it appeared that at least the innermost layer of foil (the foil attached directly to the raceway) remained intact during the hose stream test. For test article B, the foil on the bottom surface of the tray was breached, apparently by the force of the solid hose stream. GL 86-10, S 1, states, in part, that the fire endurance qualification test for fire barrier materials are successful if "[t]he cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component (e.g., cables) is visible.

On April 11, 1997, I observed Transco disassemble the fire barriers that remained on test articles H and P after the fire and hose stream tests. For both of these proposed 3-hour fire barrier designs, the inner layers of foil, water filled mylar tubes, and fiber blankets remained largely intact. Many of these mylar tubes appeared to contain their original inventory of water and those that had leaked contained some water. In addition, the ordinary adhesive-backed strapping tape that was used to attach the tubes to the raceways was largely free of fire damage.

One interesting part of the test was a test of a 12-inch by 12-inch by 8-inch thick silicone foam penetration seal that was penetrated by a ¾-inch diameter steel conduit (test article N). In addition to the normal fire resistant damming board, the seal assembly included an outer layer of intumescent-coated fiberglass cloth (on the fire side). According to Mr. Hawks, Transco considered this a "throw away" or research and development scoping test and did not instrument the seal assembly with thermocouples to obtain unexposed side temperatures. After the 3-hour fire exposure and hose stream test, Transco disassembled the penetrations seal. The seal assembly was intact. About 2 to 3 inches of the silicone foam material was consumed during the fire exposure. A full 5 to 6 inches of unreacted silicone foam material remained.

UL will base its determinations on the thermal performance of the test articles on its observations during the fire endurance and hose stream tests, analyses of the electronically recorded thermocouple data, and consideration of both the maximum single point temperatures and the average unexposed side temperatures. Presumably, UL will also consider the effects of the problems with the thermocouples that were experienced during the test. Attachment 4 is UL's record of test observations.

Docket Nos.: 50-313, 50-282, and 50-306

Attachments: As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 9, 1997

MEMORANDUM TO: L.B. Marsh, Chief
Plant Systems Branch
Office of Nuclear Reactor Regulation

FROM: K. Steven West, Chief
Fire Protection Engineering Section
Plant Systems Branch
Office of Nuclear Reactor Regulation

SUBJECT: TRIP REPORT - TRIP TO UNDERWRITERS LABORATORIES, INCORPORATED TO OBSERVE THREE HOUR FIRE TEST OF ONE AND THREE HOUR VERSAWRAP RACEWAY FIRE BARRIER SYSTEMS (TAC M82809)

During April 10 and 11, 1997, I visited to Underwriters Laboratories, Incorporated (UL), Northbrook, Illinois, to observe a full-scale fire endurance test of 1- and 3-hour Versawrap fire barrier systems. Attachment 1 is a list of individuals that observed or participated in the test. I interacted mostly with the individuals marked with asterisks.

Transco Products, Incorporated (Transco) is developing Versawrap as a stand-alone fire barrier or as an upgrade for such existing raceway fire barriers as Thermo-Lag 330-1. In general, Versawrap barriers are installed (from the item to be protected outward) as individual layers of foil, water filled mylar tubes, fiber blankets, foil, and intumescent-coated fiberglass cloth. The numbers and arrangements of the individual barrier components are dependent on the type of item to be protected (e.g., raceway, cable, support, etc.) and the desired fire rating. (Attachment 1 to a memorandum of April 15, 1997, from K.S. West to L.B. Marsh describes the components of a typical Versawrap barrier and their general arrangements.) Entergy Operations, Incorporated, is considering installing 1- and 3-hour Versawrap fire barriers at Arkansas Nuclear One, Unit 1, and Northern States Power is considering installing a 1-hour Versawrap barrier at Prairie Island Nuclear Power Station.

Attachment 2 is Transco Test Procedure TR-228, "Three Hour Fire Test of One and Three Hour VERSAWRAP Raceway Fire Barrier Systems for Conduits and Cable Trays," Revision 2, February 7, 1997. The test was a single 3 hour fire exposure followed by a solid-stream hose stream test that was intended to demonstrate the ability of both 1- and 3-hour Versawrap fire barrier systems (in the same test) to meet the acceptance criteria of Generic Letter 86-10, Supplement 1 (GL 86-10, S 1).

CONTACT: K.S. West, NRR
301-415-1220

The test specimen had been constructed and installed on the test furnace before I arrived at UL. Therefore, I did not observe fire barrier installation or thermocouple placement. The overa[illegible]st specimen consisted of a steel and concrete deck from which 18 individual 1- and 3-hour [illegible]st articles were suspended into UL's large floor furnace. According to Kevin Hawks, Transco (1) Transco personnel installed the Versawrap fire barriers on the test articles in accorda[illegible]e with Transco instructions and procedures, (2) the test articles were instrumented in accordance with GL 86-10, S 1 (3) Transco quality control witnessed and documented test specimen construction, (4) UL quality control also independently witnessed and documented test specimen construction, (5) UL will prepare the fire test report. The test articles and the conditions which they were intended to bound are described in Attachment 2. I made pen and ink changes to Attachment 2 to reflect changes that Transco had made to the test articles after it issued the test procedure. Attachment 3 shows the test article layout, construction details, and thermocouple locations. The test articles, which did not contain cable fill, were instrumented with 438 thermocouples.

On the basis of my observations, it appeared that UL exposed the test specimen in accordance with the ASTM E-119 standard time-temperature curve for 3 hours. UL programmed its data acquisition computers to electronically record the test article thermocouple temperatures every two minutes. UL also printed the thermocouple temperatures about every five minutes. UL will use the electronically recorded temperature data to judge the fire endurance performance of the individual test articles. The printed temperatures were provided for contemporaneous information during the test. About midway through the fire exposure, Transco noticed some apparently anomalous thermocouple readings. For example, closely-spaced thermocouples were reporting vastly different temperatures. Upon examination, Transco found that the insulation had melted off of some thermocouple wires that were running on top of and in direct contact with the steel test deck. Apparently, at these points the thermocouples were measuring the temperature of the test deck rather than the temperatures of the test articles. After UL and Transco placed insulating blankets between the affected thermocouple wires and the steel test deck, the printed temperatures returned (dropped) to what appeared to be a more normal range. Transco indicated that UL would assess the impact of this event on the overall test results in its fire test report.

Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 61 minutes, it appeared that test articles A, B, C, D, L, O, and R met the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 1-hour fire rating while test articles E and Q did not. Assuming that the thermocouples were working properly and on the basis of the printed temperatures at the end of about 2 hours and 55 minutes (the temperatures at 3 hours were not printed), it also appeared that test articles F, G, H, and I may meet the maximum single point temperature rise acceptance criteria of GL 86-10, S 1, for a 3-hour fire rating, but test articles J, K, M, N, and P will not.

Following the 3 hour fire exposure, UL subjected the test specimen to a solid hose stream test for 2-1/2 minutes. With the exception of test article P, most of the outer layers of intumescent-coated fiberglass cloth, foil, and fiber blankets were knocked off of the bottom and side surfaces of the test article fire barriers by the force of the hose stream. The barrier on test article P remained intact and may not have been hit by the hose stream. In addition,

ATTACHMENT 1

List of Observers and Participants
Fire Endurance Test of Versawrap Fire Barrier
Underwriters Laboratories, Inc., Northbrook, Illinois
April 10, 1997

K. Steven West	U.S. Nuclear Regulatory Commission
Robert Goss*	Transco Products, Inc.
Kevin Hawks*	Transco Products, Inc.
Greg Jaroz*	Transco Products, Inc.
Sandra Bradford*	Transco Products, Inc.
John Kmetz	Transco Products, Inc.
Jeff Deminski	Transco Products, Inc.
Gary Sharisky	Transco Products, Inc.
Ed Johanson*	Underwriters Laboratories, Inc.
Chris Jonnson	Underwriters Laboratories, Inc.
Michael Allen Boomgarden	Underwriters Laboratories, Inc.
Bill Joy	Underwriters Laboratories, Inc.
Mark Pastor	Underwriters Laboratories, Inc.
Herb Muller	Underwriters Laboratories, Inc.
Mark Izydorek	Underwriters Laboratories, Inc.
Sam Oolie	No Fire Technologies
Ron Rispoli*	Entergy Operations, Inc.
Woody Walker*	Entergy Operations, Inc.
Tom Lillehei	Northern States Power
Dan Langel	Sargent and Lundy

ATTACHMENT 2

TRANSCO PRODUCTS INC.

Transco Products Inc.
Test Procedure #TR-228

for

Three Hour Fire Test of
One and Three Hour *VERSAWRAP* Raceway Fire Barrier Systems
for Conduits and Cable Trays

(TRANSCO PRODUCTS INC. PROJECT #AR-256)

Rev.:	Description:	By:	Date:	Ck:	Date:	App.:	Date:
0	For Review and Test Specimen Fabrication	G.J. Jarosz	02/07/97	K.Hawks	02/07/97	R. Goss	02/07/97
1	For Review and Test Specimen Fabrication	G.J. Jarosz	03/01/97	K.Hawks	03/01/97	B.C. Mach-chhar	03/01/97
2	For Review and Test Specimen Fabrication	G.J. Jarosz	03/16/97	[signature]	03/17/97	[signature]	3/17/97

TABLE OF CONTENTS:

SECTION 1.0
SYNOPSIS:

Transco Fire Test #TR-228 will be a single fire test conducted in accordance with the performance requirements of NRC GL 86-10, Supplement 1 and the ASTM E-119 time/temperature curve. The purpose of this test is to demonstrate the ability of both one and three hour *VERSAWRAP* raceway fire barrier systems (in the same test) to protect a variety of raceway conditions that are representative of those commonly found in nuclear power plants. Even though some of the barrier systems to be tested are only intended for one hour applications, they will be subjected to the full three hour fire test. In these cases, the one hour barrier specimens will be considered to be successful thermally if they meet the raceway temperature pass/fail criteria of GL 86-10 for the first hour of the fire test. After the conclusion of the three hour fire test, both one and three hour specimens will be subjected to a hose stream test in accordance with Section 7.0 of this procedure. Testing will be performed at Underwriters Laboratories (Northbrook, Illinois).

The overall test specimen will consist of a metal and concrete deck from which a number of simulated conduit and cable tray raceways will be suspended. The sizes and shapes of these raceways are intended to represent conditions that bound equivalent or less severe raceway configurations in the field. These bounding conditions to be qualified by this test are described below. The metal/concrete deck with its individual raceway specimens will be placed on top of a large floor furnace where the raceways will be subjected to the three hour fire endurance test. Immediately after the conclusion of the fire test, the deck and raceway specimens are lifted as a single unit from the furnace and will then be exposed to the hose stream test.

The raceway items to be tested and conditions they are intended to bound are as follows:

ITEM: DESCRIPTION:

"A" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track - This item is intended to bound one hour *VERSAWRAP* installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled steel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum raceways. Because this is a one hour wrap, it is only required to meet the thermal pass/fail requirements of GL 86-10 Supplement 1 for one hour whereas the hose stream test for this specimen will be performed immediately after the three hour fire test. This specimen will demonstrate both horizontal and vertical raceway sections, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper cable and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading.

"B" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound one hour *VERSAWRAP* systems installed on 30" x 4" (and all smaller sizes) of both aluminum and/or steel cable trays (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "A" above*) as well as bundled conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a

"Unistrut" hanger thermal short interface. This tray will be empty except for a single #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum raceways up to this size for hose stream test qualifications of *VERSAWRAP*. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap.

"C" ¾" Diameter Rigid Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit and will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"D" 4" Diameter Rigid Steel Conduit - This item is intended to demonstrate one hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway specimen will fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"E" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound one hour *VERSAWRAP* systems installed on the smallest size of conduit found in the field (the most severe thermal mass) located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will use condulets at each end of the specimen on the exposed side of the deck. A conduit connector will also be installed on the conduit. (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"F" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~one~~ three hour *VERSAWRAP* systems installed on ¾" diameter conduit (as the most severe thermal mass) connected to a "Unistrut" hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped with *VERSAWRAP* as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"G" 2" x 2" Aluminum Solid-Back Cable Tray/Tube Track -This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest steel and/or aluminum cable tray (using aluminum as a worst case condition) as well as bundled sateel or aluminum conduit configurations. Since this is the smallest thermal mass expected for cable tray applications (and therefore the most severe), this tray is intended to bound all larger steel and aluminum trays. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend/corner, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. This item will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for small raceways.

"H" 30" x 4" Steel Ladder-Back Cable Tray - This item is intended to bound three hour *VERSAWRAP* systems installed on 30" x 4" and all smaller sizes of both aluminum and steel cable tray (*aluminum trays sizes from 2" x 2" through 30" x 4" are bounded thermally by item "G" above*) and bundled steel or aluminum conduits. This specimen will demonstrate both horizontal and vertical runs of raceway, a bend, and a "Unistrut" hanger thermal short interface. This tray will be empty except for a #8 AWG bare copper wire and thermocouples. The empty tray is used to simulate a worst case thermal mass condition for cable loading. The use of this large steel tray is also intended to bound aluminum trays up to this size for hose stream test qualifications. This specimen will also demonstrate a "free-cable airdrop" and its connection to the raceway wrap. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for both large tray and/or box wraps.

"I" ¾" Diameter Rigid Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit in the field (the most severe thermal mass). The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. A conduit connector will also be installed on one of the vertical legs of specimen to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on small diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"J" 4" Diameter Rigid Steel Conduit -This item is intended to demonstrate three hour *VERSAWRAP* systems installed on large diameter conduits. The test raceway assembly will be fabricated from standard 4" diameter rigid steel conduit that will utilize a folded "S"-shape to represent both vertical and horizontal raceway runs. One corner of the "S"-shape will consist of a standard steel condulet and couplers while the horizontal leg of the raceway will be used to show the wrap installed on a large radius bend. A conduit connector will also be installed on one end of the raceway to demonstrate the wrap installed over such typical hardware items. A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on large diameter conduit raceways. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure. The specimen will also demonstrate a wrap-to-concrete interface to bound both one and three hour applications for large and small conduit wraps.

"K" ¾" Diameter Rigid Steel Conduit Near Concrete Barrier - This item is intended to bound three hour *VERSAWRAP* systems installed on the smallest size of conduit (the most severe thermal mass) found in the field that is located approximately ¾" from a vertical or horizontal concrete barrier. The test raceway assembly will be fabricated from standard ¾" diameter rigid steel conduit that will utilize condulets at each end of the specimen. A conduit connector will also be installed on the conduit (No hanger will be used in the test as hangers in the field would be wrapped in the same manner as the conduit - the impact of the hanger thermal short in this particular case would be considered as a less severe condition as it would increase the thermal mass of the test raceway.) This conduit will be empty except for a single #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"L" Multiple Intersecting "Unistrut" Hangers and ¾" Diameter Rigid Steel Conduit - This item is intended to bound ~~three~~ one hour *VERSAWRAP* systems installed on a ¾" diameter rigid steel conduit as the smallest size of conduit found in the field (the most severe thermal mass) connected to a hanger thermal short that intersects with a second perpendicular hanger approximately 6" from the conduit. This second intersecting hanger will not be wrapped as a full length thermal short as shown in the other test specimens. The conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure.

"M" 1-½' Diameter Steel Conduit ~~and T&I "Thermo-Lag"~~ Raceway Covered with Modified VERSAWRAP - This item is intended to bound "modified" one hour *VERSAWRAP* systems installed on 1-½" (and larger) diameter conduits in the field. The test raceway assembly will be fabricated from standard 1-½" diameter rigid steel conduit that will utilize a "U"-shape to represent both vertical and horizontal raceway runs. One corner of the "U"-shape will consist of a standard steel condulet and couplers while the opposite corner will be used to show the wrap installed on a small radius bend. ~~The one hour Thermo-Lag material will be installed with "dry joints" (no trowel-grade Thermo-Lag will be used).~~ A "Unistrut" hanger will be connected to the horizontal conduit section to demonstrate the impact of thermal shorts on these raceway types. This conduit will be empty except for a #8 AWG bare copper wire and thermocouples installed

according to Section 5.0 of this procedure.

