FIRE ENDURANCE TEST OF A THERMO-LAG® 330-1 FIRE PROTECTIVE ENVELOPE (Two 3 in. Conduits with Junction Boxes)

Project No. 12340-94367c
Scheme 10
Assembly 1

FIRE ENDURANCE TEST TO QUALIFY A PROTECTIVE
ENVELOPE FOR CLASS 1E ELECTRICAL CIRCUITS

December 2, 1992

Prepared For:

TU Electric
COMANCHE PEAK STEAM ELECTRIC STATION
P.O. Box 1002
Glen Rose, Texas 76043-1002

OMEGA POINT LABORATORIES

ABSTRACT

A conduit assembly, consisting of two 3 in. conduit loops passing into a horizontal and a vertical junction box, clad with a nominal thickness of 1/2 in. Thermo-Lag® 330-1 and various upgrades as described herein were evaluated in accordance with the Texas Utilities Electric TEST PLAN, Rev. 8, based essentially on the requirements of American Nuclear Insurers Bulletin B.7.2, 11/87, Attachment B entitled: "ANI/MAERP RA Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class IEEE Electrical Circuits", Revision I, dated November 1987, and the Nuclear Regulatory Commission letter dated October 29, 1992 (see Appendix K.) This assembly was found to meet the requirements of those documents for a fire resistance period of 60 minutes

The details, procedures and observations reported herein are correct and true within the limits of sound engineering practice. All specimens and test sample assemblies were produced, installed and tested under the surveillance of either Texas Utilities' or the testing laboratory's in-house Quality Assurance Program. This report describes the analysis of a distinct assembly and includes descriptions of the test procedure followed, the assembly tested, and all results obtained. All test data are on file and remain available for review by authorized persons.

Constance A. Humphrey
Manager, QA Dept.

1/7/93
Date

Deggary N. Priest
President

1/7/93
Date

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INTRODUCTION

The protection of vital electrical circuits from the effects of an external fire exposure is of primary concern in the design and construction of an electrical power generating plant. Typical "fire protective envelopes" are designed to protect the contents of an electrical raceway for fire exposure periods of one to three hours, during which time the electrical circuitry must remain functional.

The external fire exposure selected to evaluate protective envelope systems is that described in the ASTM E119-88 Fire Tests of Building Construction and Materials (E119 Time-Temperature Curve, described later in this document.)

Typical fire test programs involve the selection and construction of a specific electrical raceway system, instrumentation for thermal and circuit integrity measurements, followed by the application of the protective envelope system by qualified personnel.

This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment that takes into account all the factors that are pertinent to an assessment of the fire hazard of a particular end use.

OBJECTIVE

The objective of this project was to evaluate a specific protective envelope system for use as a 1-hour fire-protective envelope for redundant electrical systems. The entire program was carried out in accordance with the Texas Utilities Electric, TEST PLAN, *One Hour Fire Endurance Tests of Articles Protected with the Thermo-Lag® 330 Fire Barrier System*, Rev. 8, which may be found in Appendix B of this document. For reasons of clarity and to reduce redundancy, many items discussed in the Test Plan have not been duplicated elsewhere in this document.

TEST PROCEDURE

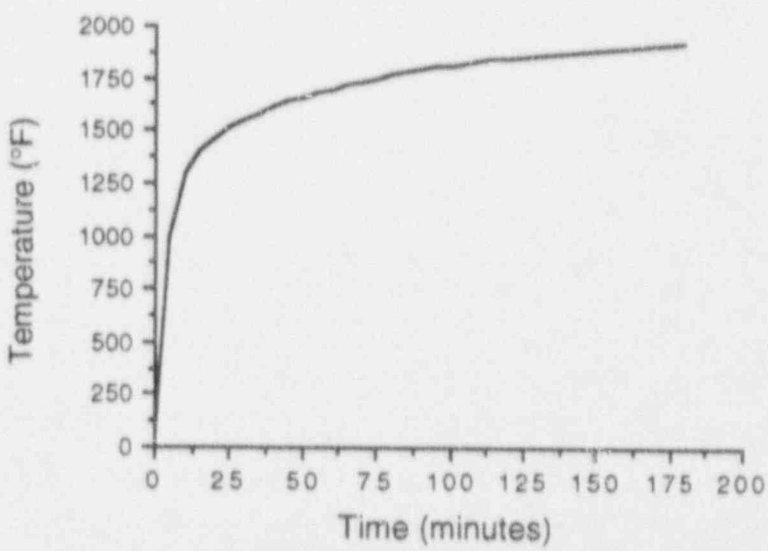
This entire test program was performed in accordance with Texas Utilities Electric TEST PLAN, Rev. 8, which has been included in Appendix B. Many of the specific details of this project will be found in that document.

FIRE TEST FURNACE

The test furnace is designed to allow the specimen to be uniformly exposed to the specified time-temperature conditions. It is fitted with symmetrically located natural gas burners designed to allow an even heat flux distribution across the surface of a test specimen.

The temperature within the furnace is determined to be the mathematical average of thermocouples located symmetrically within the furnace and positioned 12 in. away from representative parts and locations of the test specimen. The exact positioning of the thermocouples is such that the average fire exposure across the entire test specimen can be determined. The materials used in the construction of these thermocouples are those suggested in the E119 test standard. During the performance of a fire exposure test, the furnace temperatures are monitored at least every 15 seconds and displayed for the furnace operator to allow control along the specified temperature curve. All data is printed to paper every 30 seconds and saved to magnetic disk every minute.

The fire exposure is controlled to conform with the standard time-temperature curve shown in Figure 1, as determined by the table below:



Temperature (°F)	Time (min)
1000	5
1300	10
1462	20
1550	30
1700	60
1792	90
1850	120
1888	150
1925	180

Figure 1

The test furnace used consists of a large horizontal exposure chamber, with an internal dimension of 12 ft. long and 7 ft. wide. The furnace is equipped with diffuse-flame natural gas burners symmetrically located across the floor of the furnace and controlled by individual gas flow valves, with the overall gas flow to the furnace being controlled by a single overall gas control valve. Capable of a maximum heat output of 5 million Btu/hour, these burners are arranged well below the exposed face of the specimen to ensure an even temperature at the surface of the specimen. Windows are located on two sides of the furnace to allow observation of the specimen during fire exposure. The depth of the furnace is variable, being increased the desired amount by the addition of concrete blocks around the perimeter ledge. These blocks are lined with ceramic fiber blanket to minimize the heat loss from the furnace and to decrease the time required for the furnace walls to heat up. For these tests, the walls are built up from their normal height of 40 in. to a total height of slightly over 79 in. from the furnace floor to the top of the ledge.

The fire test is controlled according to the standard time/temperature cure, as indicated by the average temperature obtained from the readings of the furnace interior thermocouples symmetrically located across the specimen, 12 in. away. The thermocouples are enclosed in protection tubes of such material and dimensions that the time constant of the thermocouple assembly lies between 5.0 and 7.2 minutes, as required by the E 119 standard. The furnace temperature during a test is controlled such that the area under the time/temperature curve is within 10% of the corresponding area under the standard time/temperature curve for the one hour test period.

The furnace pressure is controlled to be as nearly neutral with respect to the surrounding laboratory atmosphere as possible, measured at the vertical mid-height of the test specimen. Adjusting the neutral plane at that position results in a nominal +0.015 in. WC pressure at the top of the specimen (under surface of the deck) and −0.015 in. WC pressure at the bottom of the specimen.

THERMOCOUPLES

Temperatures on the interior of the fire protected systems are measured with Type K, 24 gauge, Chromel-Alumel electrically welded thermocouples formed from Chromel and Alumel wires of "special limits of error (±1.1°C)," and covered with braided fiberglass insulation (unless thermocouple lead routing requires higher temperature resistance, in which case the thermocouple leads are insulated with ceramic fiber or Nexel® insulation).

CIRCUIT INTEGRITY

The purpose of the circuit integrity measurement was to enable the detection of the occurrence of a short between any two conductors or ground (the conduit steel) or an open circuit. Since the failure of any conductor within the system would result in a failure of the protective envelope, it was not important to be able to determine exactly which conductor failed, but merely that it did fail.

Consequently, all conductors in each cable type were connected in a single series circuit, with a 100Ω 1/4 watt resistor between each. (For instance, if a raceway contains 7C/#12 AWG cables, all of the conductors of a particular color are connected into a single, series electrical circuit. Each of these is then connected to the others, in an overall series circuit, with a 1/4 watt, 100Ω resistor between each, so that if a short occurs between any two [or more] conductors within a single cable, a minimum of 100Ω will be dropped from the circuit [see section on Circuit Integrity for complete details].) Finally, a 1000Ω resistor was installed between this circuit and a 12 volt battery to act as a load resistor for the data acquisition system, and a 100Ω resistor was connected between the end of the circuit and system ground (See Appendix D: CIRCUIT INTEGRITY DETAILS.)

The resultant circuit allows the measurement of steady-state voltage drops across the entire circuit, which will change accordingly as any combination of the resistors is removed from the circuit by the shorting of any conductors.

Prior to beginning the fire test, the circuit integrity signals were connected to the data acquisition system and their inputs verified. The voltage measured (using a calibrated 4-1/2 digit DVM) was noted and recorded as V_i (initial voltage). Then one of the 100Ω resistors was shorted, and the resultant voltage measured and saved as $V_{-100\Omega}$ (voltage with 100Ω removed from the circuit). This, then, indicates the minimum voltage change from V_i that would show a short had occurred in any of the cables. Following the completion of the fire exposure and hose stream test, a final voltage was measured and recorded as V_f (final voltage). Continuous collection of the circuit integrity voltage signals was performed during the entire fire exposure and hose stream tests and data collection was terminated after the hose stream test was complete. See Appendix D: CIRCUIT INTEGRITY DETAILS for circuit schematics for each of the cable types in this test.