"N" 12" x 12" x 12" x 16 Gauge Steel Box Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* conduit systems ~~that interface with a one hour "Darmatt KM1" raceway barrier system~~ installed on the box. The conduit will pass through a penetration seal to show wrap terminations as such. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1.

"O" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound one hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

"P" Two 6" x 6" x 6" x 16 Gauge Steel Boxes Attached to a ¾" Diameter Steel Conduit - This item is intended to bound three hour *VERSAWRAP* systems installed on both "free-air" junction boxes and junction boxes mounted to concrete barriers as well as intersecting conduit connections. The conduit and box will be empty except for a #8 AWG bare copper wire and thermocouples installed according to Section 5.0 of this procedure and Generic Letter 86-10, Supplement 1. The sizes of both simulated junction boxes were chosen to represent worst case small thermal masses whereas field junction boxes with large surfaces would be bounded by the 30" x 4" cable tray raceway included in this test.

aluminum hanger

"Q" 3C-500MCM Aluminum Armored Cable - This item is intended to bound one hour *VERSAWRAP* systems installed on a 3C-500MCM aluminum armored cable as supplied by Northern States Power for their Prairie Island Nuclear Power Station. The 10' (minimum) span of cable will be temporarily supported by a ~~rope~~ about mid-span. During the test, the ~~rope~~ will ~~burn~~ melt and will allow the wrapped cable to be unsupported for the remainder of the fire test. The intent here is to show that the wrap will still be effective even if the cable suddenly becomes unsupported between hanger points (maximum distance as tested herein) in the field. (In the field, the cable is located in an aluminum tray suspended on steel hangers. The utility wishes to evaluate the possibility of wrapping only the cable instead of the entire tray. It is felt that if the aluminum tray is not wrapped, it will melt or be consumed during a fire thus leaving the cable unsupported except at points where the tray was suspended on steel hangers.)

aluminum unistrut trapeze-style hanger

"R" 3" x 3" angle - structural steel

SECTION 2.0
TEST FURNACE:

The furnace to be used is Underwriters Laboratories' standard large floor furnace. The furnace shall be operated in accordance with the requirements of ASTM E-119 for the three hour fire test

SECTION 3.0
ITEMS TO BE PROTECTED:

The following is a description of the items to be used as raceway elements for the fire test:

> *(See Section 1.0, Synopsis for a general description of these items. Note: all steel trays and boxes will be manufactured from 16 gauge steel while all conduit will be standard, rigid conduit. All "free-cable air drops" will consist of single pieces of stranded 8 AWG bare copper wire according to GL 86-10, Supplement requirements. All hangers will be fabricated from standard "Unistrut" type material [hangers may be welded to the raceways for the test in lieu of using clips, straps, etc].)*

An accurate description of specimen fabrication shall be included in the final test report (as verified by Transco Products Inc. Quality Control). Hardware substitutions are permitted provided substitute material (etc.) does not increase the heat mass of the specimen and are documented by Transco QC and UL.

SECTION 4.0
FIRE BARRIER MATERIAL INSTALLATION:

The *VERSAWRAP* and Transco Products Inc. TCO-001 materials shall be installed by Transco Products Inc. personnel in accordance with the manufacturer's instruction and/or procedures. If written instructions are not available at the time of installation, then Transco Products Inc. QC personnel shall document/verify step-by-step methods used for installation. Test installation records will be included as an appendix to the final test report.

Materials used for this test shall be purchased, received, and installed in accordance with latest approved revision of Transco Products Inc.'s Quality Assurance Program and applicable procedures. All fire barrier envelope installation will be witnessed by Transco Products Inc. Quality Control personnel. Material components (except for tie wire and ceramic blanket) will be identified with the responsible QC's initials as each layer is installed.

Note: This test will be performed as a "Safety Related" quality program in accordance with the latest approved revision of Transco Products Inc.'s Quality Assurance Manual (10CFR, Part 21 applies) with the exception that all materials will be provided as "Q-Class" with Certificates of Conformances.

SECTION 5.0
THERMOCOUPLES:

A.) Fire Barrier Envelope:

The fire barrier envelope is considered all areas of the specimen on the exposed side of the test slab. For these areas, thermocouples shall be mounted to the specimen to gather temperature data for the duration of the fire test. At a minimum, temperatures shall be documented at nominal two minute intervals for the duration of the test. Thermocouple placement for the fire barrier envelope (quantity and locations) shall be as specified in NRC GL 86-10 and Supplement 1 as follows:

"**.... Cable Trays** - The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray shall be measured by placing the thermocouples every 152 mm (6 - inches) on the exterior surface of each tray side rails between the cable tray side rail and the fire barrier material.

Internal raceway temperatures shall be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm (6- inches) along the length of the copper conductor. Thermocouples shall be placed immediately adjacent to all structural members, supports, and barrier penetrations. ...."(1)

"....**Conduits** - The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite of the test deck and closest to the furnace fire source. The internal raceway temperatures should be measured by a stranded AWG 8 bare copper

conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations...."(1)

Free-Cable Air Drops: Thermocouples will be installed on the stranded 8 AWG wire used for demonstrating the "free-cable air drop" every 152 mm [6 inches] in accordance with the same requirements for monitoring internal conduit/cable tray temperatures.

(Note: *In accordance with NRC GL 86-10, Supplement 1 requirements, "for the thermocouples installed on conduits, cable tray side rails, and bare copper conductors, a ± 13 mm (±1/2 inch) installation tolerance is acceptable". Hence, this tolerance shall be considered acceptable for use in this test. The tolerance is considered to be from the point of individual thermocouple placement and not compounded from one thermocouple to the next (i.e., all thermocouples can not be 6 1/2" from each other but rather must be ±1/2" from the measured 6" [minimum] mark on the item being monitored.)*

Junction box thermocouples will be installed in accordance with the requirements of Generic Letter 86-10, Supplement 1.

B.) Penetration Seal:

Thermocouple placement for the unexposed penetration seal surface (test item "N") will comply with the typical requirements of ASTM E814. As an optional method for protecting thermocouple tips, the thermojunctions of each thermocouple may be embedded into the seal surface or seal surface/penetrating member interface approximately ⅛ -¼" below the seal surface (because of the nature of the seal material, this placement can be performed at any time after the installation of the seal material). For this alternate method, insulation pads for covering the thermocouple tips will not be used.

All specimen temperatures shall be monitored using thermocouples (with special limits of error equal or less than 1.1°C). Thermojunctions of all specimen thermocouples shall be electrically welded. All thermocouple wire shall be supplied with certifications of purity, accuracy, and calibration.

Furnace atmosphere thermocouples shall be placed 12" below the furnace deck/slab as well as 12" away from representative elements of the test specimen accordance with ASTM E-119-88 requirements (not less than nine [9] thermocouples will be used to monitor furnace atmosphere temperatures). Additional furnace atmosphere thermocouples be employed around the specimen as it protrudes into the furnace. These will be placed at the laboratories discretion to supplement data acquisition in areas where furnace atmosphere thermocouples can not be mounted to satisfy ASTM E-119 requirements because of the specimen's configuration, et cetera.

The installation and location of each uniquely identified thermocouple (for both the specimen and furnace) shall

be mapped and verified (measured) by Transco Products Inc. Quality Control. Verification may be performed as hand written notes and shall become part of the permanent records of the test. Also, all thermocouple certifications shall also become a permanent record of the test.

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[1] Generic Letter 86-10 and Supplement 1

SECTION 6.0
FIRE TEST:

The fire test shall be conducted in accordance with the ASTM E-119 time/temperature curve (and temperature tolerance) for a minimum of three (3) hours. As a minimum, temperature data provided by both furnace and specimen thermocouples should be monitored and documented at nominal two (2) minute intervals. The laboratory shall verify and document visual specimen performance and occurrences (*i.e.*, smoke, et cetera) for the duration of the test.

It is intent of the test to demonstrate as many different raceway configurations as possible. As such, several raceway test specimens exhibit multiple features (*i.e.*, the 3 hour large tray demonstrates the tray wrap, a "free- air" cable and interface, a wrap-to-concrete interface, *etc.*). If one of these features fails thermally or during the hose stream test, it is the intent of the test to then exclude that feature from the configuration being qualified. In the case of the large tray for example, if the "free-air" cable or wrap-to-concrete interface fails for any reason, it is does not cause the tray to fail provided the rest of the tray specimen meets the acceptance criteria of Generic Letter 86-10, Supplement 1. Any failed portion of a specimen will then not be qualified by this test.

SECTION 7.0
HOSE STREAM TEST:

After the conclusion of the three hour fire test, the fire barrier envelope specimen (along with the surrounding penetration seal) shall be subjected to a minimum of one of the following hose stream tests (as identified in NRC GL 86-10, Supplement 1):

(a.) "The stream applied at random to all exposed surfaces of the test specimen through a 3.8 cm (1-1/2-inch) fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 1pm (75gpm) with the tip of the nozzle at a maximum of 1.5 meters (5 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3 -hour barriers); or[2]

(b.) "The stream applied at random to all exposed surfaces of the test specimen through a 6.4 cm (2 ½-inch) national standard playpipe with a 2.9 cm (1-1/8 -inch) orifice at a pressure of 207 kPa (30psi) at a distance of 6.1 meters (20 feet) from the specimen, (Duration of the hose stream application - 1 minute for a 1-hour barrier and 2 ½ minutes for a 3-hour barrier); or"[2]

(c.) "The stream applied at random to all exposed surfaces of the test specimen through 3.8 cm (1 ½-inch) fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa (75psi) and a minimum discharge of 284 lpm (75gpm) with the tip of the nozzle at a maximum of 3 meters (10 feet) from the test specimen. (Duration of the hose stream application - 5 minutes for both 1-hour and 3-hour barriers)."[2]

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2. Generic Letter 86-10 and Supplement 1

The responsible QC shall verify and document the type of hose stream, distance, time et cetera employed in each hose stream test.

SECTION 8.0
TEST REPORT:

The laboratory performing the test shall provide a written report which accurately describes the following minimum elements of the test:

1.) Verification of specimen materials and dimensions used;

2.) Verification of fire barrier envelope materials, dimensions, and installation techniques (procedures) used;

3.) Verification of general furnace construction/dimensions and locations of burner, thermocouples, et cetera;

4.) Verification of specimen thermocouple locations (along with copies of thermocouple material certifications);

5.) Verification of standards used for conducting fire test along with record of both furnace atmosphere and specimen temperature data acquired during test;

6.) Record of furnace pressure during fire test;

7.) Record of visual occurrences/observations of fire and hose stream tests;

8.) Record of hose stream test(s);

9.) Photographic records of specimen before fire barrier envelope installation, after fire barrier installation, and post fire/hose stream tests;

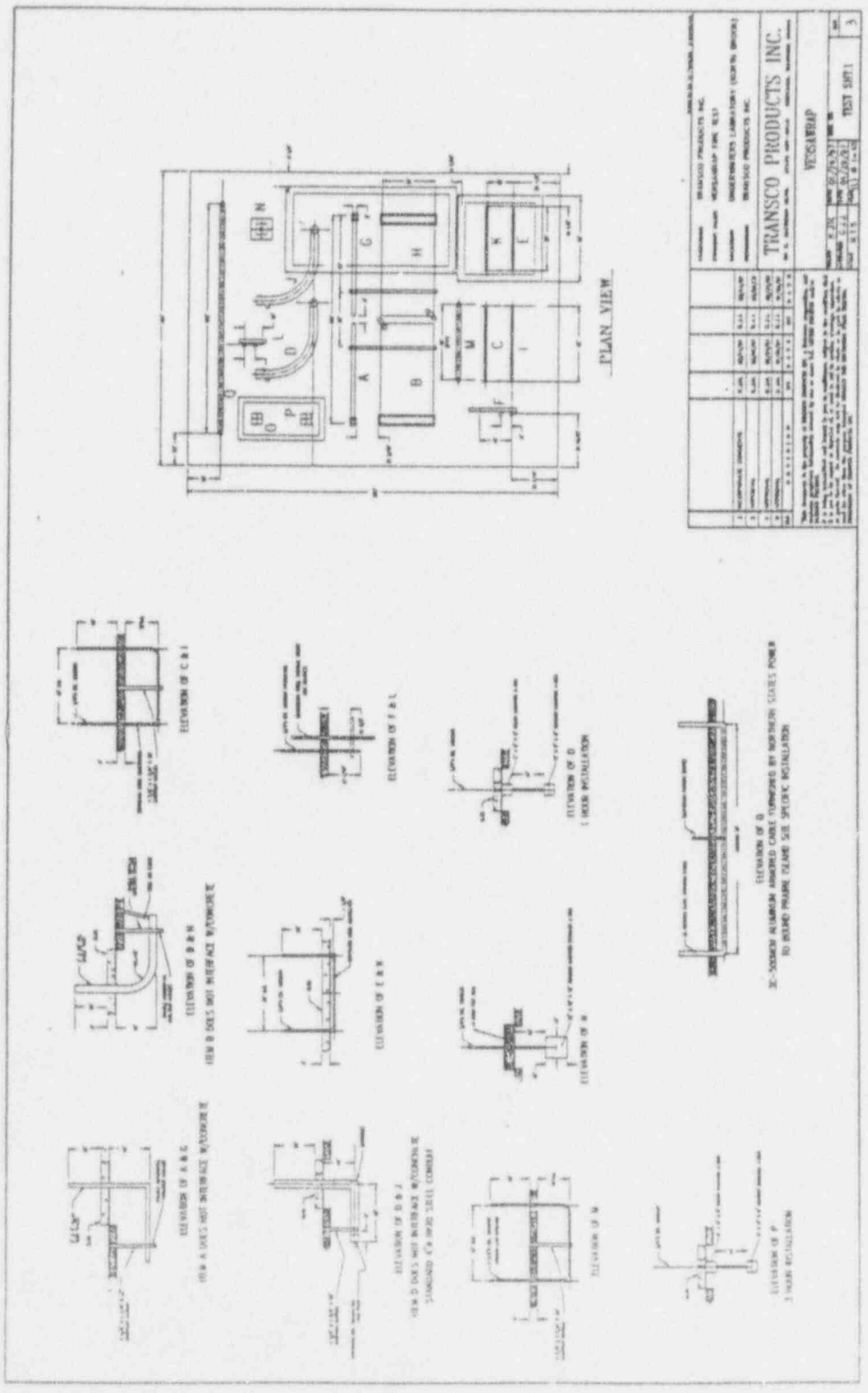
10.) Post test observations including measurements of material loss/degradation, et cetera;