INSULATION RESISTANCE TESTING

As an additional check on the condition of the conductor insulation, insulation resistance testing was performed on each cable type before the fire and after the hose stream test. The insulation resistance tests were performed using a TU Electric owned and calibrated adjustable megohmmeter, set to the 500 volt DC level for insulation resistance testing on all instrumentation cables and the 1500 volt DC level for all power and control cables. To perform the insulation resistance test, the connection to ground was broken for each cable type and the test instrument leads connected from conductor to conductor and from each conductor to ground. Any leakage between that cable type's conductors and ground, or from conductor to conductor, is readily detected in this manner. Upon discovery of an ohmic reading which is lower than the criteria set in the October 29, 1992, NRC Letter (Appendix K) , the reading will be documented in the test report and the splices between cables will be broken and each cable tested separately to determine which cable conductor is bad or if there is a bad splice or test lead. Provided the low reading is on a cable, that cable is then removed from the raceway and visually examined to determine where and how the failure occurred.

DATA ACQUISITION SYSTEM

The outputs of the test article thermocouples and circuit integrity lines and the furnace probes are monitored by a data acquisition system consisting of a John Fluke Mfg. Co., Model HELIOS 2289A Computer Front End, a John Fluke Mfg. Co., Model HELIOS 2281A Extender Chassis (in the case of the 200 channel capacity unit), and an Apple Computer Co., Macintosh Classic microcomputer, a 100 or 200 input thermocouple jack panel and voltage input terminal strips. The Computer Front End is connected to the RS422 Serial Interface Port of the Macintosh and the Extender Chassis is serially connected to the Computer Front End. The computer is programmed in Microsoft BASIC to command the HELIOS units to sample the data input lines (from the thermocouple jack panel and/or the voltage input terminal strips), receive and convert the data into a digital format, and to manipulate the raw data into usable units for display on screen and paper and for saving to floppy disk.

Two data acquisition units are used for the majority of tests due to the large number of data channels. One data acquisition unit is configured for monitoring 200 data input channels and is used to sample all (or most) of the test article thermocouples. A second data acquisition unit is configured for monitoring 100 data input channels and is used to sample the circuit integrity lines of the test article, ambient laboratory temperature, furnace temperature probes and, if necessary, the remaining test article thermocouple inputs.

HOSE STREAM TEST

According to the Test Plan, following the fire exposure test, the test specimen is removed from the test furnace, lifted approximately 6 ft. from the ground (as measured from the lowermost part of the specimen), slowly turned (nominally 6 to 8 revolutions per minute) and exposed to the impact, erosion, and cooling effects of a hose stream directed perpendicularly at the exposed surface of the test specimen as outlined in the standard. The stream is delivered, for a minimum period of 5 minutes, through a 1-1/2 in. fog nozzle with an adjustable stream, with a nozzle pressure of 75 psi, a spray angle of 30° and with the tip of the nozzle a distance of 5 ft. from the exposed face. The nozzle is to flow a minimum of 75 gpm during the hose stream test. It is recognized that, with a three-dimensional object, not all surfaces can be attacked by the hose stream test. For this reason, the specimen is lifted high enough to allow the stream to play against the sides, inside and outside vertical surfaces and the underside of the item, resulting in little, if any, direct force being applied to the inside top surface of the specimen.

BARRIER INSPECTION

Following the hose stream test, all barrier materials, joints and seams are to be visually inspected for burnthrough or openings in the barrier envelope in accordance with the acceptance criteria outlined in the NRC letter dated October 29, 1992, (Appendix K.)

VISUAL CABLE INSPECTION

Following the barrier inspection, the barrier materials will be systematically removed and the condition of the various assembly aspects will be noted (see Post Test Observations). The cables in each system will be visually inspected for damage in accordance with the acceptance criteria outlined in the NRC letter dated October 29, 1992, (Appendix K.) If any visible thermal damage exists, the outer jacket of the cable in question will be slit open and the condition of the inner conductor insulation will be assessed.

TEST ASSEMBLY

TEST DECK

The test deck consisted of a perimeter of 3 in. structural steel channel, welded together into an 8 ft. by 13 ft. rectangle, with the flanges outward. Over the top of this framework a layer of 10 GA steel sheet was welded to form a continuous, smooth top. Pipe sockets (4 in. ø, sch. 40 steel pipe) were then welded onto each corner, so that 3 in. ø steel pipe legs could be attached to hold the assembly at a comfortable working level. Holes were then cut into the deck steel at the appropriate locations to allow the test item to be installed into the deck assembly. Structural elements were typically attached to the test item above the deck level, to rigidly fix the item to the deck. Following the installation of the test item, the deck was reinforced with steel channel positioned so as to minimize any warping, bending or sagging during the fire test (the size of the channel being selected after consideration of the amount of stiffness required for that particular assembly), and then insulated on the underside with two 2 in. thick layers of 6 pcf ceramic fiber blanket, held in place with impaling pins, spaced a maximum of 12 in. o.c. The figure below illustrates a cross-sectional view of one edge of a typical deck assembly, showing the structural steel, the decking and the insulation.

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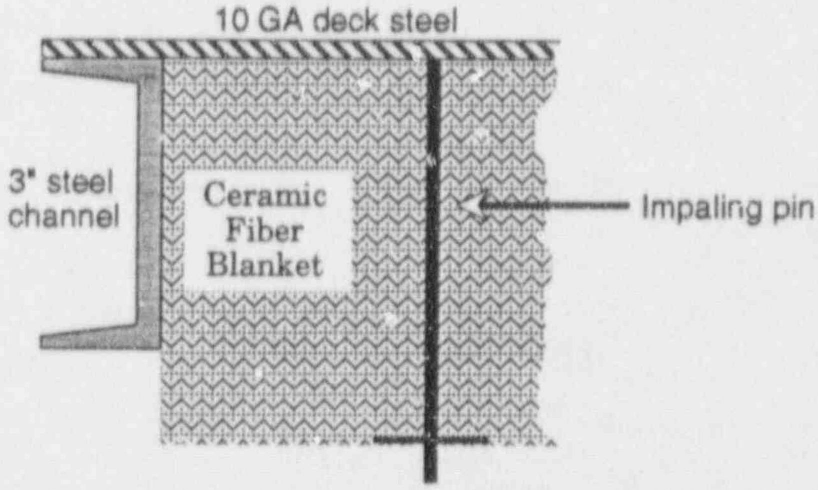
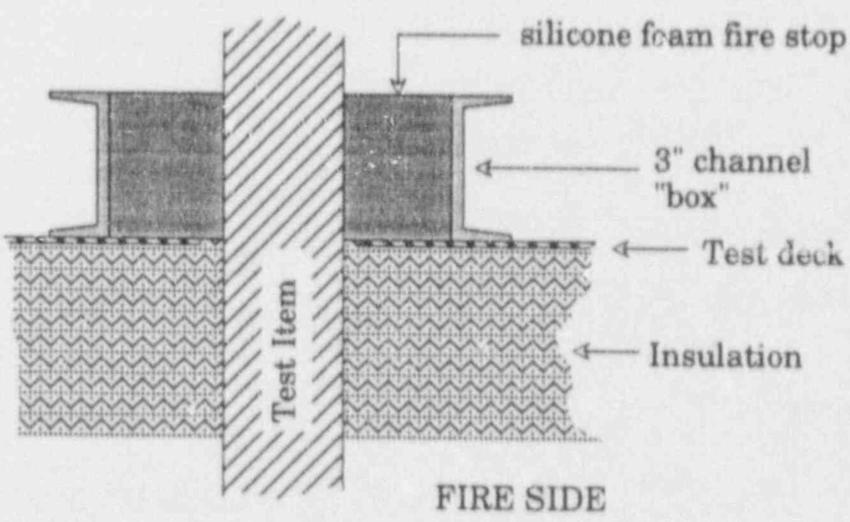


Following complete installation of the test item, the underside of the deck was insulated as previously described, with the ceramic blanket being pushed into direct contact with the test item. A "box" around the penetration point in the deck steel was formed of 3 in. steel channel on edge and the enclosed area completely filled to a nominal depth of 3 in. with silicone foam fire seal.



CROSS-SECTION VIEW OF POINT OF PENETRATION
OF THE DECK BY A TEST ITEM

This method of sealing around the point where a test item penetrates the test deck has proven very effective at withstanding the 60 minute fire exposure. Since the penetration seal is considered a part of the support system, and is not in itself being evaluated by this test method, the important aspect of the seal is that it be "typical" of a field installation and withstand the fire exposure test. The silicone foam system used in this design does not unduly act as a heat sink, nor does it offer significant physical support to the penetrating item. Its purpose is to seal the gap without affecting the evaluation of the protective envelope system.

TEST ITEMS (GENERAL)

As with conduit materials installed at CPSES, the materials used in the test were subjected to on-site commercial grade dedication programs prior to acceptance and subsequent installation. The conduit materials used in the test were provided to Texas Utilities by various vendors, and are similar in design and representative of those installed at CPSES.

All test items were constructed from materials extracted from TU Electric's Comanche Peak Steam Electric Station stock material storage areas in accordance with existing site procedures.

Electrical cables used in this test consisted of site-specific cables supplied by TU Electric and taken from CPSES lot inventory. These cables were as follows:

CABLE TYPE	CABLE FUNCTION	DESCRIPTION	DIAMETER (in.)	CROSS-SECTIONAL AREA (in²)
W-020	Power	3C/#6 AWG 600v.	0.980	0.754
W-023	Power	3C/#8 AWG 600v.	0.747	0.438
W-046	Control	9C/#12 AWG 600v.	0.690	0.374
W-047	Control	7C/#12 AWG 600v.	0.605	0.287
W-048	Control	5C/#12 AWG 600v.	0.575	0.260
W-063	Instrumentation	4 Shielded, Twisted Pair 16 AWG 600v.	0.737	0.427
W-071	Instrumentation	5C/#16 AWG 600v.	0.474	0.176

The diameters and cross-sectional areas listed herein represent the Laboratory's average of ten measurements of each cable type.

Thermo-Lag® 330-1 Materials

Thermo-Lag® materials were procured from Thermal Science, Inc. (TSI), St. Louis, MO. The Thermo-Lag® materials extracted from CPSES site stock were representative of materials installed in the plant. Each one hour rated Thermo-Lag® 330-1 Flat panel and each one hour rated Thermo-Lag® 330-1 V-ribbed panel is 1/2 in. thick (nominal) x 48 in. wide x 78 in. long, with stress skin monolithically adhered to the panel on one face. Each panel was received with 350 Topcoat factory applied. The stress skin is installed adjacent to the surface of the protected commodity. Other materials supplied by TSI were 330-69 stress skin sheets 4 ft. x 7 ft., 350 Topcoat (two part water-based mixture), 330-1 trowel grade subliming compound (used with 330-1 panels). All Thermo-Lag® panels were measured, saw cut and installed onto the respective test assembly by Peak Seals craft personnel using approved CPSES drawings, procedures and specifications. Installations were inspected by CPSES-certified quality control inspectors.

Other Materials

Materials used in conjunction with Thermo-Lag® components, but furnished by other vendors included: Silicone elastomer (Promatec 45B) seal material, Dow Corning 3-6548 RTV silicone foam fire stop material and Thermal Ceramic Kaowool M-Board (ceramic fiber damming board). These materials were all previously supplied by Promatec, Houston, Texas. Other commercial grade products used were: 1/2 in. wide x 0.020 in. thick type 304 stainless steel rolled-edge banding straps with wing seals; 16 to 18 GA stainless steel tie wire; and, 0.010 in. stainless steel sheet metal.

TEST ITEM (CONDUITS & JUNCTION BOXES)

This assembly consisted of two parallel 3 in. ø conduit loops passing through two junction boxes. Each conduit loop extends through the right side of the deck, into the 18 in. side of an 18 in. x 12 in. x 6 in. junction box (vertically situated, 21 in. above the horizontal raceway), into a 90° elbow (long side horizontal), into the 18 in. side of a second 18 in. x 12 in. x 6 in. junction box (horizontally situated mid-span of the horizontal raceway), into a second 90° elbow (long side vertical) and back up through the left side of the deck. Both of the conduit assemblies extended three feet above the surface of the deck.

JUNCTION BOX SUPPORTS

A single box tube steel support was fabricated to support the horizontal junction box mid-span of the conduit runs. The hanger consisted of a 29 in. long vertical section of 3 in. x 3 in. x 1/4 in. wall square steel tubing with a 1/2 in. thick, 12 in. square plate centered and welded to each end with a 1/4 in. fillet weld all around the tubing. The support was centered on and bolted to the top of the mid-span horizontal junction box with 1/2 in. hardware. This placement situated the bottom of the junction box 36 in. below the deck insulation.

ELECTRICAL CABLES

All electrical cables used in this project were site-specific for CPSES. Where possible, an approximate 1/3 mix of Power, Instrumentation and Control cables were pulled into each conduit. The internal cross-sectional areas for both conduits is as follows:

CONDUIT SIZE (INCHES)	CROSS-SECTIONAL AREA (in^2)
3	7.069

The table below shows the cable types used in each conduit, the number of each cable installed, the total cross-sectional area of each cable type and the percent of the total available area taken up by each type.

3 in. CONDUIT (two required)

CABLE TYPE	NUMBER PRESENT	CROSS-SECTIONAL AREA (in2)	% OF TOTAL AREA
W-020	1	0.754	10.67
W-023	1	0.438	6.20
W-046	1	0.374	5.29
W-047	1	0.287	4.06
W-048	1	0.260	3.68
W-063	1	0.427	6.04
W-071	3	0.528	7.47
TOTAL FILL =>		3.068	43.40

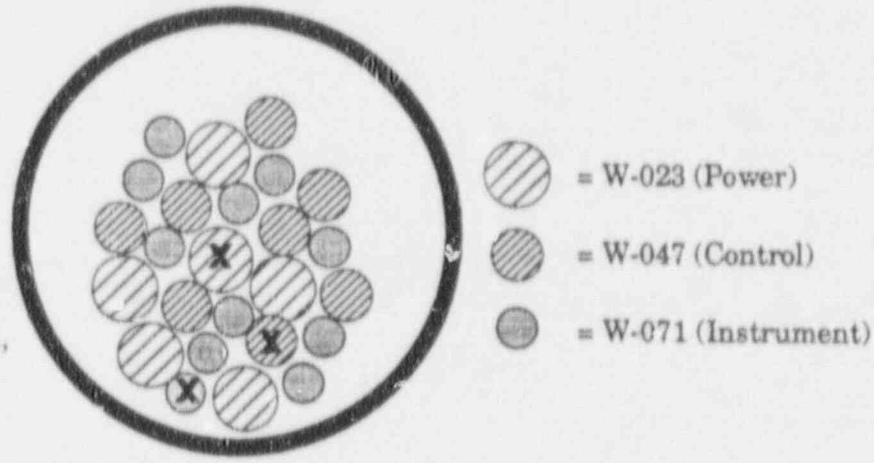
THERMOCOUPLE PLACEMENT

24 gauge, Type K, Chromel-Alumel electrically welded thermocouples (Special Limits of Error: ±1.1°C, purchased with lot traceability and calibration certifications) were attached nominally every 6 in. along one each of power, control and instrumentation cables, by placing the thermojunction in direct contact with the top surface of the cable and covering with a double wrap of glass

fiber reinforced electrical tape (Glass Cloth Electrical Tape, Class "B" Insulation, 1/2 in. wide, 3M Corporation, Item No. 27) for a minimum distance of 3-1/2 in.

In both 3 in. ø conduits, the instrumented Power cable was located at the nominal center of the cable bundle, while the instrumented Control cable was located midway in the bundle and the Instrumentation cable with thermocouples was located on the outside of the cable bundle.

Note: Exact cable placement is not shown here. This drawing is merely to illustrate the relative placements of the instrumented cables, marked by X's.



Cable Bundle in Conduit

In order to get a realistic measurement of the temperatures at the conduit steel, similar thermocouples were positioned nominally every 12 in. along the top surface of each conduit, being held in position by a short piece of Glass Cloth Electrical tape. The thermocouple leads were taped securely to the conduits at points away from the thermojunction by wrapping the tape completely around the conduit and thermocouple lead. Thermocouples were also located in each junction box. These thermocouples were held in position by clamping the junction under the head of a #8 x 32 x 1/4 in. long stainless steel round-head machine screw threaded into tapped holes from the inside of the junction box. One thermocouple was placed on the center of each side of the junction box. Two additional thermocouples were placed on the conduit entry and exit sides of the junction boxes, halfway between the conduit nut and the adjacent junction box side.

THERMO-LAG® INSTALLATION HIGHLIGHTS

Thermo-Lag® materials were installed in accordance with the instructions contained in the CPSES Site Procedures referenced in Test Plan, Rev. 8. Short abstracts of the installation are included herein to clarify specific details.

Drawings of the installed Thermo-Lag® on the test assembly are shown in Appendix J.

Thermo-Lag® 330-1 Flat Panel (1/2 in. nom. thickness)

These panels were used to construct the LBD box design, junction box (first layer) and support steel protective envelopes.

Thermo-Lag® 330-1 Subliming Trowel Grade Material

This material was used to pre-caulk all joints, seams and upgraded areas between pre-shaped sections, flat and V-ribbed panels and underneath and over stress skin.

Thermo-Lag® 330-1 Pre-Shaped Conduit Sections (1/2 in. nom. thickness)

This material was used to construct the 3 in. diameter raceway design protective envelopes.

Thermo-Lag® 330-1 V-rib Panel Material

This material was used as a second layer on each junction box.

Thermo-Lag® 330-1 V-rib Panel Orientation

V-rib panels were used only as a second layer on the junction boxes. As such, the ribs were installed in contact with the first layer of flat panels. On top and bottom (18 in. x 12 in.) surfaces, the V-ribs were oriented parallel to the conduit runs. On remaining junction box surfaces, the V-ribs were oriented perpendicular to the conduit runs.

Application Methods

Each 3 in. diameter raceway segment was covered first (prior to installing material on the junction boxes) with Thermo-Lag® 330-1 Pre-Shaped Conduit Material. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding material.

Each raceway LBD fitting was covered with a 330-1 flat panel material in a manner similar to an L-shaped box configuration. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding.

Each junction box was first covered with Thermo-Lag® 330-1 1/2 in. thick flat panel material. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding.

The tube steel support member was covered with a single layer of flat panel for a 9 in. distance from the V-rib panel surface of the horizontal junction box envelope. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel tie wires or banding material.

Upgrade Techniques

Following application of the flat panel layer, a second layer was applied to each junction box using Thermo-Lag® 330-1 V-ribbed panel material secured with stainless steel banding material. All joints were pre-caulked with Thermo-Lag® 330-1 Trowel Grade Material. A layer of Thermo-Lag® trowel grade (approximately 3/16 in. thick) was applied 2 in. minimum beyond all junction box joints. The trowel grade was allowed to set until "tacky" to the touch. Strips of 4 in. wide Thermo-Lag® 330-69 Stress Skin were applied (2 in. in each direction from a corner) over the "tacky" trowel grade and "worked in" to achieve proper bonding. The stress skin was secured in place using 1/2 in. long staples and stainless steel tie wire to hold it flat against the panel surface. A skim coat of Thermo-Lag® 330-1 Trowel Grade was applied over the stress skin.