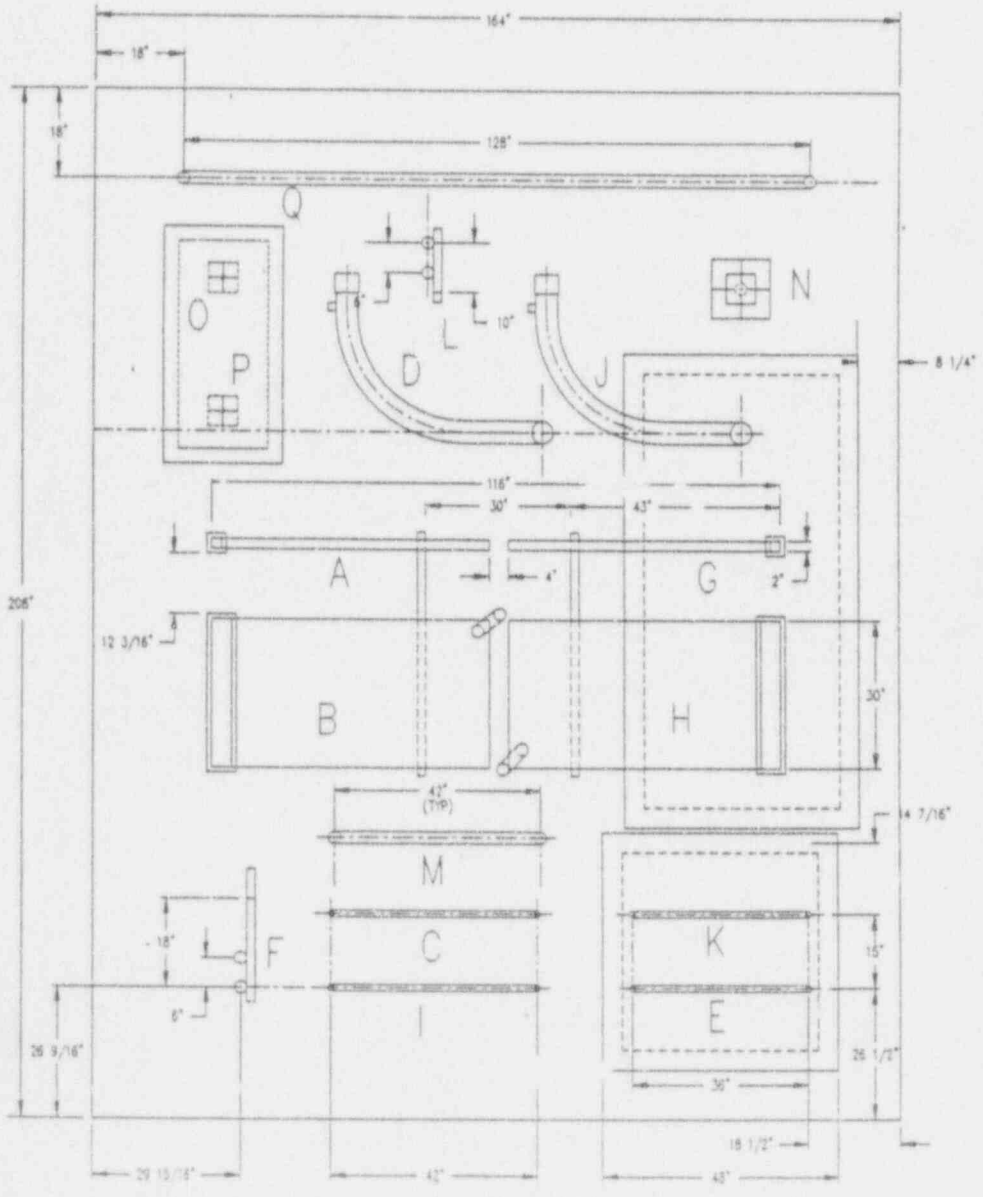
11.) Certification of the report by the agency performing test; and,

12.) QC records and notes from installation and test as an appendix to the report.

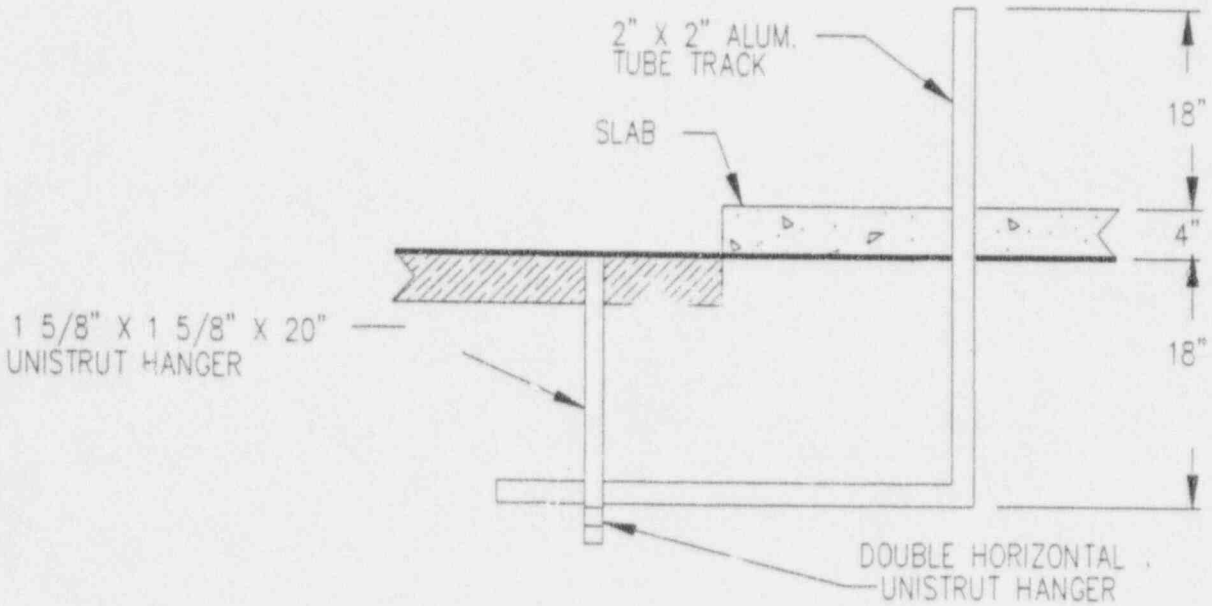
13.) Record of test items thermocouple temperature readings.

ALL TEST RECORDS, NOTES, CERTIFICATIONS, REQUIRED BY THIS TEST WILL BE LEGIBLE AND SUITABLE FOR REPRODUCTION.


PLAN VIEW
TRANSCO PRODUCTS INC.
VERSABUS
TEST SHT1

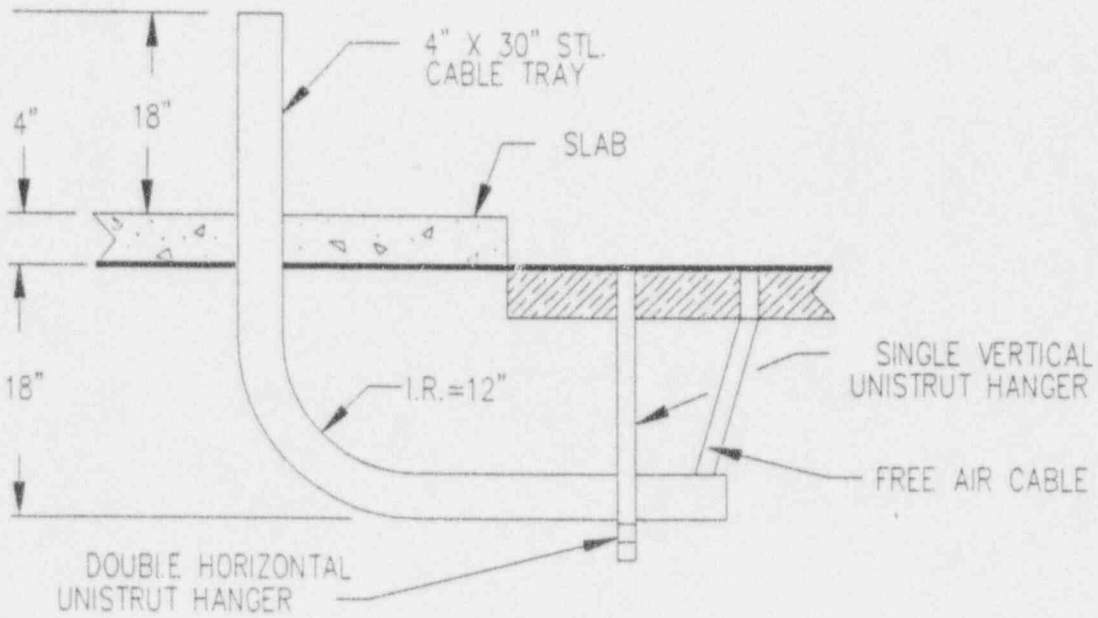

164"
18"
18"
128"
Q
O
P
L
10"
D
J
N
8 1/4"
116"
30"
43"
A
4"
G
2"
208"
12 3/16"
B
H
30"
43"
(TYP)
14 7/16"
M
C
K
18"
F
6"
I
E
15"
26 9/16"
26 1/2"
30"
18 1/2"
43"
43"

PLAN VIEW



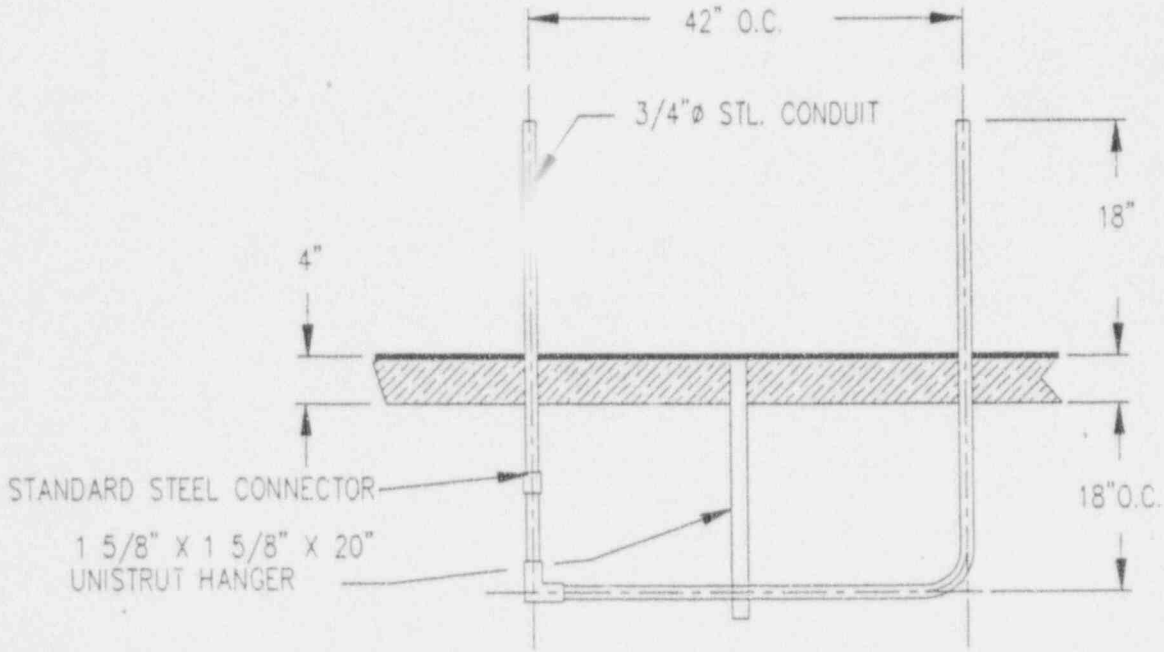
ELEVATION OF A & G

ITEM A DOES NOT INTERFACE W/CONCRETE

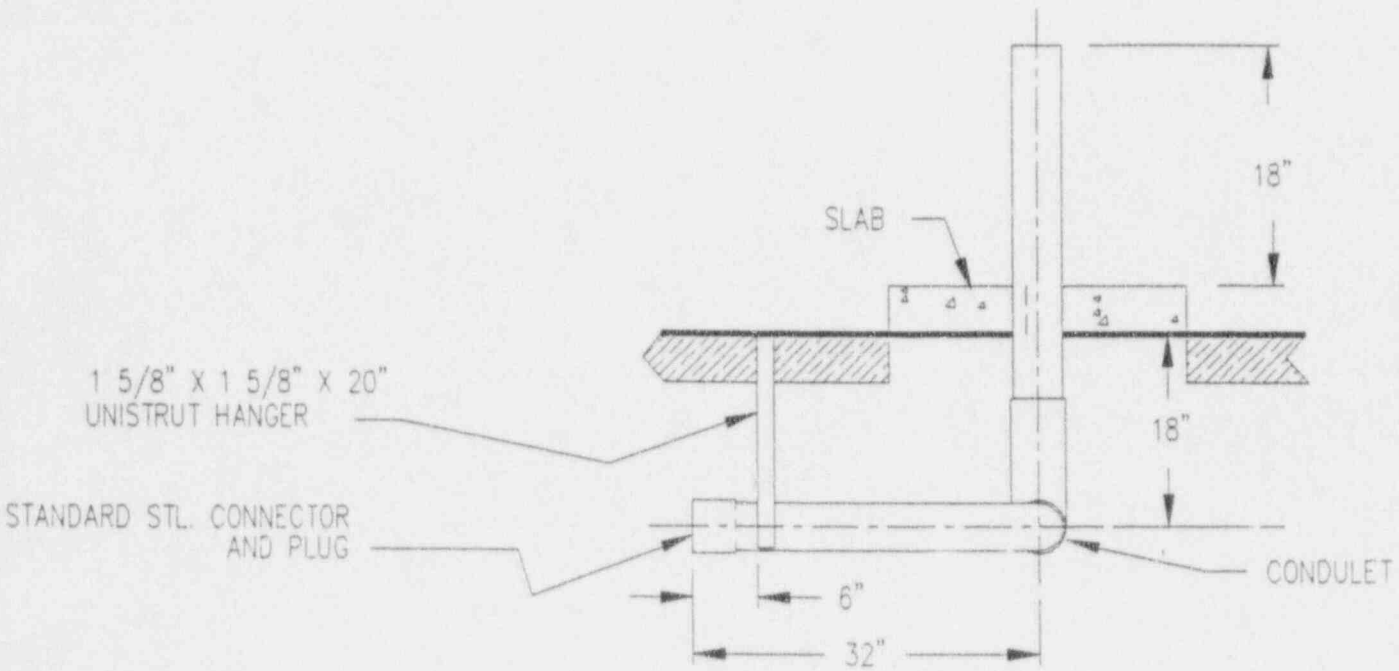


ELEVATION OF B & H

ITEM B DOES NOT INTERFACE W/CONCRETE



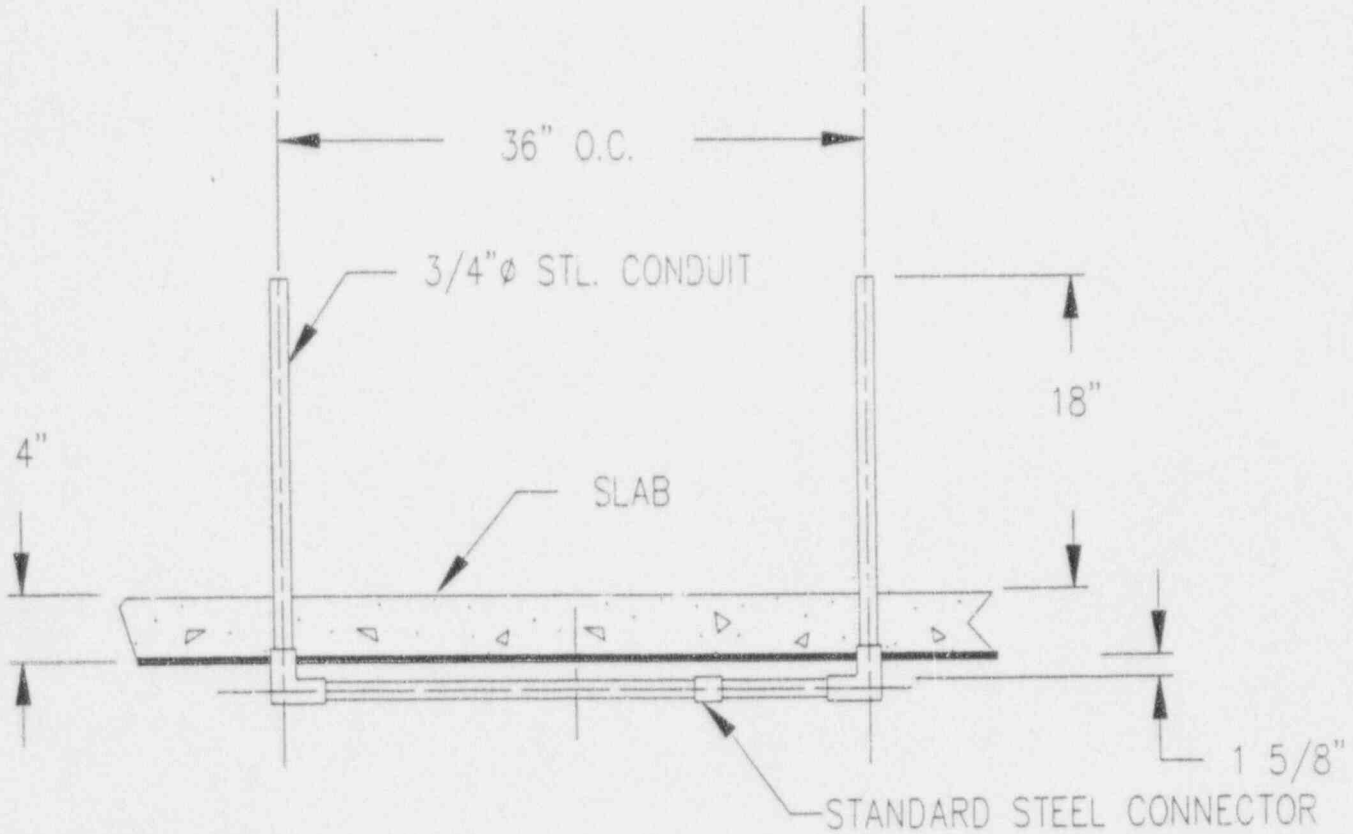
ELEVATION OF C & I



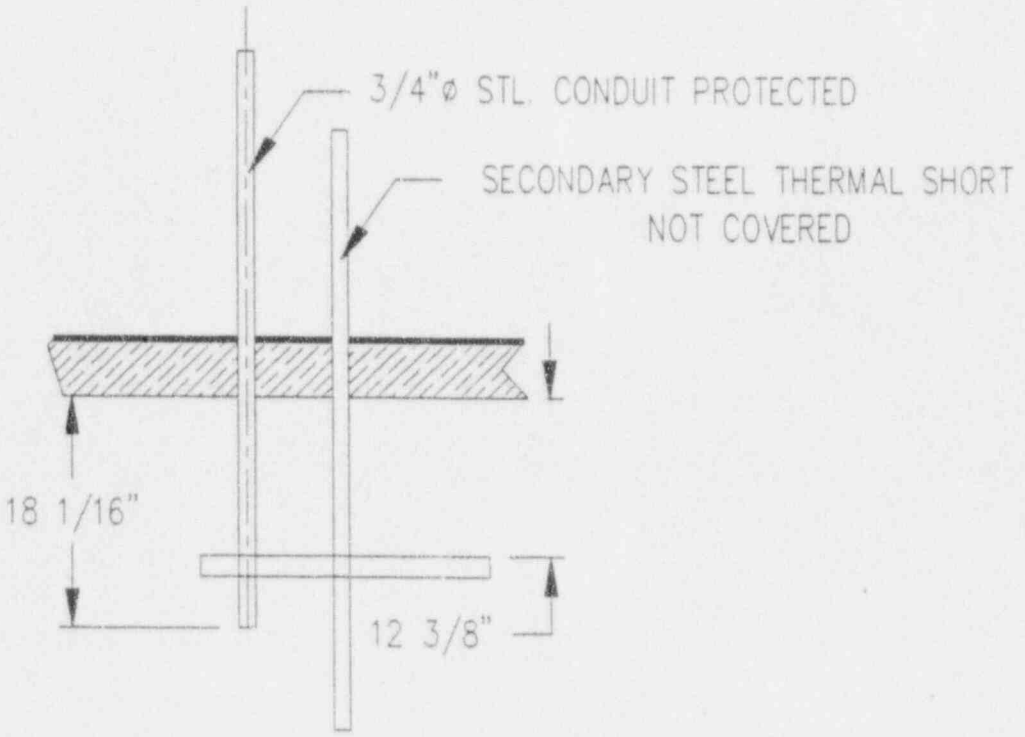
ELEVATION OF D & J

ITEM D DOES NOT INTERFACE W/CONCRETE

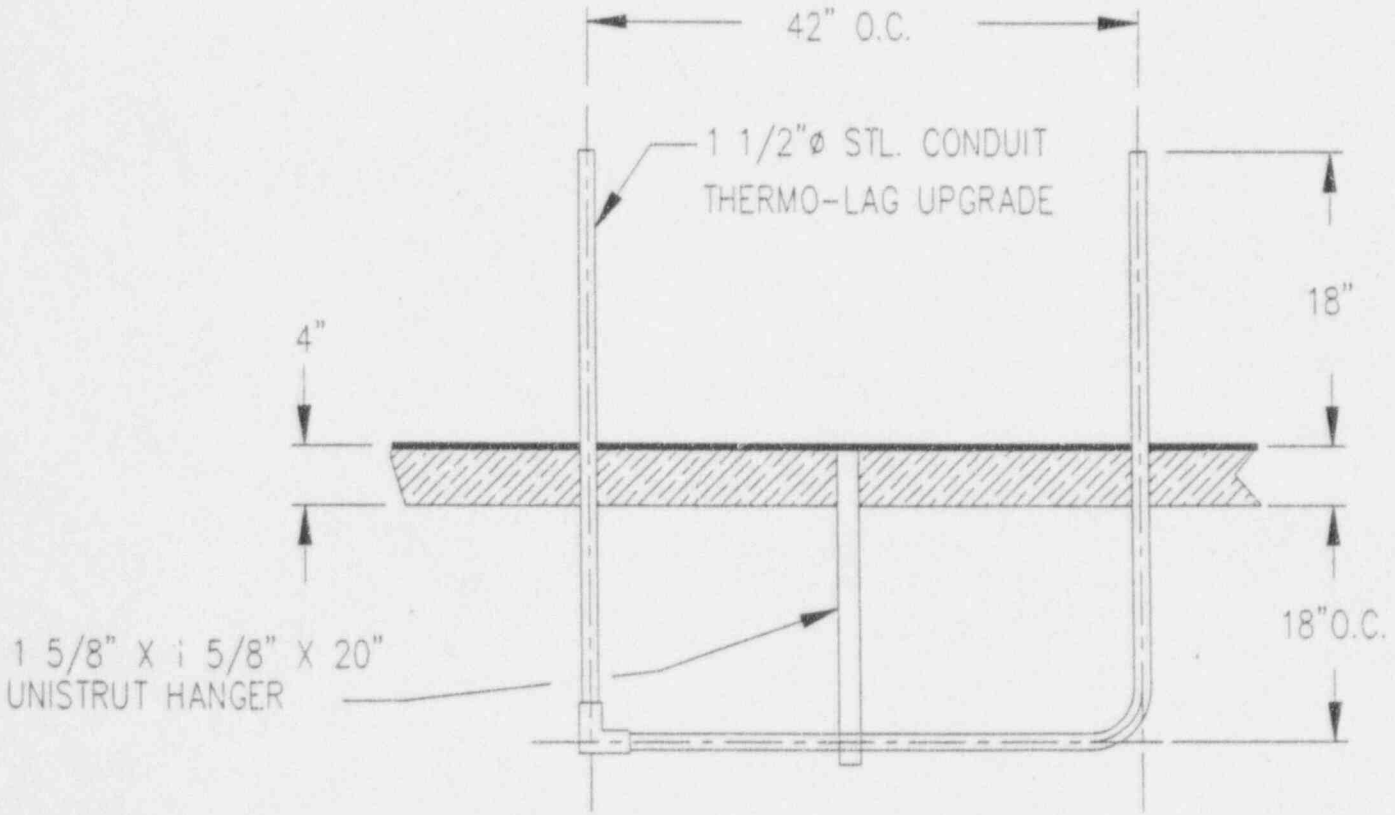
STANDARD 4"ø RIGID STEEL CONDUIT



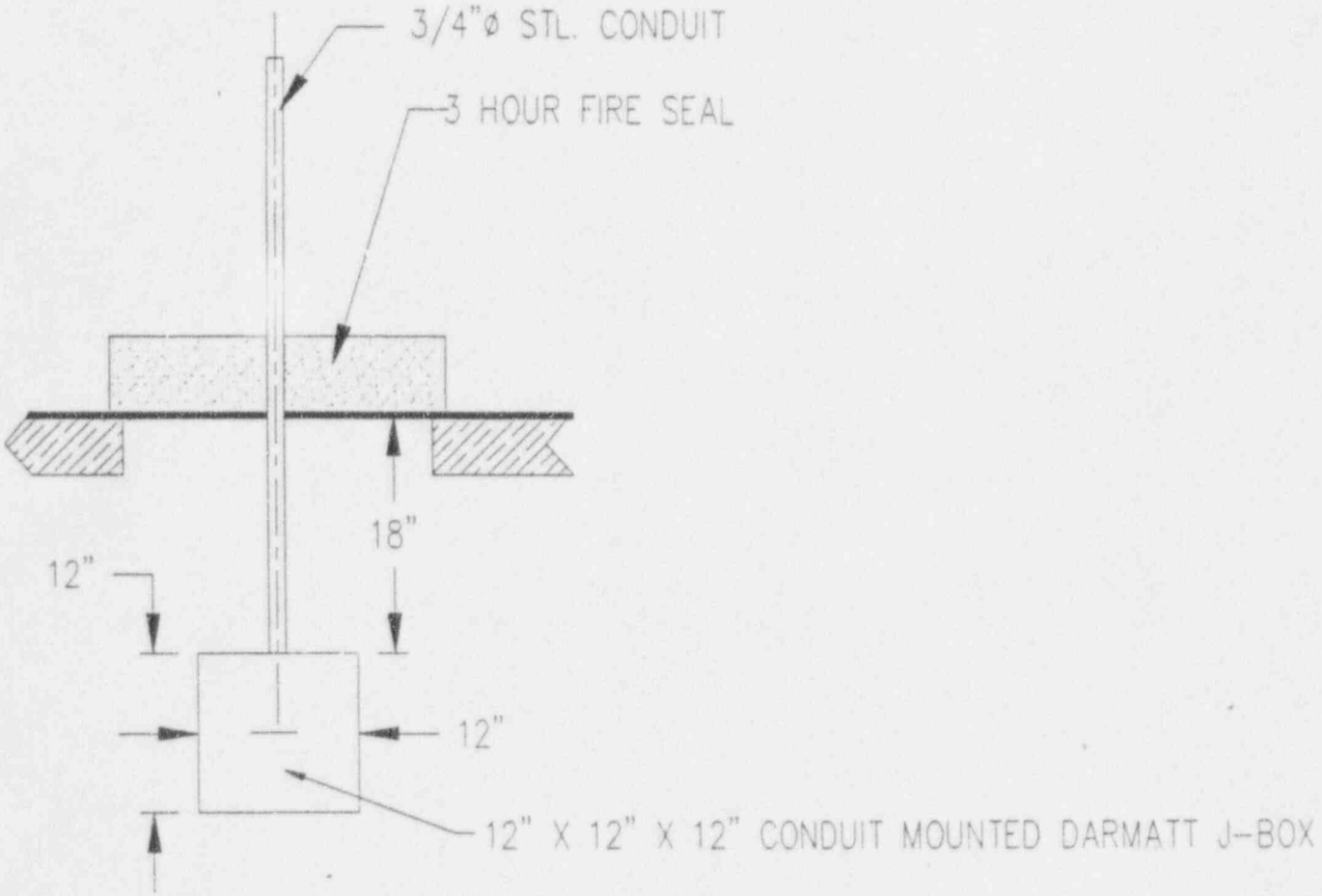
ELEVATION OF E & K



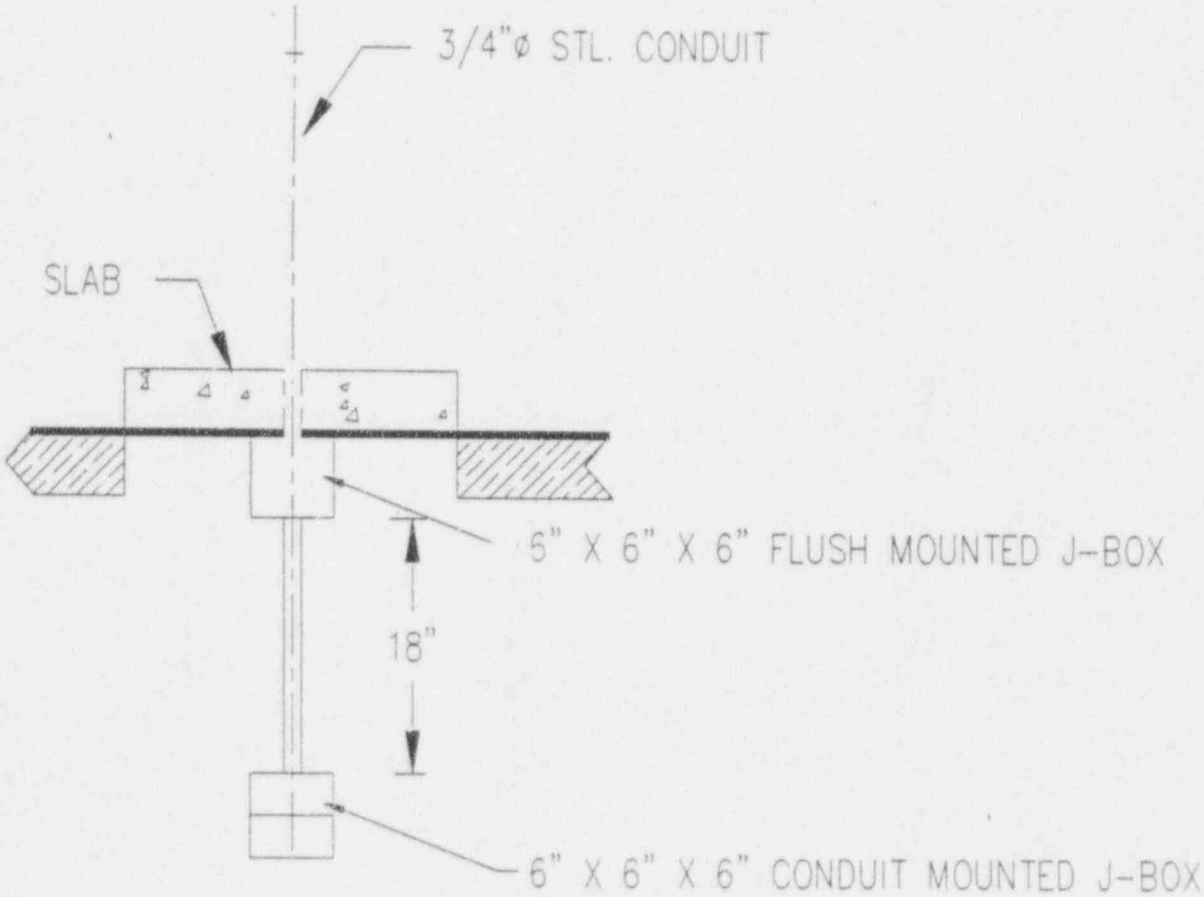
ELEVATION OF F & L



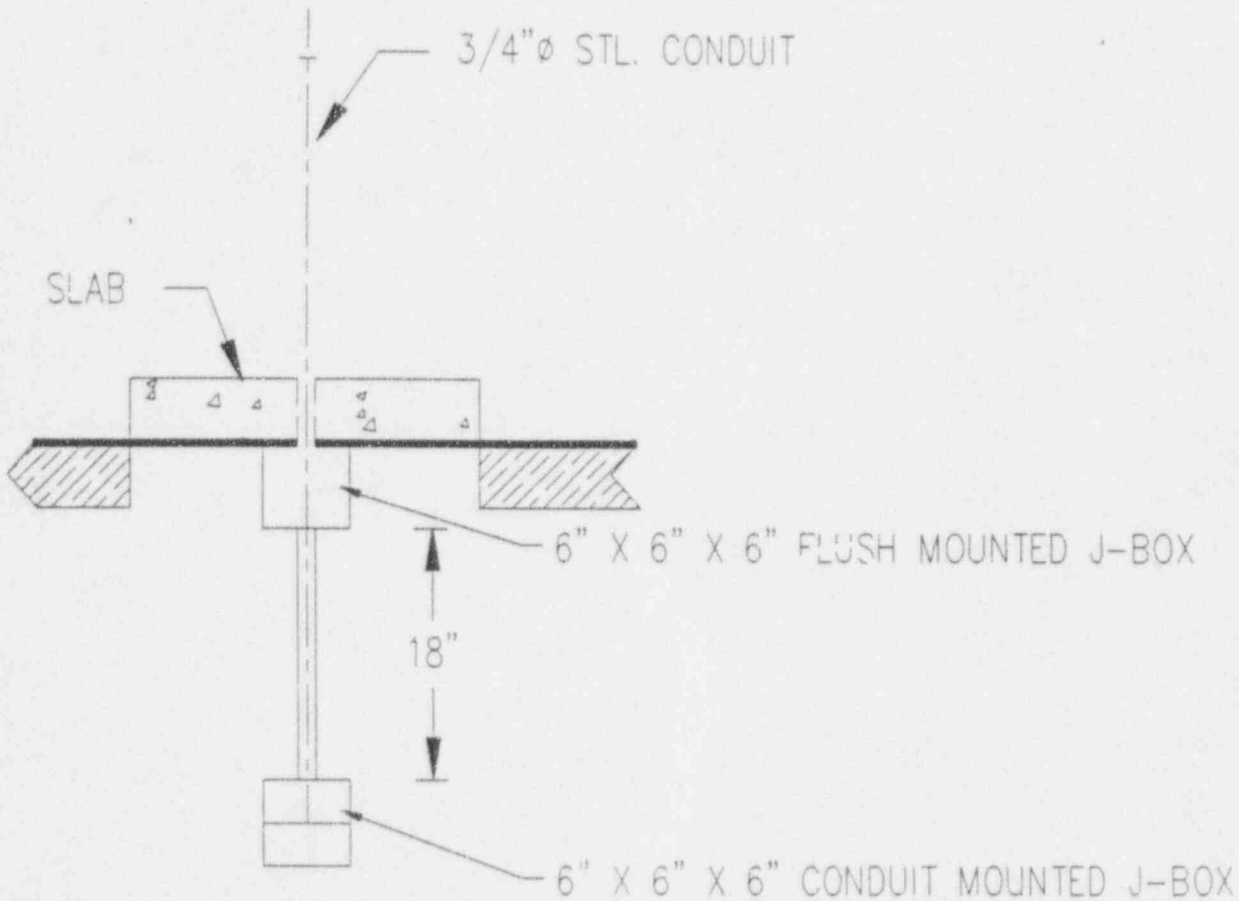
ELEVATION OF M