Each raceway LBD box design was "upgraded" using approximately 3/16 in. thick trowel grade build up over all joints. This was allowed to set until "tacky" to the touch. Strips of 4 in. wide Thermo-Lag® 330-69 Stress Skin were applied over the trowel grade material and "worked in" to achieve proper bonding. The stress skin was then secured using 1/2 in. staples and a skim coat of 330-1 trowel grade applied.

At locations where the raceway entered and exited an LBD or junction box, a 2 in. high collar of 330-69 stress skin was circumferentially wrapped around the raceway, lapping the joint from the box, and stapled in place. After all joints were lapped a minimum of 2 in. with 330-69 stress skin, a skim coat of 330-1 trowel grade was applied.

TEST RESULTS

The completed test specimen was placed on the Laboratory's horizontal fire test furnace and the thermocouples and circuit integrity systems connected to the data acquisition system and their outputs verified. Thermocouples #122 and #153 were found to be inoperative. Thermocouple #122 was located on the conduit steel surface of the rear 3 in. ø conduit, approximately 13 in. above the top of the left condulet. Thermocouple #153 was located on the instrumentation cable inside the rear 2 in. ø conduit, 6 in. left of center. Due to the large number of thermocouples present in the test article, the lack of operation of a small number of thermocouples can be overlooked. The test was conducted on November 5, 1992, by Herbert W. Stansberry II, project manager, with the following persons present:

Joe Ulie	-	USNRC
Steve West	-	USNRC
Chester Pruett	-	TU Electric (Fluor-Daniel Corporation)
Rick Dible	-	TU Electric (ABB Impell Corporation)
Cal Banning	-	TU Electric (ABB Impell Corporation)
Obaid Bhatty	-	TU Electric
Melvin Quick	-	TU Electric (Stone & Webster Engineering)
Randy Hooten	-	TU Electric
Frank Collins	-	TU Electric (Stone & Webster Engineering)
Charles Illingworth	-	TU Electric
Dave McAfee	-	TU Electric
Jim Wren	-	TU Electric
Lance Terry	-	TU Electric
Herschel Crawford	-	TU Electric
Bob Braddy	-	TU Electric
Scott Harrison	-	TU Electric
Deggary N. Priest	-	Omega Point Laboratories, Inc.
Kerry Hitchcock	-	Omega Point Laboratories, Inc.
Connie Humphry	-	Omega Point Laboratories, Inc.
Cleda Patton	-	Omega Point Laboratories, Inc.
Richard Beasley	-	Omega Point Laboratories, Inc.
Laudencio Castanon	-	Omega Point Laboratories, Inc.
Brian Ohlenbusch	-	Alamo Crane Co.
Chris Herman	-	Alexander Utilities, Inc.
Steve Linick	-	Alexander Utilities, Inc.
Rick Lohman	-	Thermal Science, Inc.

The furnace was fired and the ASTM E119 standard time-temperature curve followed for a period of 60 minutes. The pressure differential between the laboratory surrounding the furnace and a point within the furnace level with the vertical midpoint of the exposed portion of the specimen was maintained at approximately 0.00 in. water column throughout the test.

The furnace was fired at 9:18 p.m. By 0:28 (min:sec) the outside surface of the test item was beginning to turn brown, and by 0:55 (min:sec) had ignited fairly uniformly across the exposed surfaces. By 1:19 (min:sec) the furnace was filled with intense smoke and heavy flaming. During the fire exposure, no visual openings into the raceway were observed.

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In the course of the fire endurance test, several problems were encountered. These problems are discussed, in detail, in the following passages:

- Due to the time constant (5.0 - 7.2 minutes) inherent in the furnace probe thermocouples required by the test standard, the furnace operator detected an over-temperature condition (due to the combination of furnace fuel flow and burning test item) and turned the furnace fuel down. When that happened, the flaming on the surface of the Thermo-Lag® material slowly stopped, causing the furnace probes to register an under-temperature condition. Consequently, the operator increased the fuel flow to the furnace and the surface of the test item then re-ignited and filled the furnace with smoke and flames again. The furnace temperature thus "saw-toothed" its way along the E119 heating curve until the temperature was considerably above 1,000°F, at which time the previously-mentioned phenomenon ceased, and the specimen burned steadily for the remainder of the fire exposure period.

- During the fire test, several of the thermocouples located along the conduit steel began reading excessively high temperatures. The affected thermocouple channels which continued to rise during the test typically would peak during the latter portions of the test and then the readings would start lowering significantly as the actual temperature inside the test assemblies (as indicated by the cable thermocouples) began to climb toward the boiling point of water. The problem was attributed, upon post-test disassembly and based on past experience, to electro-chemical reactions caused by saturation of the fiberglass thermocouple insulation braiding by condensate accumulated on the conduit steel. Early in the test, the condensate saturated the thermocouple lead wires and caused erroneous readings. As the test continued, the condensate began to "cook" out of the thermocouple lead wires and the readings began to decrease, showing temperatures closer to the actual temperature of the conduit steel. The condensate discovered on the conduits upon disassembly had a thick, syrupy consistency and was dark brown or black. The material found was a mixture, of unknown proportions, of the water condensed on the conduits and the gaseous and liquid byproducts of the combustion of the Thermo-Lag® material.

At the end of the fire exposure period, the thermocouples were disconnected, the furnace extinguished and the specimen removed from the furnace. Circuit continuity measurements were continued throughout the fire and hose stream exposure. The test specimen was elevated to a distance of approximately 6 ft. between the floor and the bottom of the test item and spun on a swivel at a rate of 6 - 8 revolutions per minute (to ensure exposure of as much of the exterior surface as possible) while being exposed to a 30° angle spray nozzle hose stream test with a minimum pressure at the nozzle of 75 psi at a distance of 5 feet, for a 5 minute duration. The minimum flow from the nozzle was 75 gpm (in accordance with Ref. 4.1.21). The hose stream was thus positioned to attack the sides, bottom and inside vertical surfaces of the test item, with only minimal exposure to the top surface.

No failure of any of the circuit integrity systems was noted throughout the fire and hose stream exposures. When the test item was removed from the furnace it was still flaming, which slowly decreased as it was positioned for the hose stream test. Prior to the hose stream test, no openings or other severe damage was noticed on the specimen. The outer layer of the stress-skin upgrade was exposed along the corners of the LBD boxes and the junction boxes. The remainder of the exposed surface of the test item was covered with a layer of black ash.

Following the hose stream test, the Thermo-Lag® pieces remained firmly affixed and the stainless steel banding was still tightly wrapped around the assemblies. A fuller description of the condition of the protective envelope is presented later in this document.

The significant temperatures within the raceway system at the end of the fire exposure test are presented in the table below. (Shaded values are above the allowable limits.)

LOCATION	MAX. TEMPERATURE (°F)	AVG. TEMPERATURE (°F)
FRONT 3 in. CONDUIT		
Conduit Steel†	1141	576
W-023 (Power) Cable	174	135
W-047 (Control) Cable	233	166
W-071 (Instr.) Cable	232	165
REAR 3 in. CONDUIT		
Conduit Steel†	722	491
W-023 (Power) Cable	206	148
W-047 (Control) Cable	174	127
W-071 (Instr.) Cable	232	163

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LOCATION	MAX. TEMPERATURE (°F)	AVG. TEMPERATURE (°F)
HORIZONTAL J-BOX		
Junction Box Steel	186	172
VERTICAL J-BOX		
Junction Box Steel	198	146

† All conduit steel temperatures were affected by condensate saturation.

The average initial temperature for all thermocouples at the start of the test was 63°F, yielding an allowable temperature increase of 250°F, or 313°F actual for the average temperatures. (A 325°F increase above the 63°F initial temperature yields a maximum allowable individual temperature of 388°F, in accordance with ASTM E119-88.) All thermocouples on the junction box steel and on cables within both 3 in. ø conduit systems and both junction boxes met these criteria.

Prior to the fire test, the voltage signals from each of the circuit integrity systems was measured to establish a baseline (V_i). Then, after shorting across a single 100Ω resistor, the minimum voltage necessary to indicate failure ($V_{-100\Omega}$) was measured. At the completion of the fire and hose stream exposure tests, the voltage was again measured (V_f). These values are displayed in the table below. Additionally, a 500 volt insulation resistance test of each instrumentation cable (conductor to conductor and conductor to ground) and a 1500 volt insulation resistance test of each power and control cable (conductor to conductor and conductor to ground) was performed before (R_i). and after (R_f) the fire and hose stream tests. These results may be found in Appendix E: Insulation Resistance Testing Details.

CABLE	V_i	$V_{-100\Omega}$	V_f
FRONT 3 IN. CONDUIT			
W-020	2.972	2.185	2.961
W-023	2.970	2.195	2.964
W-046	6.012	5.645	5.999
W-047	5.133	4.681	5.130
W-048	4.263	3.687	4.251
W-063	6.003	5.639	5.986
W-071	4.702	4.194	4.692

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CABLE	V_i	$V_{-100\Omega}$	V_f
REAR 3 IN. CONDUIT			
W-020	2.988	2.204	2.97[illegible]
W-023	2.979	2.206	2.971
W-046	5.952	5.586	5.938
W-047	5.147	4.700	5.135
W-048	4.230	3.650	4.220
W-063	5.936	5.598	5.946
W-071	4.659	4.162	4.649

All data may be found in the Appendices attached to this document.

Post-Test Examination

Immediately following the hose stream test, the test item was systematically disassembled and examined for damage and general condition. A listing of those findings follows. In all cases, when describing a particular Thermo-Lag® 330-1 Flat, V-Ribbed Panel or Pre-Shaped Conduit Section, the term "panel" or "pre-shaped section" will be used.

FRONT & REAR 3 IN. Ø CONDUIT

LOCATION	OBSERVATION
Left side, above 90° condulet.	The outermost layer of stress skin was partially exposed with 1-1/2 in. of char build up on top where the conduits entered the condulets. Char depth elsewhere was 3/4 in. Most areas had 1/8 in. uncharred material remaining. Small areas present with no remaining uncharred material over the stress skin.