ELEVATION OF N

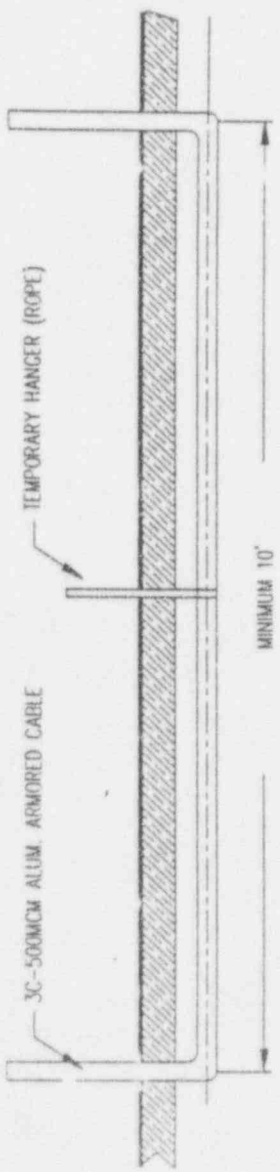


ELEVATION OF O
1 HOUR INSTALLATION



ELEVATION OF P

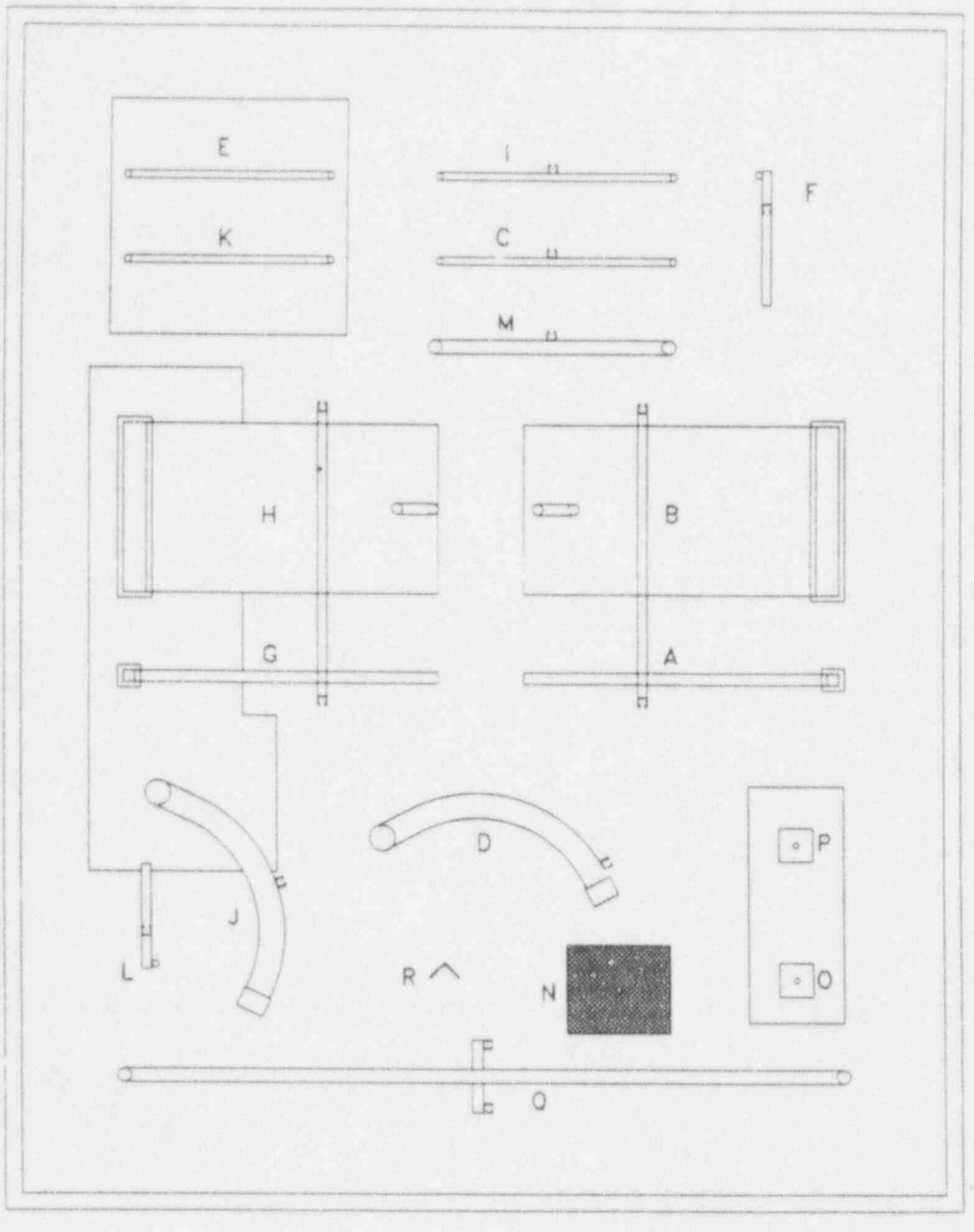
3 HOUR INSTALLATION



ELEVATION OF Q

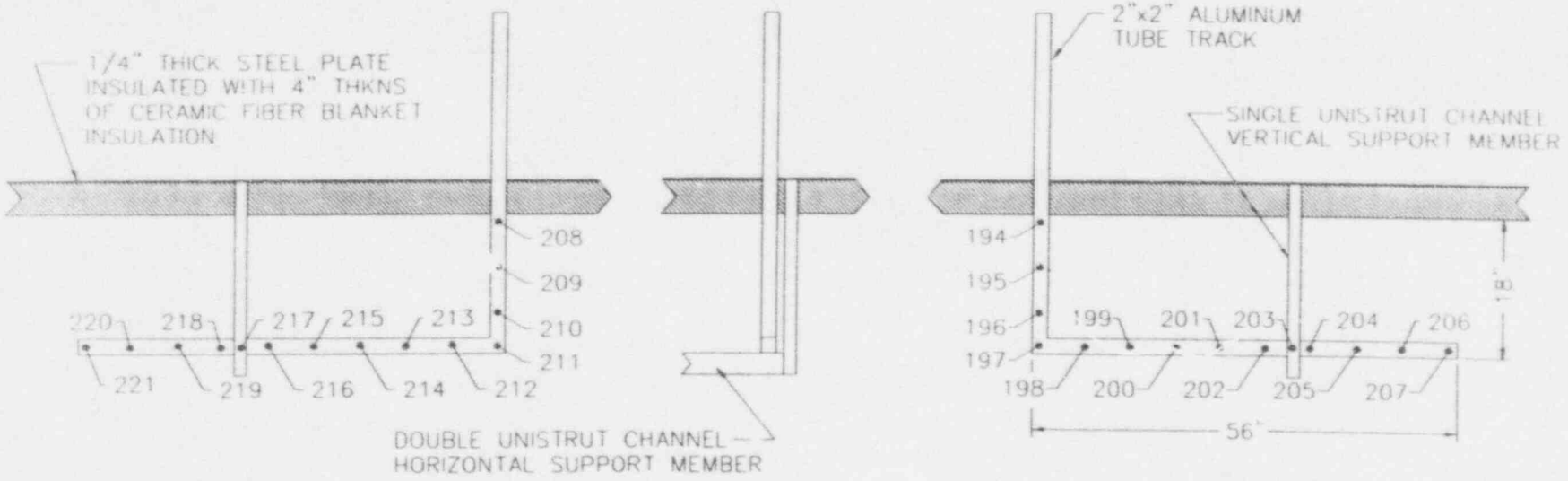
3C-500MCM ALUMINUM ARMORED CABLE FURNISHED BY NORTHERN STATES POWER TO BOUND PRAIRIE ISLAND SITE SPECIFIC INSTALLATION

NORTH



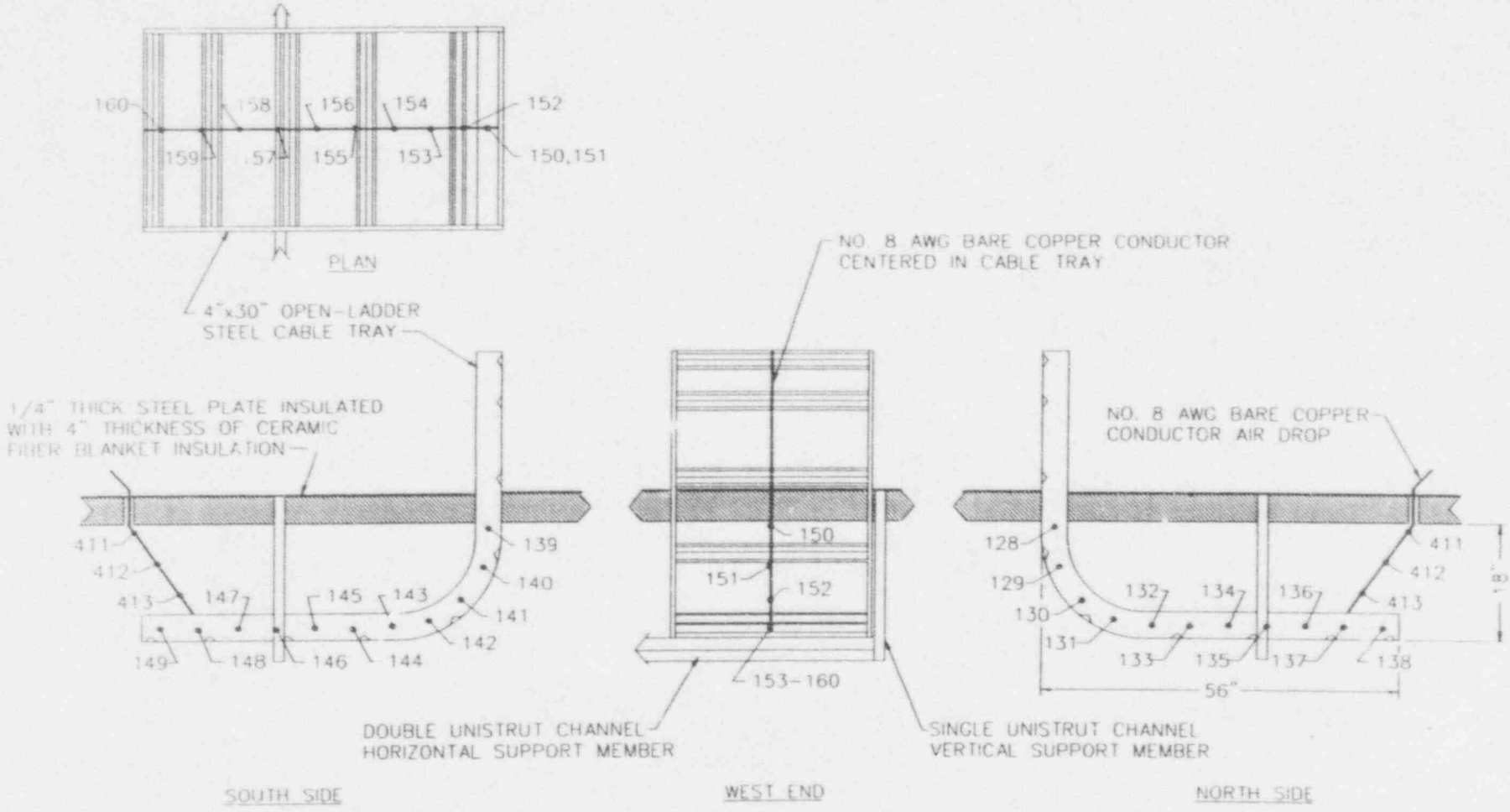
ARTICLE	TC NOS.	ARTICLE	TC NOS.
A	194-234	J	324-349 & 426
B	128-160 & 411-413	K	112-127
C	39-67	L	377-384 & 427
D	350-376	M	68-95
E	96-111	N	407-410 & 417-420
F	1-8 & 428	O	299-323
G	235-273	P	274-298
H	161-193 & 414-416	Q	429-438
I	9-38	R	385-406