LOCATION	OBSERVATION
Left side, 90° condulet.	The pre-shaped sections were in place on all sides of the condulet. The outermost layer of stress skin was completely exposed along all corner edges and 1 in. to 1-1/4 in. of char was present on all sides of the condulet box. Between 1/8 in. and 1/4 in. uncharred material remained on all four outer sides with small area having as little as 1/16 in. The Thermo-Lag® material between the two condulets was totally intact. The overlapped areas at the intersection of the condulet box and both the horizontal and vertical conduit sections were completely intact.
Horizontal section, between left 90° condulet and mid-span junction box.	The char depth on top of the stress skin was 1-1/2 in. Over most of the conduit section, 1/8 in. Thermo-Lag® remained uncharred against the conduit, with the exception of the conduit to LBD box overlapped intersection, which was completely intact.
Horizontal section, between mid-span junction box and right 90° condulet.	The char depth on top of the stress skin was 1 in. to 1-1/2 in. Up to 1/8 in. uncharred material remained on the inside of the pre-shaped sections with several areas having no remaining uncharred material.
Right side, 90° condulet.	The char depth on top of the outermost layer of stress skin was between 1 in. and 2 in. Approximately 1/4 in. Thermo-Lag® remained uncharred on the outer layer. The inner layer was intact but blistered (top coat). The conduit to LBD box overlapped intersection was completely intact.
Cables	The cables were visibly undamaged. The cable jacket was slightly stiffened in the condulet area. The remainder of the cable length was still flexible.

JUNCTION BOXES

LOCATION	OBSERVATION
Horizontal junction box (mid-span).	The stress skin overlay was exposed along all edges. Char depth on the outer panels was 1 in. with 1/4 in. uncharred material present on the inside of the four vertical sides. The top had 1/8 in. remaining and the bottom had 1/8 in. with several spots having no remaining uncharred material. The top coat of the inner panels was blistered, but the inner layer was otherwise intact. All overlaps at conduit entry and exits sites were totally intact on the inner layer.
Vertical junction box	The stress skin overlay was exposed along all edges. Char depth on the outer panels was 1 in. with 1/8 in. uncharred material present on the inside of all sides. The top coat of the inner panels was blistered, but the inner layer was otherwise intact. All overlaps at conduit entry and exits sites were totally intact on the inner layer.

CONCLUSIONS

The horizontal and vertical junction boxes and the two 3 in. ø, conduit assemblies, clad in a nominal 1/2 in. thickness Thermo-Lag® 330-1 material with additional upgrades presented herein, met the requirements of the TEST PLAN (essentially those of American Nuclear Insurers Bulletin B.7.2, 11/87, Attachment B entitled: "ANI/MAERP RA Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class IEEE Electrical Circuits," Revision I, dated November 1987), for a fire resistance rating of one hour.

The assembly met the acceptance criteria contained in the TEST PLAN and the NRC letter dated October 29, 1992 for the following parameters: 1) single point temperature increase remained below 325°F (with the previously noted exception of the conduit steel temperatures), 2) no burnthrough was evident on the assembly following the fire endurance and hose stream tests, 3) visual cable inspection revealed no apparent thermal damage, 4) no loss of circuit integrity occurred during the course of the fire and hose stream tests, and 5) the results of the insulation resistance tests were well within the allowable limits.

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Appendix A

CONSTRUCTION DRAWINGS

report and the splices between cables will be broken and each cable tested separately to determine which cable conductor is bad or if there is a bad splice or test lead. Provided the low reading is on a cable, that cable is then removed from the raceway and visually examined to determine where and how the failure occurred.

DATA ACQUISITION SYSTEM

The outputs of the test article thermocouples and circuit integrity lines and the furnace probes are monitored by a data acquisition system consisting of a John Fluke Mfg. Co., Model HELIOS 2289A Computer Front End, a John Fluke Mfg. Co., Model HELIOS 2281A Extender Chassis (in the case of the 200 channel capacity unit), and an Apple Computer Co., Macintosh Classic microcomputer, a 100 or 200 input thermocouple jack panel and voltage input terminal strips. The Computer Front End is connected to the RS422 Serial Interface Port of the Macintosh and the Extender Chassis is serially connected to the Computer Front End. The computer is programmed in Microsoft BASIC to command the HELIOS units to sample the data input lines (from the thermocouple jack panel and/or the voltage input terminal strips), receive and convert the data into a digital format, and to manipulate the raw data into usable units for display on screen and paper and for saving to floppy disk.

Two data acquisition units are used for the majority of tests due to the large number of data channels. One data acquisition unit is configured for monitoring 200 data input channels and is used to sample all (or most) of the test article thermocouples. A second data acquisition unit is configured for monitoring 100 data input channels and is used to sample the circuit integrity lines of the test article, ambient laboratory temperature, furnace temperature probes and, if necessary, the remaining test article thermocouple inputs.

HOSE STREAM TEST

According to the Test Plan, following the fire exposure test, the test specimen is removed from the test furnace, lifted approximately 6 ft. from the ground (as measured from the lowermost part of the specimen), slowly turned (nominally 6 to 8 revolutions per minute) and exposed to the impact, erosion, and cooling effects of a hose stream directed perpendicularly at the exposed surface of the test specimen as outlined in the standard. The stream is delivered, for a minimum period of 5 minutes, through a 1-1/2 in. fog nozzle with an adjustable stream, with a nozzle pressure of 75 psi, a spray angle of 30° and with the tip of the nozzle a distance of 5 ft. from the exposed face. The nozzle is to flow a minimum of 75 gpm during the hose stream test. It is recognized that, with a three-dimensional object, not all surfaces can be attacked by the hose stream test. For this reason, the specimen is lifted high enough to allow the stream to play against the sides, inside and outside vertical surfaces and the underside of the item, resulting in little, if any, direct force being applied to the inside top surface of the specimen.

BARRIER INSPECTION

Following the hose stream test, all barrier materials, joints and seams are to be visually inspected for burnthrough or openings in the barrier envelope in accordance with the acceptance criteria outlined in the NRC letter dated October 29, 1992, (Appendix K.)

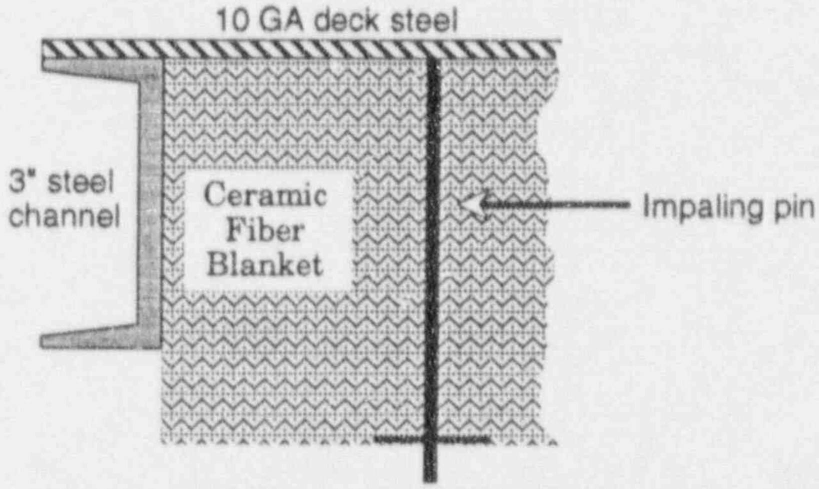
VISUAL CABLE INSPECTION

Following the barrier inspection, the barrier materials will be systematically removed and the condition of the various assembly aspects will be noted (see Post Test Observations). The cables in each system will be visually inspected for damage in accordance with the acceptance criteria outlined in the NRC letter dated October 29, 1992, (Appendix K.) If any visible thermal damage exists, the outer jacket of the cable in question will be slit open and the condition of the inner conductor insulation will be assessed.

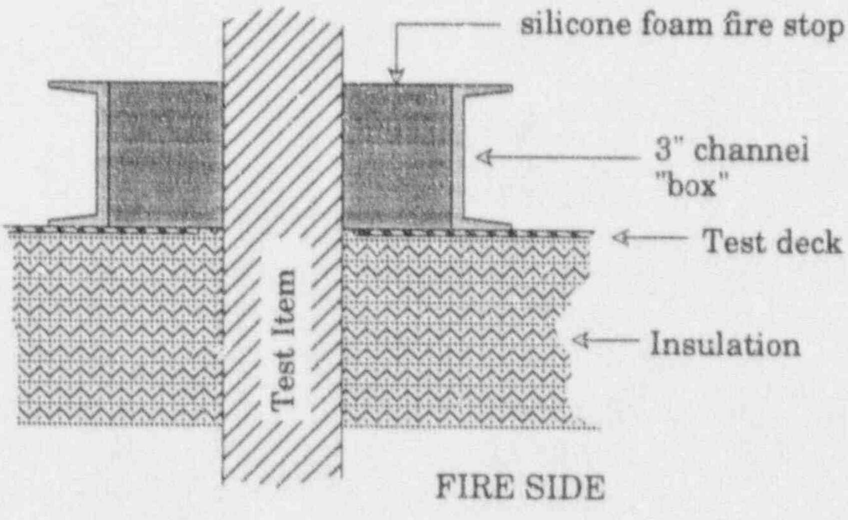
TEST ASSEMBLY

TEST DECK

The test deck consisted of a perimeter of 3 in. structural steel channel, welded together into an 8 ft. by 13 ft. rectangle, with the flanges outward. Over the top of this framework a layer of 10 GA steel sheet was welded to form a continuous, smooth top. Pipe sockets (4 in. ø, sch. 40 steel pipe) were then welded onto each corner, so that 3 in. ø steel pipe legs could be attached to hold the assembly at a comfortable working level. Holes were then cut into the deck steel at the appropriate locations to allow the test item to be installed into the deck assembly. Structural elements were typically attached to the test item above the deck level, to rigidly fix the item to the deck. Following the installation of the test item, the deck was reinforced with steel channel positioned so as to minimize any warping, bending or sagging during the fire test (the size of the channel being selected after consideration of the amount of stiffness required for that particular assembly), and then insulated on the underside with two 2 in. thick layers of 6 pcf ceramic fiber blanket, held in place with impaling pins, spaced a maximum of 12 in. o.c. The figure below illustrates a cross-sectional view of one edge of a typical deck assembly, showing the structural steel, the decking and the insulation.