TEST ARTICLE LAYOUT &
THERMOCOUPLE LOCATIONS

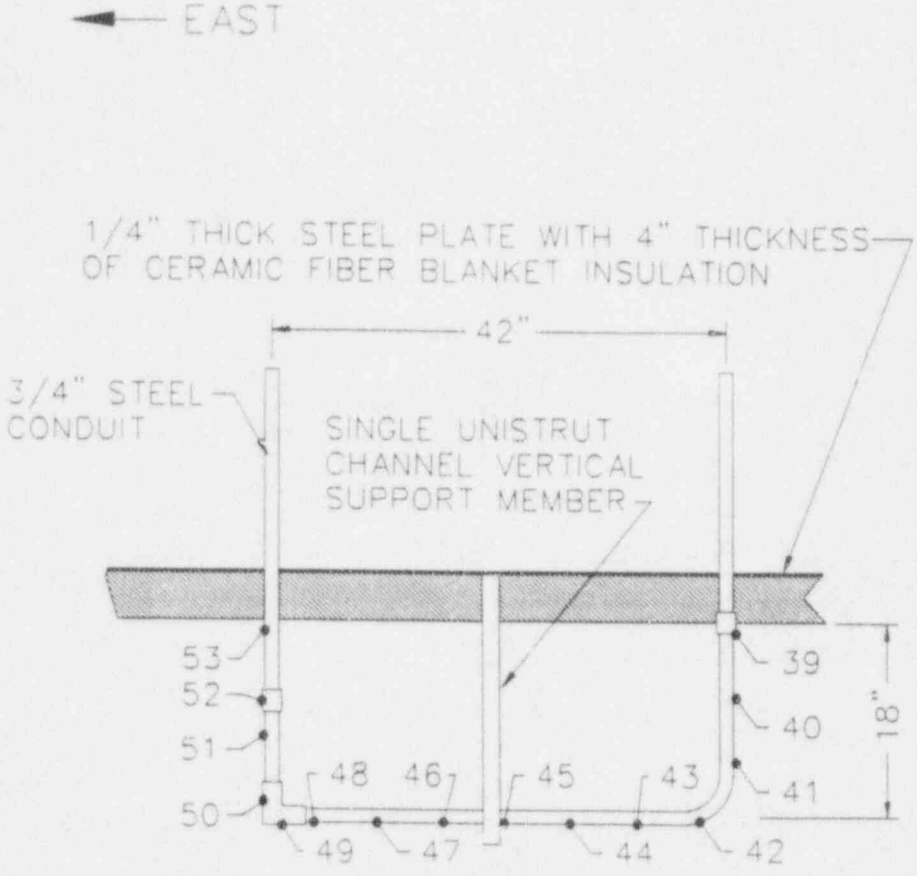


TC NOS. 222-234 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 222 COINCIDES WITH TC NOS. 194 AND 208 ON TUBE TRACK.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE A

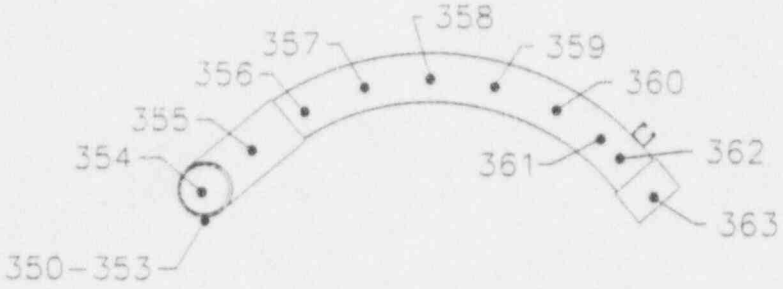


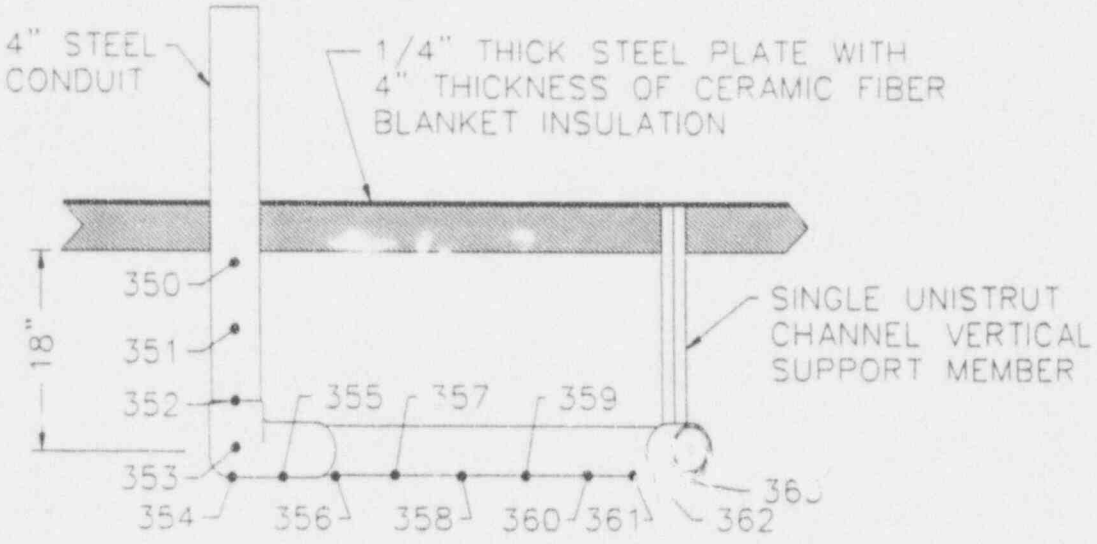
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE B



TC NOS. 54–67 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 54 COINCIDES WITH TC NO. 39.

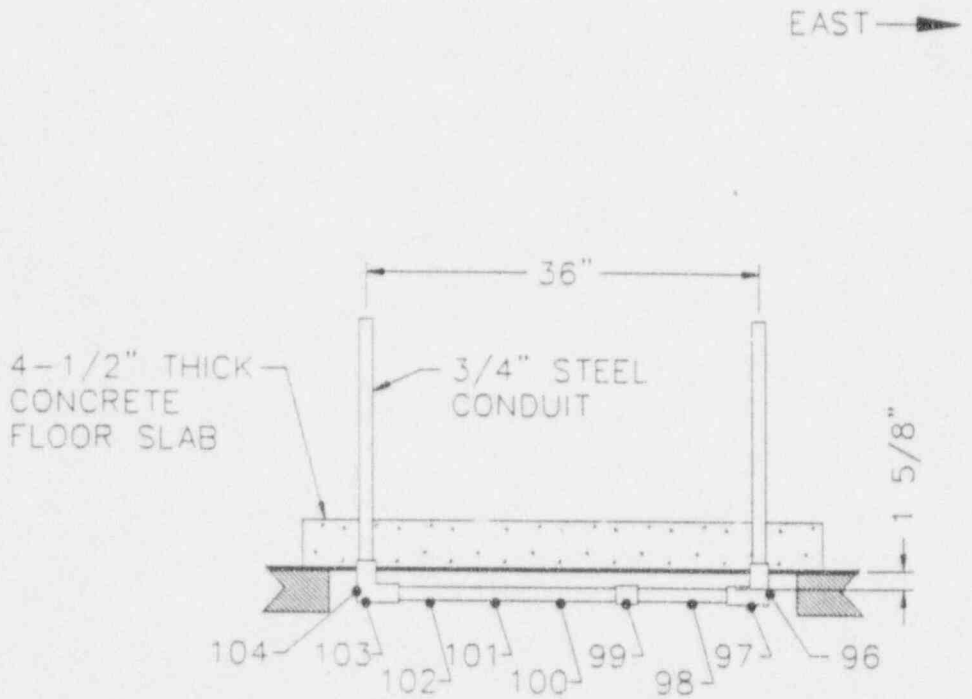
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE C





TC NOS. 364-376 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350.

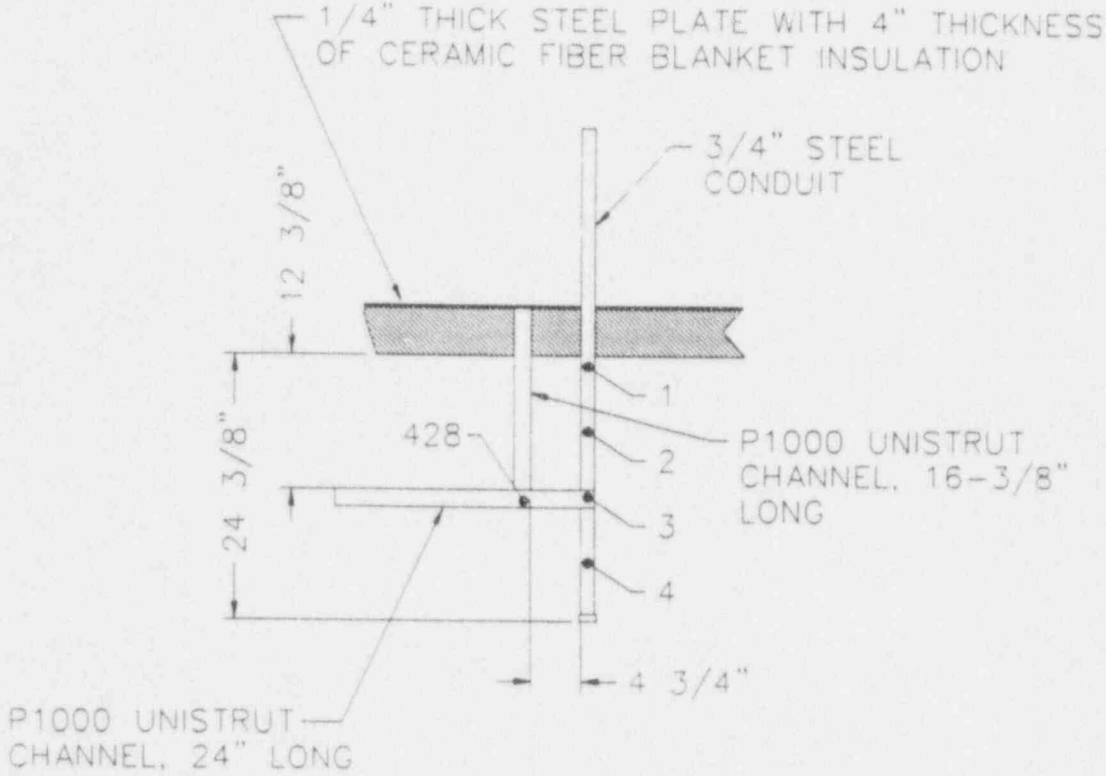
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE D



TC NOS. 105-111 (6" OC) ON NO. 8 AWG
BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 105 COINCIDES WITH TC NO. 96.

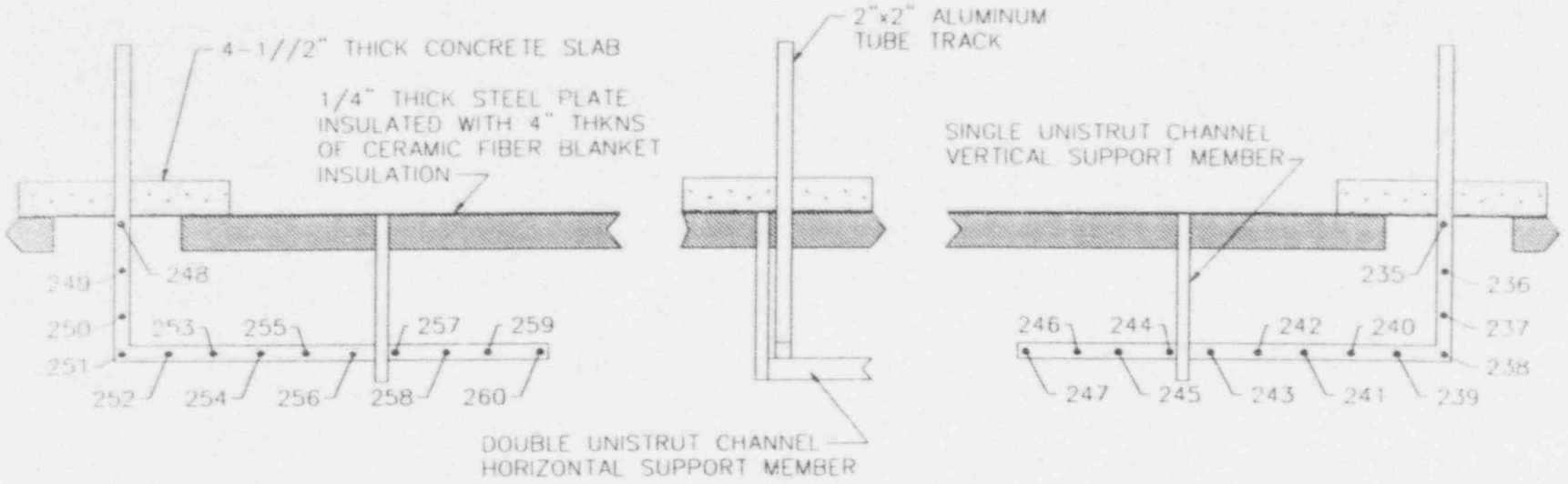
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE E

NORTH



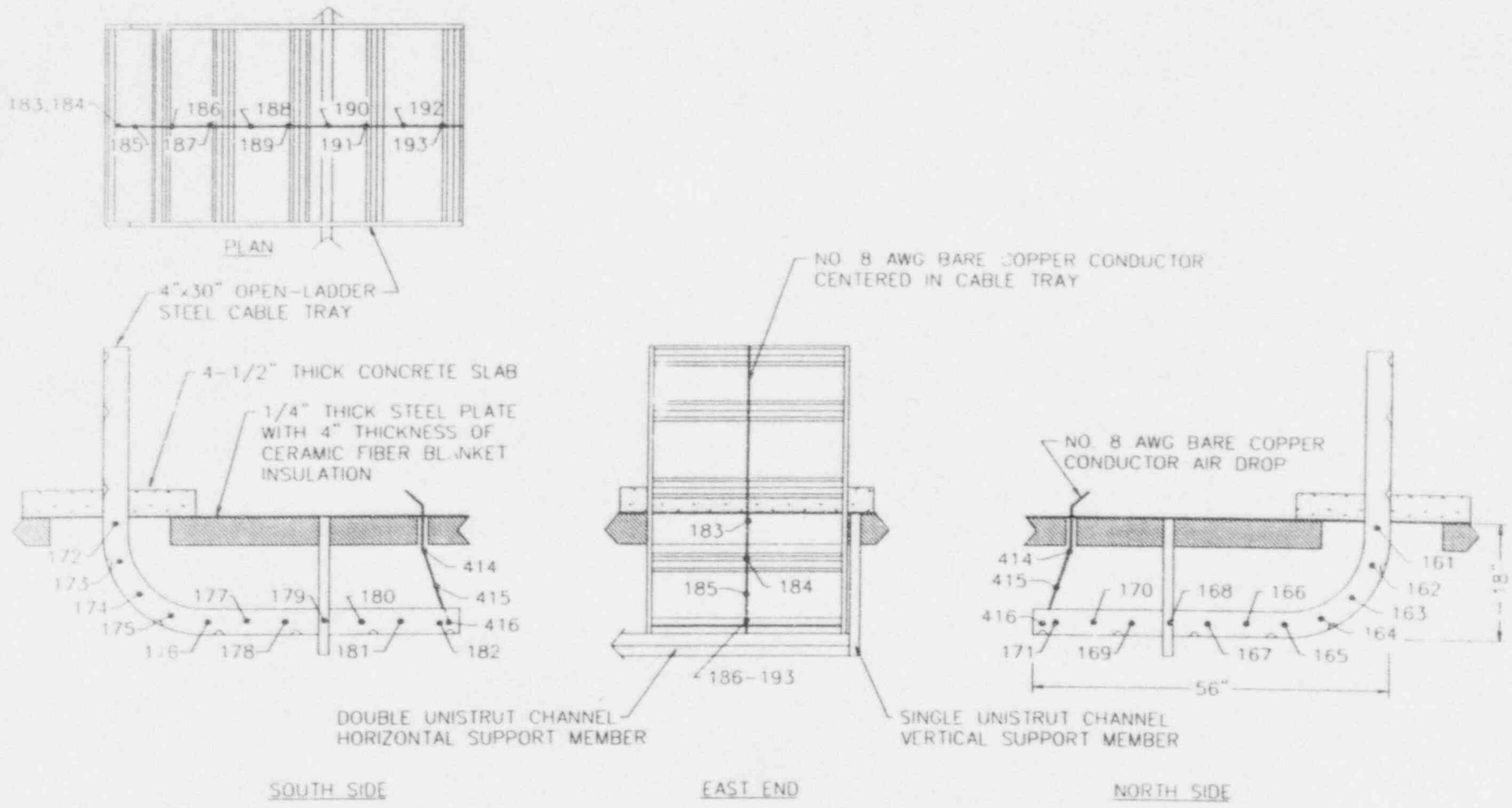
TC NOS. 1-4 ON WEST SIDE OF CONDUIT.
TC NOS. 5-8 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 5 COINCIDES WITH TC NO. 1.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE F