Following complete installation of the test item, the underside of the deck was insulated as previously described, with the ceramic blanket being pushed into direct contact with the test item. A "box" around the penetration point in the deck steel was formed of 3 in. steel channel on edge and the enclosed area completely filled to a nominal depth of 3 in. with silicone foam fire seal.



CROSS-SECTION VIEW OF POINT OF PENETRATION OF THE DECK BY A TEST ITEM

This method of sealing around the point where a test item penetrates the test deck has proven very effective at withstanding the 60 minute fire exposure. Since the penetration seal is considered a part of the support system, and is not in itself being evaluated by this test method, the important aspect of the seal is that it be "typical" of a field installation and withstand the fire exposure test. The silicone foam system used in this design does not unduly act as a heat sink, nor does it offer significant physical support to the penetrating item. Its purpose is to seal the gap without affecting the evaluation of the protective envelope system.

TEST ITEMS (GENERAL)

As with conduit materials installed at CPSES, the materials used in the test were subjected to on-site commercial grade dedication programs prior to acceptance and subsequent installation. The conduit materials used in the test were provided to Texas Utilities by various vendors, and are similar in design and representative of those installed at CPSES.

All test items were constructed from materials extracted from TU Electric's Comanche Peak Steam Electric Station stock material storage areas in accordance with existing site procedures.

Electrical cables used in this test consisted of site-specific cables supplied by TU Electric and taken from CPSES lot inventory. These cables were as follows:

CABLE TYPE	CABLE FUNCTION	DESCRIPTION	DIAMETER (in.)	CROSS-SECTIONAL AREA (in^2)
W-020	Power	3C/#6 AWG 600v.	0.980	0.754
W-023	Power	3C/#8 AWG 600v.	0.747	0.438
W-046	Control	9C/#12 AWG 600v.	0.690	0.374
W-047	Control	7C/#12 AWG 600v.	0.605	0.287
W-048	Control	5C/#12 AWG 600v.	0.575	0.260
W-063	Instrumentation	4 Shielded, Twisted Pair 16 AWG 600v.	0.737	0.427
W-071	Instrumentation	5C/#16 AWG 600v.	0.474	0.176

The diameters and cross-sectional areas listed herein represent the Laboratory's average of ten measurements of each cable type.

Thermo-Lag® 330-1 Materials

Thermo-Lag® materials were procured from Thermal Science, Inc. (TSI), St. Louis, MO. The Thermo-Lag® materials extracted from CPSES site stock were representative of materials installed in the plant. Each one hour rated Thermo-Lag® 330-1 Flat panel and each one hour rated Thermo-Lag® 330-1 V-ribbed panel is 1/2 in. thick (nominal) x 48 in. wide x 78 in. long, with stress skin monolithically adhered to the panel on one face. Each panel was received with 350 Topcoat factory applied. The stress skin is installed adjacent to the surface of the protected commodity. Other materials supplied by TSI were 330-69 stress skin sheets 4 ft. x 7 ft., 350 Topcoat (two part water-based mixture), 330-1 trowel grade subliming compound (used with 330-1 panels). All Thermo-Lag® panels were measured, saw cut and installed onto the respective test assembly by Peak Seals craft personnel using approved CPSES drawings, procedures and specifications. Installations were inspected by CPSES-certified quality control inspectors.

Other Materials

Materials used in conjunction with Thermo-Lag® components, but furnished by other vendors included: Silicone elastomer (Promatec 45B) seal material, Dow Corning 3-6548 RTV silicone foam fire stop material and Thermal Ceramic Kaowool M-Board (ceramic fiber damming board). These materials were all previously supplied by Promatec, Houston, Texas. Other commercial grade products used were: 1/2 in. wide x 0.020 in. thick type 304 stainless steel rolled-edge banding straps with wing seals; 16 to 18 GA stainless steel tie wire; and, 0.010 in. stainless steel sheet metal.

TEST ITEM (CONDUITS & JUNCTION BOXES)

This assembly consisted of two parallel 3 in. ø conduit loops passing through two junction boxes. Each conduit loop extends through the right side of the deck, into the 18 in. side of an 18 in. x 12 in. x 6 in. junction box (vertically situated, 21 in. above the horizontal raceway), into a 90° elbow (long side horizontal), into the 18 in. side of a second 18 in. x 12 in. x 6 in. junction box (horizontally situated mid-span of the horizontal raceway), into a second 90° elbow (long side vertical) and back up through the left side of the deck. Both of the conduit assemblies extended three feet above the surface of the deck.

JUNCTION BOX SUPPORTS

A single box tube steel support was fabricated to support the horizontal junction box mid-span of the conduit runs. The hanger consisted of a 29 in. long vertical section of 3 in. x 3 in. x 1/4 in. wall square steel tubing with a 1/2 in. thick, 12 in. square plate centered and welded to each end with a 1/4 in. fillet weld all around the tubing. The support was centered on and bolted to the top of the mid-span horizontal junction box with 1/2 in. hardware. This placement situated the bottom of the junction box 36 in. below the deck insulation.

ELECTRICAL CABLES

All electrical cables used in this project were site-specific for CPSES. Where possible, an approximate 1/3 mix of Power, Instrumentation and Control cables were pulled into each conduit. The internal cross-sectional areas for both conduits is as follows:

CONDUIT SIZE (INCHES)	CROSS-SECTIONAL AREA (in^2)
3	7.069

The table below shows the cable types used in each conduit, the number of each cable installed, the total cross-sectional area of each cable type and the percent of the total available area taken up by each type.

3 in. CONDUIT (two required)

CABLE TYPE	NUMBER PRESENT	CROSS-SECTIONAL AREA (in2)	% OF TOTAL AREA
W-020	1	0.754	10.67
W-023	1	0.438	6.20
W-046	1	0.374	5.29
W-047	1	0.287	4.06
W-048	1	0.260	3.68
W-063	1	0.427	6.04
W-071	3	0.528	7.47
TOTAL FILL =>		**3.068**	**43.40**

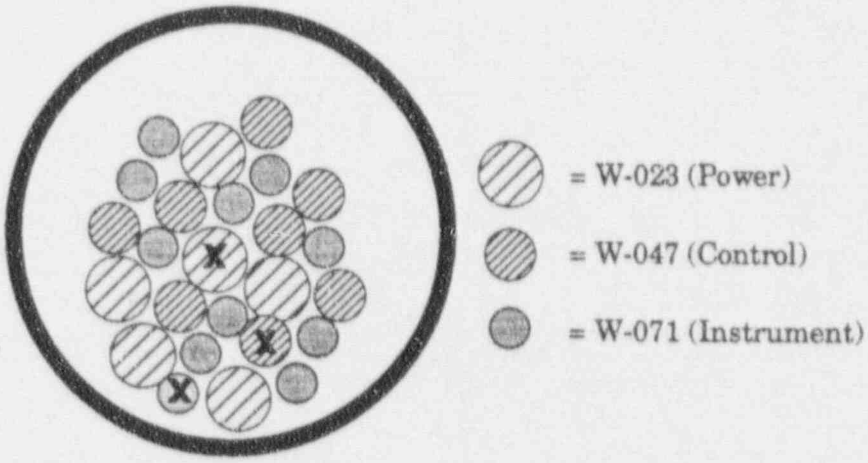
THERMOCOUPLE PLACEMENT

24 gauge, Type K, Chromel-Alumel electrically welded thermocouples (Special Limits of Error: ±1.1°C, purchased with lot traceability and calibration certifications) were attached nominally every 6 in. along one each of power, control and instrumentation cables, by placing the thermojunction in direct contact with the top surface of the cable and covering with a double wrap of glass

fiber reinforced electrical tape (Glass Cloth Electrical Tape, Class "B" Insulation, 1/2 in. wide, 3M Corporation, Item No. 27) for a minimum distance of 3-1/2 in.

In both 3 in. ø conduits, the instrumented Power cable was located at the nominal center of the cable bundle, while the instrumented Control cable was located midway in the bundle and the Instrumentation cable with thermocouples was located on the outside of the cable bundle.

Note: Exact cable placement is not shown here. This drawing is merely to illustrate the relative placements of the instrumented cables, marked by X's.



Cable Bundle in Conduit

In order to get a realistic measurement of the temperatures at the conduit steel, similar thermocouples were positioned nominally every 12 in. along the top surface of each conduit, being held in position by a short piece of Glass Cloth Electrical tape. The thermocouple leads were taped securely to the conduits at points away from the thermojunction by wrapping the tape completely around the conduit and thermocouple lead. Thermocouples were also located in each junction box. These thermocouples were held in position by clamping the junction under the head of a #8 x 32 x 1/4 in. long stainless steel round-head machine screw threaded into tapped holes from the inside of the junction box. One thermocouple was placed on the center of each side of the junction box. Two additional thermocouples were placed on the conduit entry and exit sides of the junction boxes, halfway between the conduit nut and the adjacent junction box side.

THERMO-LAG® INSTALLATION HIGHLIGHTS

Thermo-Lag® materials were installed in accordance with the instructions contained in the CPSES Site Procedures referenced in Test Plan, Rev. 8. Short abstracts of the installation are included herein to clarify specific details.

Drawings of the installed Thermo-Lag® on the test assembly are shown in Appendix J.