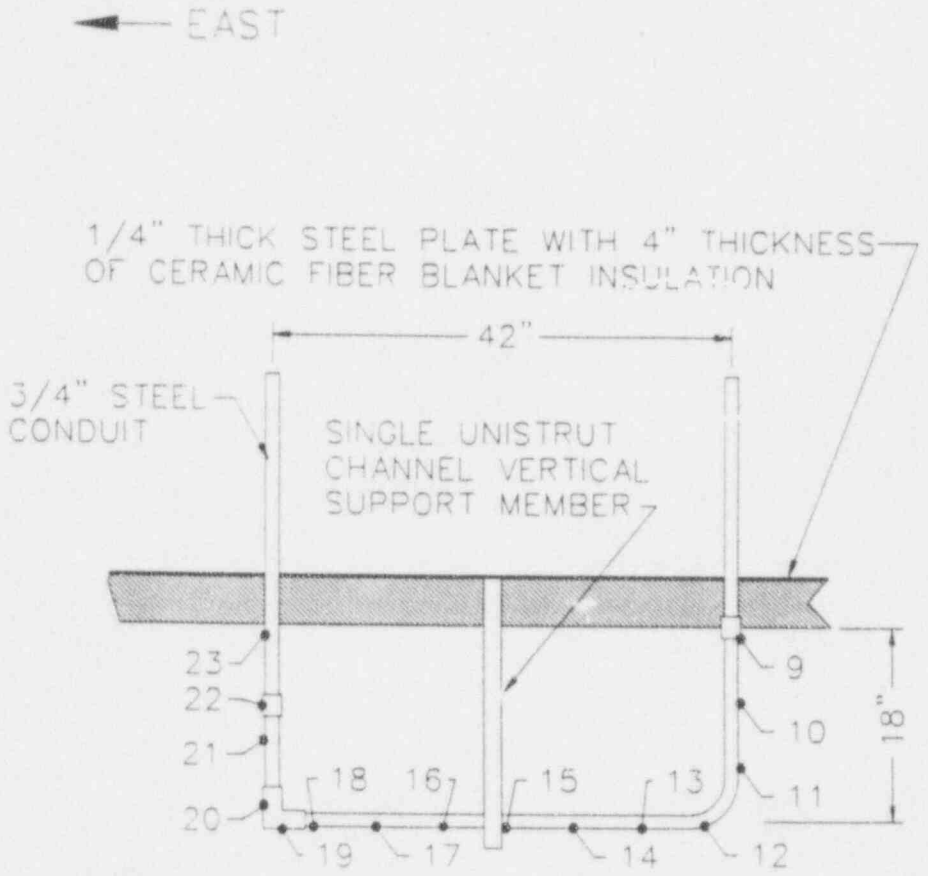


TC NOS. 261-273 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN ALUMINUM TUBE TRACK. TC NO. 261 COINCIDES WITH TC NOS. 235 AND 248 ON TUBE TRACK.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE G

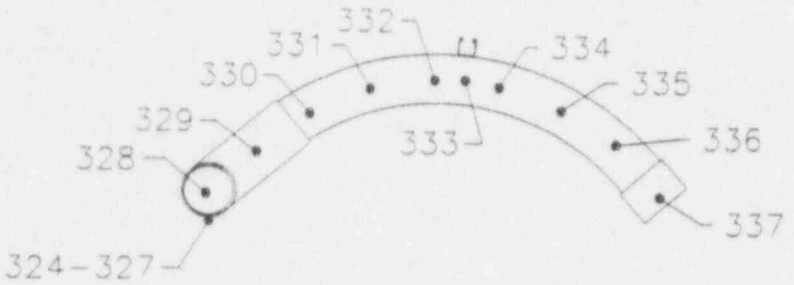


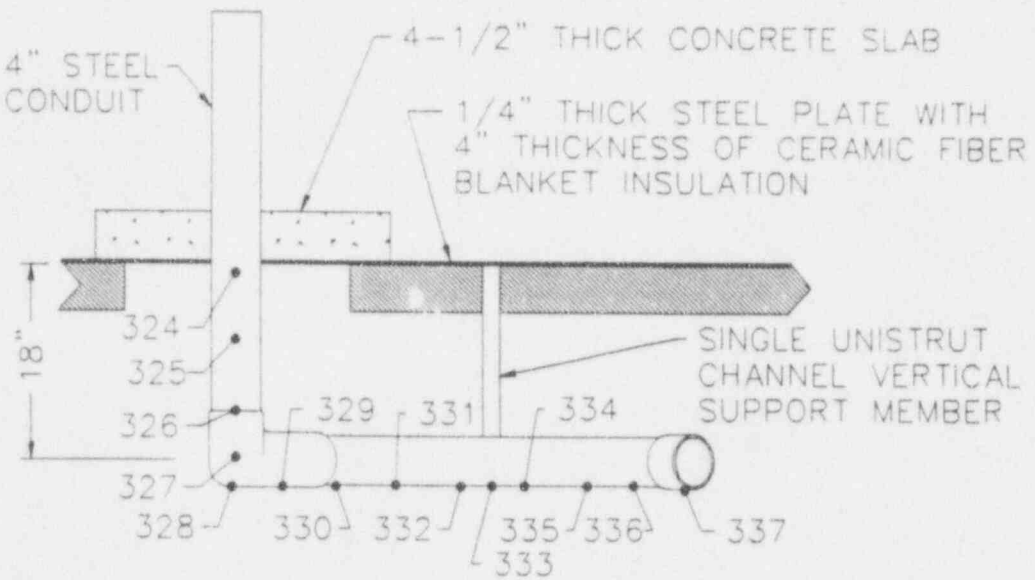
CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE H



TC NOS. 25-38 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 25 COINCIDES WITH TC NO. 9.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE I

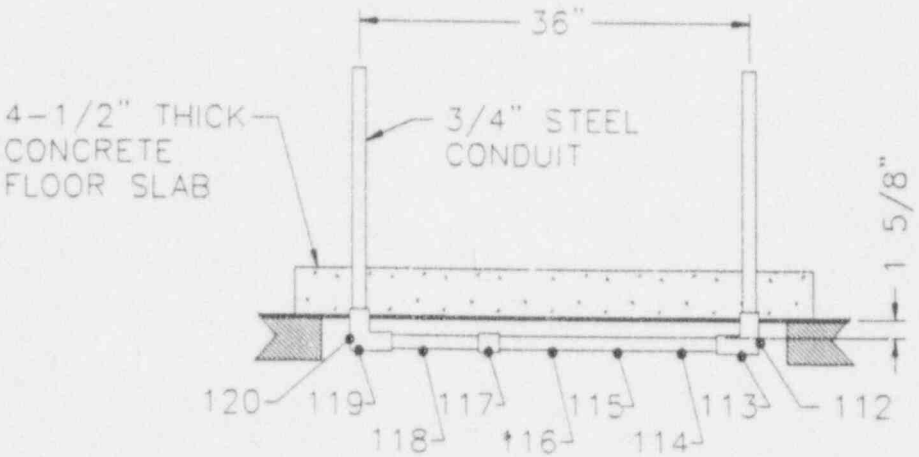




TC NOS. 338-349 & 426 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 364 COINCIDES WITH TC NO. 350. TC NO. 426 COINCIDES WITH TC NO. 337.

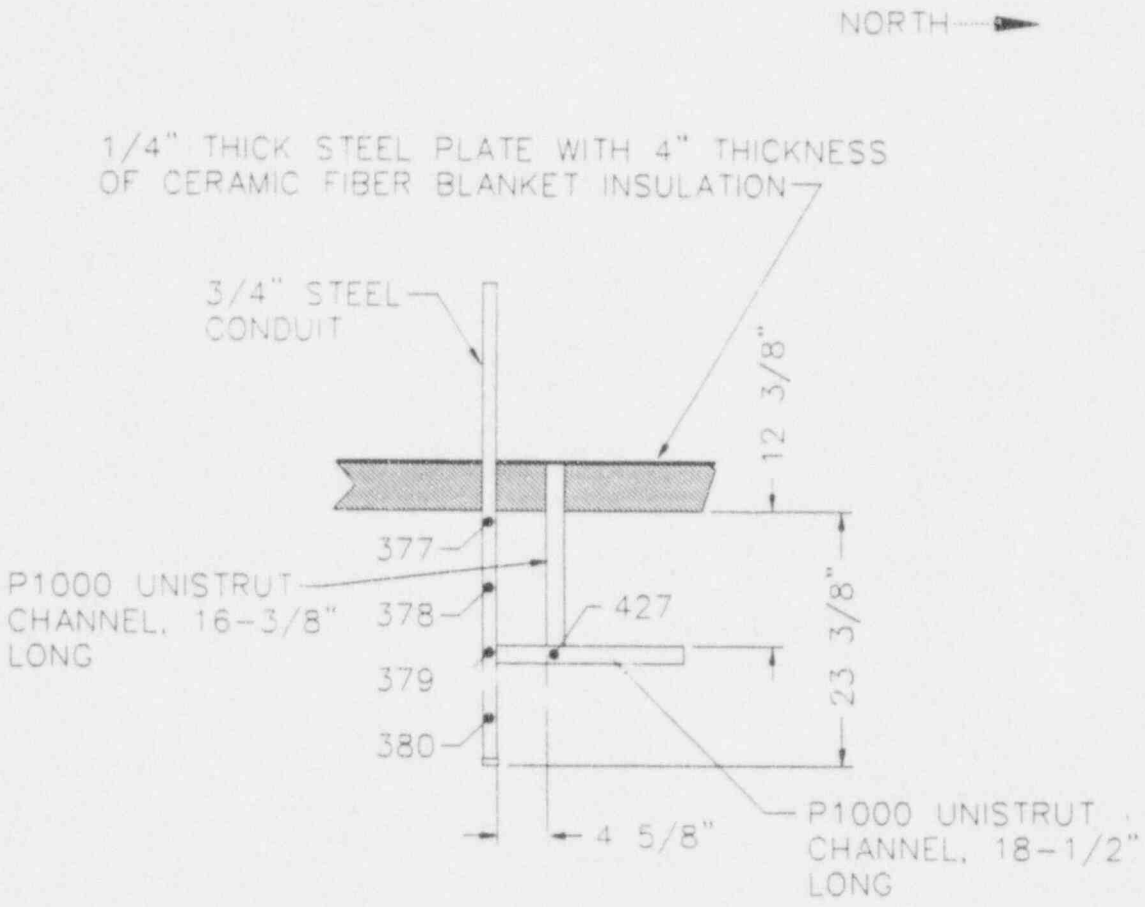
CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS-
ARTICLE J

EAST →



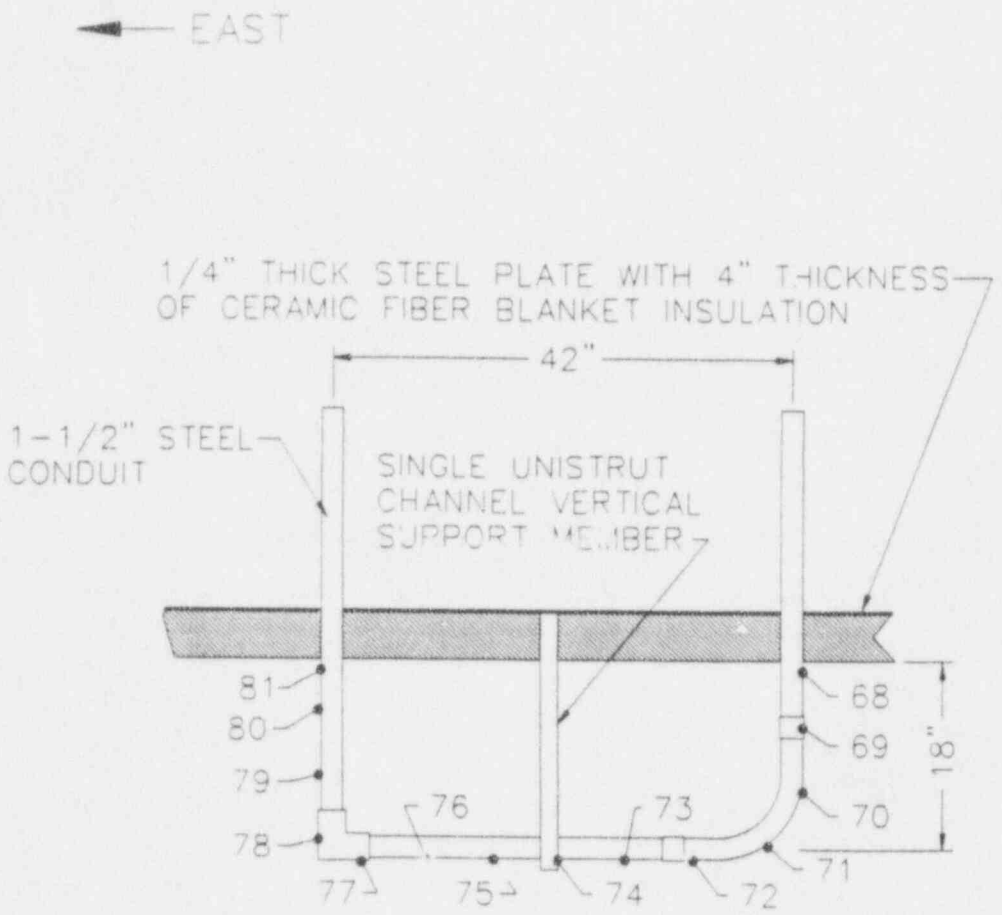
TC NOS. 121-127 (6" OC) ON NO. 8 AWG
BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 121COINCIDES WITH TC NO. 112.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE K



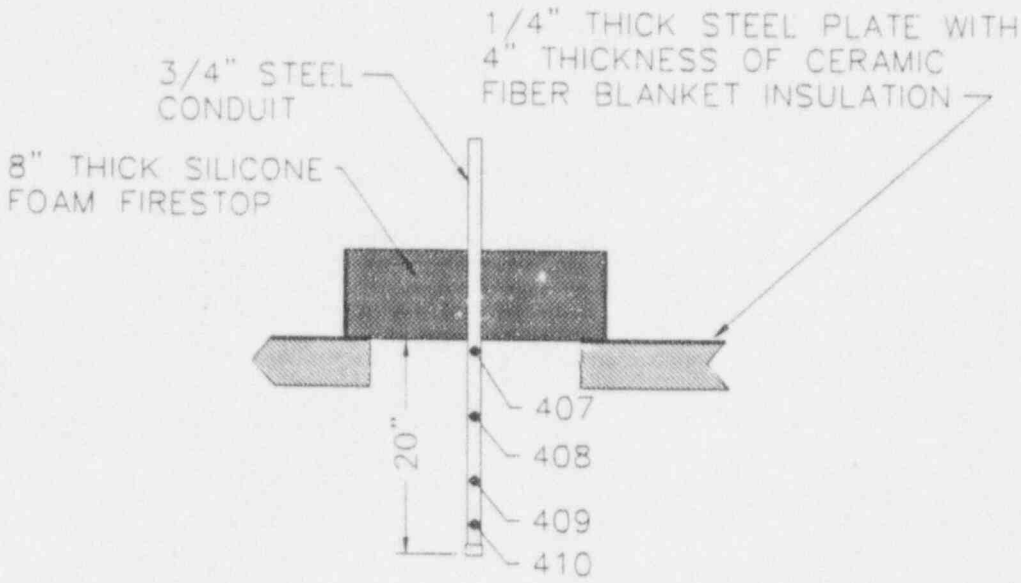
TC NOS. 377-380 ON EAST SIDE OF CONDUIT.
TC NOS. 381-384 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 381 COINCIDES WITH TC NO. 377.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE L