Thermo-Lag® 330-1 Flat Panel (1/2 in. nom. thickness)

These panels were used to construct the LBD box design, junction box (first layer) and support steel protective envelopes.

Thermo-Lag® 330-1 Subliming Trowel Grade Material

This material was used to pre-caulk all joints, seams and upgraded areas between pre-shaped sections, flat and V-ribbed panels and underneath and over stress skin.

Thermo-Lag® 330-1 Pre-Shaped Conduit Sections (1/2 in. nom. thickness)

This material was used to construct the 3 in. diameter raceway design protective envelopes.

Thermo-Lag® 330-1 V-rib Panel Material

This material was used as a second layer on each junction box.

Thermo-Lag® 330-1 V-rib Panel Orientation

V-rib panels were used only as a second layer on the junction boxes. As such, the ribs were installed in contact with the first layer of flat panels. On top and bottom (18 in. x 12 in.) surfaces, the V-ribs were oriented parallel to the conduit runs. On remaining junction box surfaces, the V-ribs were oriented perpendicular to the conduit runs.

Application Methods

Each 3 in. diameter raceway segment was covered first (prior to installing material on the junction boxes) with Thermo-Lag® 330-1 Pre-Shaped Conduit Material. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding material.

Each raceway LBD fitting was covered with a 330-1 flat panel material in a manner similar to an L-shaped box configuration. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding.

Each junction box was first covered with Thermo-Lag® 330-1 1/2 in. thick flat panel material. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel banding.

The tube steel support member was covered with a single layer of flat panel for a 9 in. distance from the V-rib panel surface of the horizontal junction box envelope. All joints and seams were pre-caulked with 330-1 Trowel Grade Material and secured in place with stainless steel tie wires or banding material.

Upgrade Techniques

Following application of the flat panel layer, a second layer was applied to each junction box using Thermo-Lag® 330-1 V-ribbed panel material secured with stainless steel banding material. All joints were pre-caulked with Thermo-Lag® 330-1 Trowel Grade Material. A layer of Thermo-Lag® trowel grade (approximately 3/16 in. thick) was applied 2 in. minimum beyond all junction box joints. The trowel grade was allowed to set until "tacky" to the touch. Strips of 4 in. wide Thermo-Lag® 330-69 Stress Skin were applied (2 in. in each direction from a corner) over the "tacky" trowel grade and "worked in" to achieve proper bonding. The stress skin was secured in place using 1/2 in. long staples and stainless steel tie wire to hold it flat against the panel surface. A skim coat of Thermo-Lag® 330-1 Trowel Grade was applied over the stress skin.

Each raceway LBD box design was "upgraded" using approximately 3/16 in. thick trowel grade build up over all joints. This was allowed to set until "tacky" to the touch. Strips of 4 in. wide Thermo-Lag® 330-69 Stress Skin were applied over the trowel grade material and "worked in" to achieve proper bonding. The stress skin was then secured using 1/2 in. staples and a skim coat of 330-1 trowel grade applied.

At locations where the raceway entered and exited an LBD or junction box, a 2 in. high collar of 330-69 stress skin was circumferentially wrapped around the raceway, lapping the joint from the box, and stapled in place. After all joints were lapped a minimum of 2 in. with 330-69 stress skin, a skim coat of 330-1 trowel grade was applied.

TEST RESULTS

The completed test specimen was placed on the Laboratory's horizontal fire test furnace and the thermocouples and circuit integrity systems connected to the data acquisition system and their outputs verified. Thermocouples #122 and #153 were found to be inoperative. Thermocouple #122 was located on the conduit steel surface of the rear 3 in. ø conduit, approximately 13 in. above the top of the left condulet. Thermocouple #153 was located on the instrumentation cable inside the rear 3 in. ø conduit, 6 in. left of center. Due to the large number of thermocouples present in the test article, the lack of operation of a small number of thermocouples can be overlooked. The test was conducted on November 5, 1992, by Herbert W. Stansberry II, project manager, with the following persons present:

Joe Ulie	-	USNRC
Steve West	-	USNRC
Chester Pruett	-	TU Electric (Fluor-Daniel Corporation)
Rick Dible	-	TU Electric (ABB Impell Corporation)
Cal Banning	-	TU Electric (ABB Impell Corporation)
Obaid Bhatty	-	TU Electric
Melvin Quick	-	TU Electric (Stone & Webster Engineering)
Randy Hooton	-	TU Electric
Frank Collins	-	TU Electric (Stone & Webster Engineering)
Charles Illingworth	-	TU Electric
Dave McAfie	-	TU Electric
Jim Wren	-	TU Electric
Lance Terry	-	TU Electric
Herschel Crawford	-	TU Electric
Bob Braddy	-	TU Electric
Scott Harrison	-	TU Electric
Deggary N. Priest	-	Omega Point Laboratories, Inc.
Kerry Hitchcock	-	Omega Point Laboratories, Inc.
Connie Humphry	-	Omega Point Laboratories, Inc.
Cleda Patton	-	Omega Point Laboratories, Inc.
Richard Beasley	-	Omega Point Laboratories, Inc.
Laudencio Castanon	-	Omega Point Laboratories, Inc.
Brian Ohlenbusch	-	Alamo Crane Co.
Chris Herman	-	Alexander Utilities, Inc.
Steve Linick	-	Alexander Utilities, Inc.
Rick Lohman	-	Thermal Science, Inc.

The furnace was fired and the ASTM E119 standard time-temperature curve followed for a period of 60 minutes. The pressure differential between the laboratory surrounding the furnace and a point within the furnace level with the vertical midpoint of the exposed portion of the specimen was maintained at approximately 0.00 in. water column throughout the test.

The furnace was fired at 9:18 p.m. By 0:28 (min:sec) the outside surface of the test item was beginning to turn brown, and by 0:55 (min:sec) had ignited fairly uniformly across the exposed surfaces. By 1:19 (min:sec) the furnace was filled with intense smoke and heavy flaming. During the fire exposure, no visual openings into the raceway were observed.

OMEGA POINT LABORATORIES

In the course of the fire endurance test, several problems were encountered. These problems are discussed, in detail, in the following passages:

- Due to the time constant (5.0 - 7.2 minutes) inherent in the furnace probe thermocouples required by the test standard, the furnace operator detected an over-temperature condition (due to the combination of furnace fuel flow and burning test item) and turned the furnace fuel down. When that happened, the flaming on the surface of the Thermo-Lag® material slowly stopped, causing the furnace probes to register an under-temperature condition. Consequently, the operator increased the fuel flow to the furnace and the surface of the test item then re-ignited and filled the furnace with smoke and flames again. The furnace temperature thus "saw-toothed" its way along the E119 heating curve until the temperature was considerably above 1,000°F, at which time the previously-mentioned phenomenon ceased, and the specimen burned steadily for the remainder of the fire exposure period.

- During the fire test, several of the thermocouples located along the conduit steel began reading excessively high temperatures. The affected thermocouple channels which continued to rise during the test typically would peak during the latter portions of the test and then the readings would start lowering significantly as the actual temperature inside the test assemblies (as indicated by the cable thermocouples) began to climb toward the boiling point of water. The problem was attributed, upon post-test disassembly and based on past experience, to electro-chemical reactions caused by saturation of the fiberglass thermocouple insulation braiding by condensate accumulated on the conduit steel. Early in the test, the condensate saturated the thermocouple lead wires and caused erroneous readings. As the test continued, the condensate began to "cook" out of the thermocouple lead wires and the readings began to decrease, showing temperatures closer to the actual temperature of the conduit steel. The condensate discovered on the conduits upon disassembly had a thick, syrupy consistency and was dark brown or black. The material found was a mixture, of unknown proportions, of the water condensed on the conduits and the gaseous and liquid byproducts of the combustion of the Thermo-Lag® material.

At the end of the fire exposure period, the thermocouples were disconnected, the furnace extinguished and the specimen removed from the furnace. Circuit continuity measurements were continued throughout the fire and hose stream exposure. The test specimen was elevated to a distance of approximately 6 ft. between the floor and the bottom of the test item and spun on a swivel at a rate of 6 - 8 revolutions per minute (to ensure exposure of as much of the exterior surface as possible) while being exposed to a 30° angle spray nozzle hose stream test with a minimum pressure at the nozzle of 75 psi at a distance of 5 feet, for a 5 minute duration. The minimum flow from the nozzle was 75 gpm (in accordance with Ref. 4.1.21). The hose stream was thus positioned to attack the sides, bottom and inside vertical surfaces of the test item, with only minimal exposure to the top surface.

No failure of any of the circuit integrity systems was noted throughout the fire and hose stream exposures. When the test item was removed from the furnace it was still flaming, which slowly decreased as it was positioned for the hose stream test. Prior to the hose stream test, no openings or other severe damage was noticed on the specimen. The outer layer of the stress-skin upgrade was exposed along the corners of the LBD boxes and the junction boxes. The remainder of the exposed surface of the test item was covered with a layer of black ash.

Following the hose stream test, the Thermo-Lag® pieces remained firmly affixed and the stainless steel banding was still tightly wrapped around the assemblies. A fuller description of the condition of the protective envelope is presented later in this document.

The significant temperatures within the raceway system at the end of the fire exposure test are presented in the table below. (Shaded values are above the allowable limits.)

LOCATION	MAX. TEMPERATURE (°F)	AVG. TEMPERATURE (°F)
FRONT 3 in. CONDUIT		
Conduit Steel†	1141	576
W-023 (Power) Cable	174	135
W-047 (Control) Cable	233	166
W-071 (Instr.) Cable	232	165
REAR 3 in. CONDUIT		
Conduit Steel†	722	491
W-023 (Power) Cable	206	148
W-047 (Control) Cable	174	127
W-071 (Instr.) Cable	232	163

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LOCATION	MAX. TEMPERATURE (°F)	AVG. TEMPERATURE (°F)
HORIZONTAL J-BOX		
Junction Box Steel	186	172
VERTICAL J-BOX		
Junction Box Steel	198	146

† All conduit steel temperatures were affected by condensate saturation.