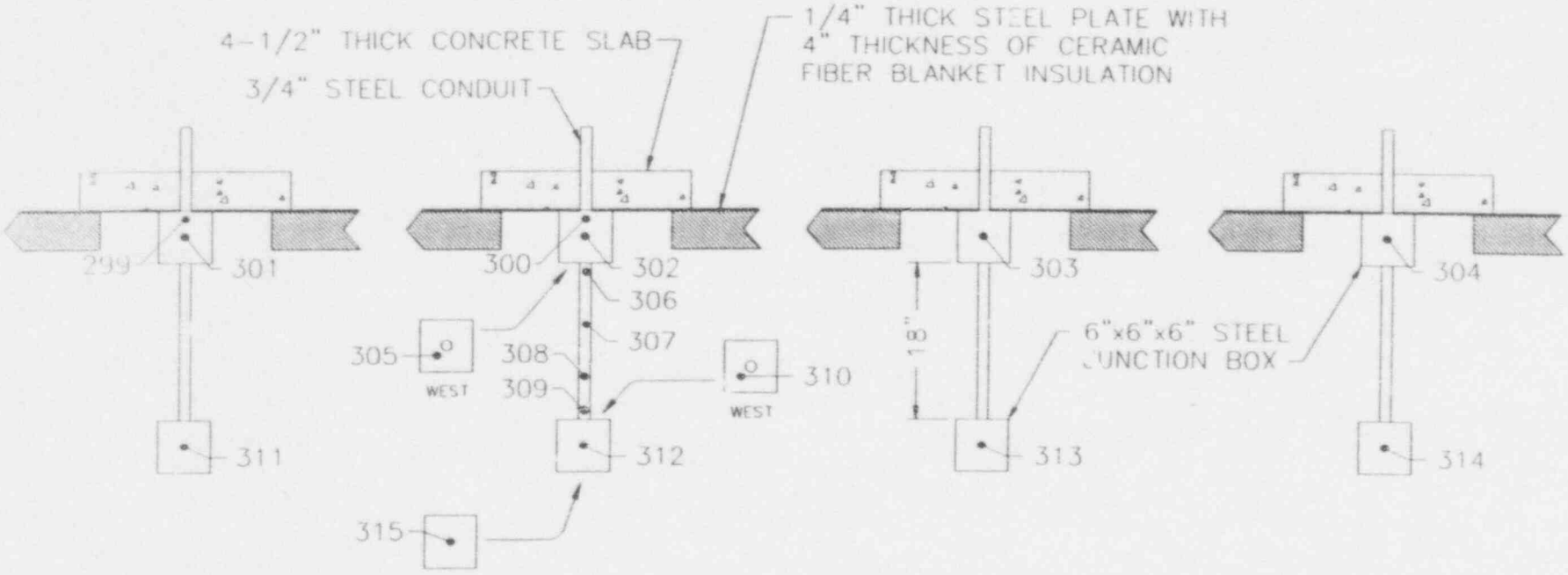
TC NOS. 82-95 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT.
TC NO. 82 COINCIDES WITH TC NO. 68.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE M



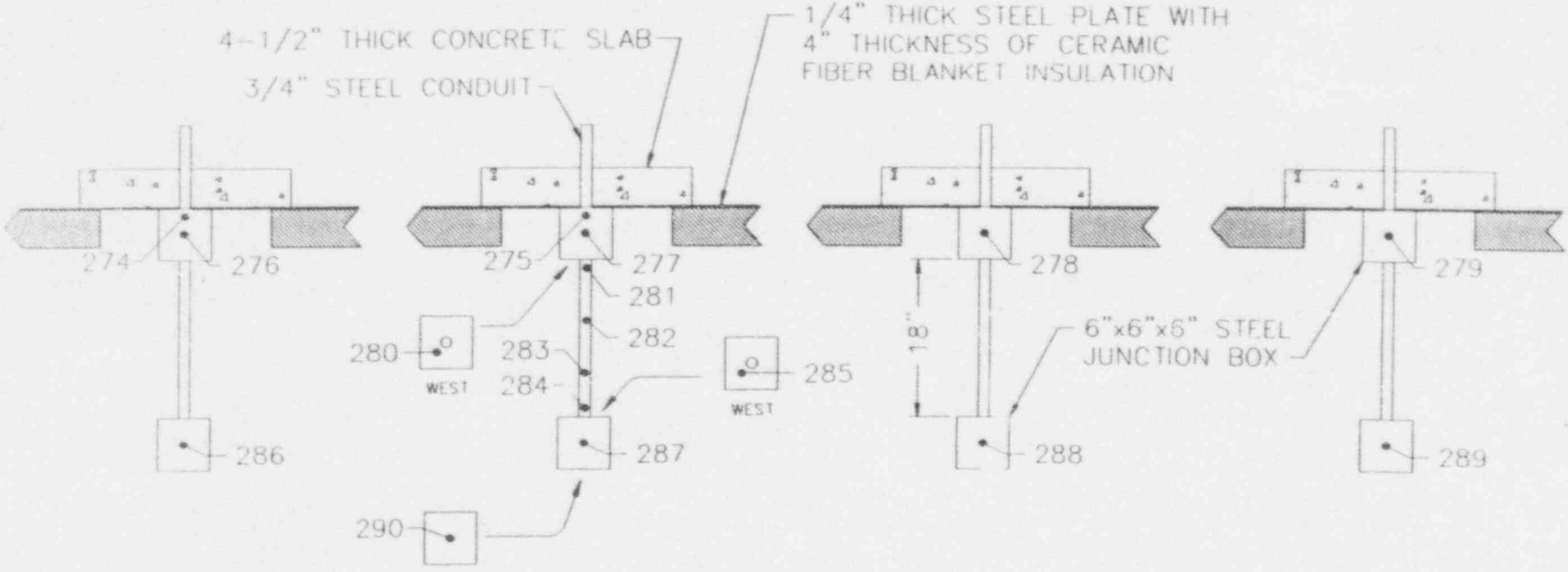
TC NOS. 417–420 (6" OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT. TC NO. 417 COINCIDES WITH TC NO. 407.

CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS –
ARTICLE N



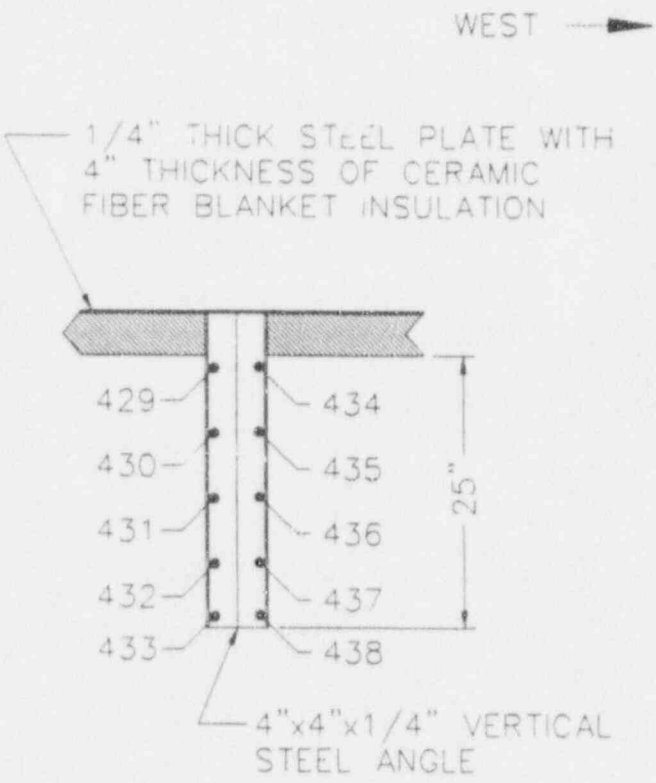
TC NOS. 316-323 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 316 COINCIDES WITH TC NOS. 299 & 300. TC NOS. 321-323 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE 0

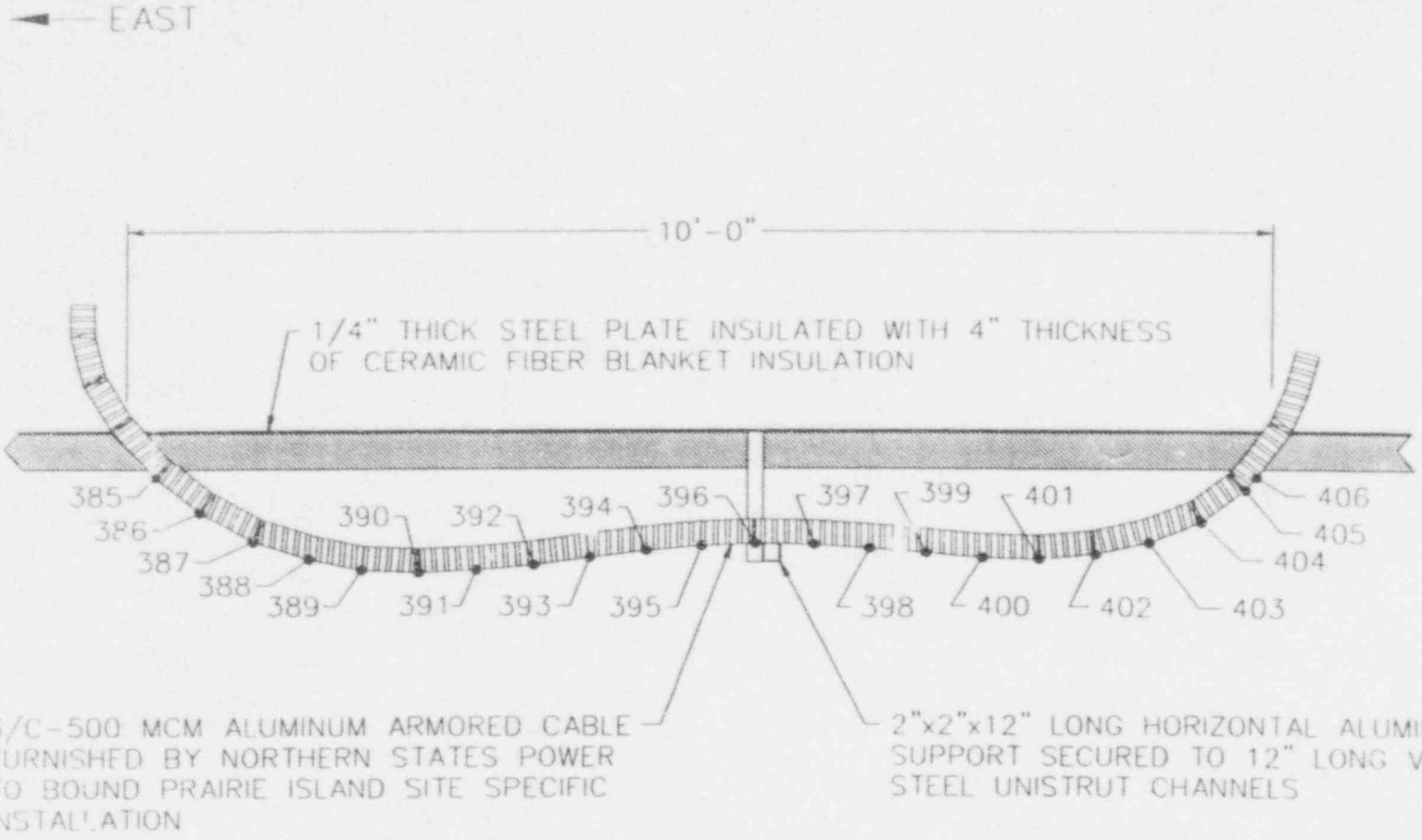


TC NOS. 291-298 (6"OC) ON NO. 8 AWG BARE COPPER CONDUCTOR WITHIN CONDUIT AND JUNCTION BOX. TC NO. 291 COINCIDES WITH TC NOS. 274 & 275. TC NOS. 296-298 ON COPPER CONDUCTOR COILED WITHIN THE LOWER STEEL JUNCTION BOX.

CONSTRUCTION DETAILS & THERMOCOUPLE LOCATIONS - ARTICLE P



CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE R



CONSTRUCTION DETAILS &
THERMOCOUPLE LOCATIONS -
ARTICLE Q

NBK – FACSIMILE REQUEST FORM ATTACHMENT 4

Underwriters Laboratories Inc.®

FAX NUMBERS
ME - (516) 271-8259
RTP - (919) 549-1842
SC - (408) 296-3256
CAM - (360) 817-6000
TW-FUS - 01-886-2-717-2405
TW-ES - 01-886-2-891-7644
HK - 01-852-695-8196

TO: ☑ 5A NBK COMMUNICATIONS CENTER
(5A Reception)

Date: 4-22-97

FAX No. (847) 272-2020 (If PROBLEMS (847) 272-8800 X 2021)
PLEASE TRANSMIT TO: (Circle or Check as Appropriate)

MEL SC CAM RTP HK TW (FUS) TW (ES) OTHER _____

TOTAL No. PAGES 3

NAME: Steven West

ORGANIZATION: USNRC

CITY, STATE, COUNTRY:

FAX NO.: 301 415 3577

SUBJECT: Transco

MESSAGE: Following are the test observation which you requested

Regards
Edward A. Johnson

SPECIAL INSTRUCTIONS:

REQUESTED BY: Johanson EMPLOYEE NO.: 17811

DEPARTMENT/SECTION: 4411 B EXT.: 42075

NUMBER OF ATTEMPTS: OPERATOR:

2000-5A
1/96

Record of Test Observations

File No.: R18500
Project No.: 97NK4087
Date: April 10, 1997

Client: Transco Inc.
Recorded By: M. Izydorek

Test Time Hr:Min:Sec	Exposed (E) or Unexposed (U) Surface	Article No.	Observation
0:0:5:00	E	All	All of the exposed material was charred and black in color.
0:0:6:15	E	N	The bottom piece of material (the cap) fell form the article.
0:08:22	E	B	Flames were issuing from the sample.
0:09:40	E	All	Flames issued from the exposed surfaces of the articles near the top of the exposed surface.
0:12:56	U	All	Smoke was issuing from the entire unexposed surface with the heaviest amount from Article H.
0:15:07	E	H	A crack, running in a North-South direction had developed at the West side of the article. the crack was 1/8 in. deep.
0:19:21	E	B,F,C,M	Flames continued to issue from the exposed surface of the articles.
0:20:03	E	All	The surfaces were becoming beige in color.
0:31:23	E	H	There were gaps present between the banding straps and the bottom surface of the protection material.
0:37:36	E	All	The surfaces were becoming white in color.
0:41:43	E	P	There was a slight separation in the material on the bottom surface of the protection material.
0:52:57	E	H	A Westerly view of the article shows a 1 in. separation near the West end on the bottom of the article.
1:10:26	E	J	On the South end of the article at the interface of the vertical and horizontal runs, there were two 1/4 in. wide openings in the protection material.
1:29:37	E	H	The area described at 0:15:07 had opened to a width of 2 in.
1:30:17	E	J	The openings described at 1:10:26 had closed.
1:33:28	E	G	A "flap" of protection material, 3 x 4 in., was hanging at the interface with the hanger.
1:35:18	E	Q	Heavy black smoke accompanied by flames was issuing from the article at the center and at both ends where it entered the furnace chamber. These flames were impinging on Article N.
1:49:24	E	B	Flames and black smoke issued from the top of

			the sample.
1:50:31	E	B	An area of flames issued from the bottom of the article at the interface with the support near the center of the article.
2:00:00	E	All	No significant changes observed.
2:16:00	E	A	the West half of the article fell to the furnace floor.
2:35:35	E	Q	The heavy black smoke ceased. Gray smoke issued from the center of the article at the bottom. The smoke was issuing from a crack.
2:40:00	E	All	Slight changes in color had occurred
2:41:03	E	Q	The crack described at 2:40:00 was 2 in. wide.
3:00:00	E & U	All	Fire test terminated.