The average initial temperature for all thermocouples at the start of the test was 63°F, yielding an allowable temperature increase of 250°F, or 313°F actual for the average temperatures. (A 325°F increase above the 63°F initial temperature yields a maximum allowable individual temperature of 388°F, in accordance with ASTM E119-88.) All thermocouples on the junction box steel and on cables within both 3 in. ø conduit systems and both junction boxes met these criteria.

Prior to the fire test, the voltage signals from each of the circuit integrity systems was measured to establish a baseline (V_i). Then, after shorting across a single 100Ω resistor, the minimum voltage necessary to indicate failure ($V_{-100\Omega}$) was measured. At the completion of the fire and hose stream exposure tests, the voltage was again measured (V_f). These values are displayed in the table below. Additionally, a 500 volt insulation resistance test of each instrumentation cable (conductor to conductor and conductor to ground) and a 1500 volt insulation resistance test of each power and control cable (conductor to conductor and conductor to ground) was performed before (R_i). and after (R_f) the fire and hose stream tests. These results may be found in Appendix E: Insulation Resistance Testing Details.

CABLE	V_i	$V_{-100\Omega}$	V_f
FRONT 3 IN. CONDUIT			
W-020	2.972	2.185	2.961
W-023	2.970	2.195	2.964
W-046	6.012	5.645	5.999
W-047	5.133	4.681	5.130
W-048	4.263	3.687	4.251
W-063	6.003	5.639	5.986
W-071	4.702	4.194	4.692

CABLE	V_i	$V_{-100\Omega}$	V_f
REAR 3 IN. CONDUIT			
W-020	2.988	2.204	2.975
W-023	2.979	2.206	2.971
W-046	5.952	5.586	5.938
W-047	5.147	4.700	5.135
W-048	4.230	3.650	4.220
W-063	5.936	5.598	5.946
W-071	4.659	4.162	4.649

All data may be found in the Appendices attached to this document.

Post-Test Examination

Immediately following the hose stream test, the test item was systematically disassembled and examined for damage and general condition. A listing of those findings follows. In all cases, when describing a particular Thermo-Lag® 330-1 Flat, V-Ribbed Panel or Pre-Shaped Conduit Section, the term "panel" or "pre-shaped section" will be used.

FRONT & REAR 3 IN. Ø CONDUIT

LOCATION	OBSERVATION
Left side, above 90° condulet.	The outermost layer of stress skin was partially exposed with 1-1/2 in. of char build up on top where the conduits entered the condulets. Char depth elsewhere was 3/4 in. Most areas had 1/8 in. uncharred material remaining. Small areas present with no remaining uncharred material over the stress skin.

LOCATION	OBSERVATION
Left side, 90° condulet.	The pre-shaped sections were in place on all sides of the condulet. The outermost layer of stress skin was completely exposed along all corner edges and 1 in. to 1-1/4 in. of char was present on all sides of the condulet box. Between 1/8 in. and 1/4 in. uncharred material remained on all four outer sides with small area having as little as 1/16 in. The Thermo-Lag® material between the two condulets was totally intact. The overlapped areas at the intersection of the condulet box and both the horizontal and vertical conduit sections were completely intact.
Horizontal section, between left 90° condulet and mid-span junction box.	The char depth on top of the stress skin was 1-1/2 in. Over most of the conduit section, 1/8 in. Thermo-Lag® remained uncharred against the conduit, with the exception of the conduit to LBD box overlapped intersection, which was completely intact.
Horizontal section, between mid-span junction box and right 90° condulet.	The char depth on top of the stress skin was 1 in. to 1-1/2 in. Up to 1/8 in. uncharred material remained on the inside of the pre-shaped sections with several areas having no remaining uncharred material.
Right side, 90° condulet.	The char depth on top of the outermost layer of stress skin was between 1 in. and 2 in. Approximately 1/4 in. Thermo-Lag® remained uncharred on the outer layer. The inner layer was intact but blistered (top coat). The conduit to LBD box overlapped intersection was completely intact.
Cables	The cables were visibly undamaged. The cable jacket was slightly stiffened in the condulet area. The remainder of the cable length was still flexible.

JUNCTION BOXES

LOCATION	OBSERVATION
Horizontal junction box (mid-span).	The stress skin overlay was exposed along all edges. Char depth on the outer panels was 1 in. with 1/4 in. uncharred material present on the inside of the four vertical sides. The top had 1/8 in. remaining and the bottom had 1/8 in. with several spots having no remaining uncharred material. The top coat of the inner panels was blistered, but the inner layer was otherwise intact. All overlaps at conduit entry and exits sites were totally intact on the inner layer.
Vertical junction box	The stress skin overlay was exposed along all edges. Char depth on the outer panels was 1 in. with 1/8 in. uncharred material present on the inside of all sides. The top coat of the inner panels was blistered, but the inner layer was otherwise intact. All overlaps at conduit entry and exits sites were totally intact on the inner layer.

CONCLUSIONS

The horizontal and vertical junction boxes and the two 3 in. ø, conduit assemblies, clad in a nominal 1/2 in. thickness Thermo-Lag® 330-1 material with additional upgrades presented herein, met the requirements of the TEST PLAN (essentially those of American Nuclear Insurers Bulletin B.7.2, 11/87, Attachment B entitled: "ANI/MAERP RA Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class IEEE Electrical Circuits," Revision I, dated November 1987), for a fire resistance rating of one hour.

The assembly met the acceptance criteria contained in the TEST PLAN and the NRC letter dated October 29, 1992 for the following parameters: 1) single point temperature increase remained below 325°F (with the previously noted exception of the conduit steel temperatures), 2) no burnthrough was evident on the assembly following the fire endurance and hose stream tests, 3) visual cable inspection revealed no apparent thermal damage, 4) no loss of circuit integrity occurred during the course of the fire and hose stream tests, and 5) the results of the insulation resistance tests were well within the allowable limits.

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Appendix A

CONSTRUCTION DRAWINGS

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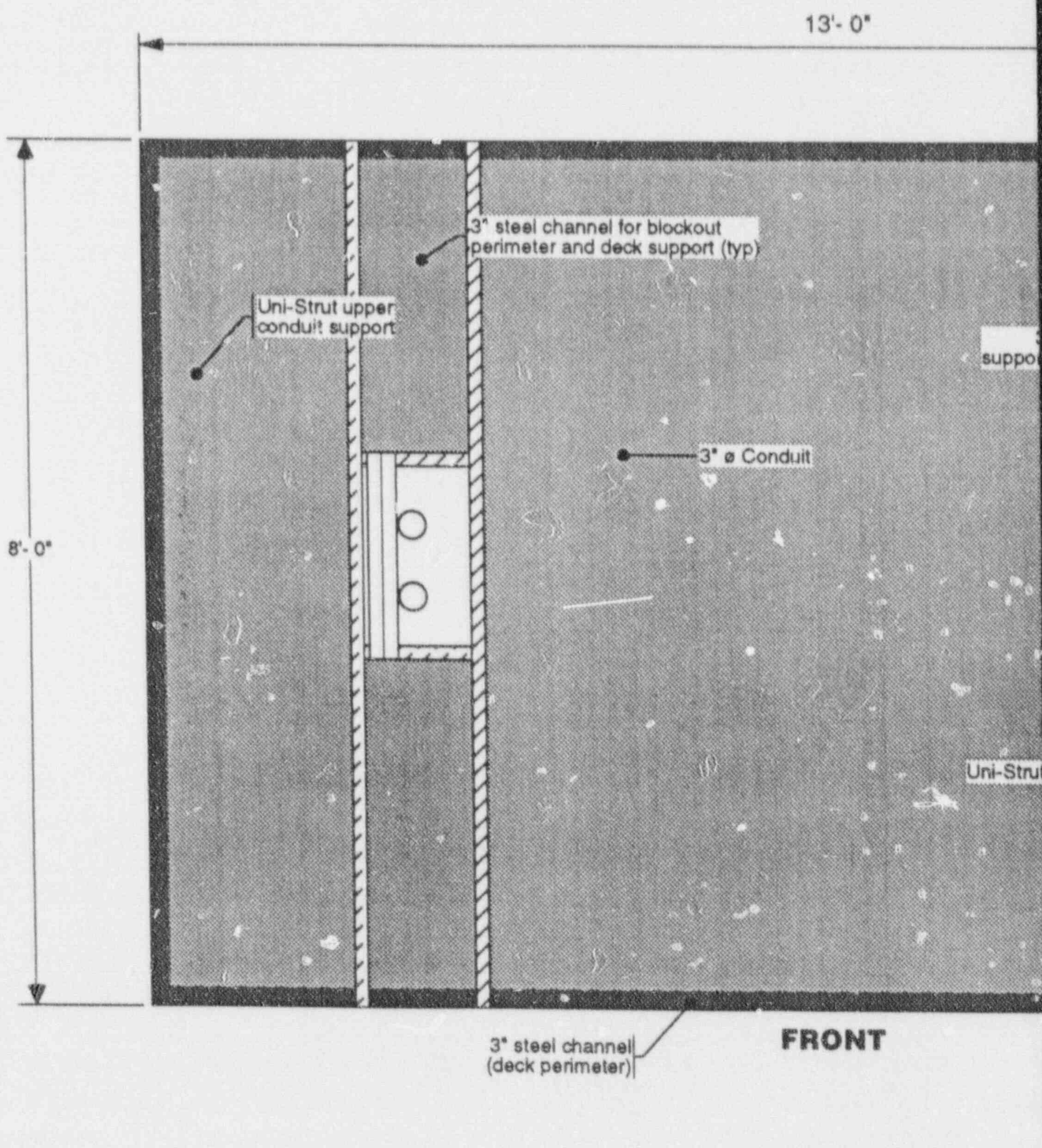
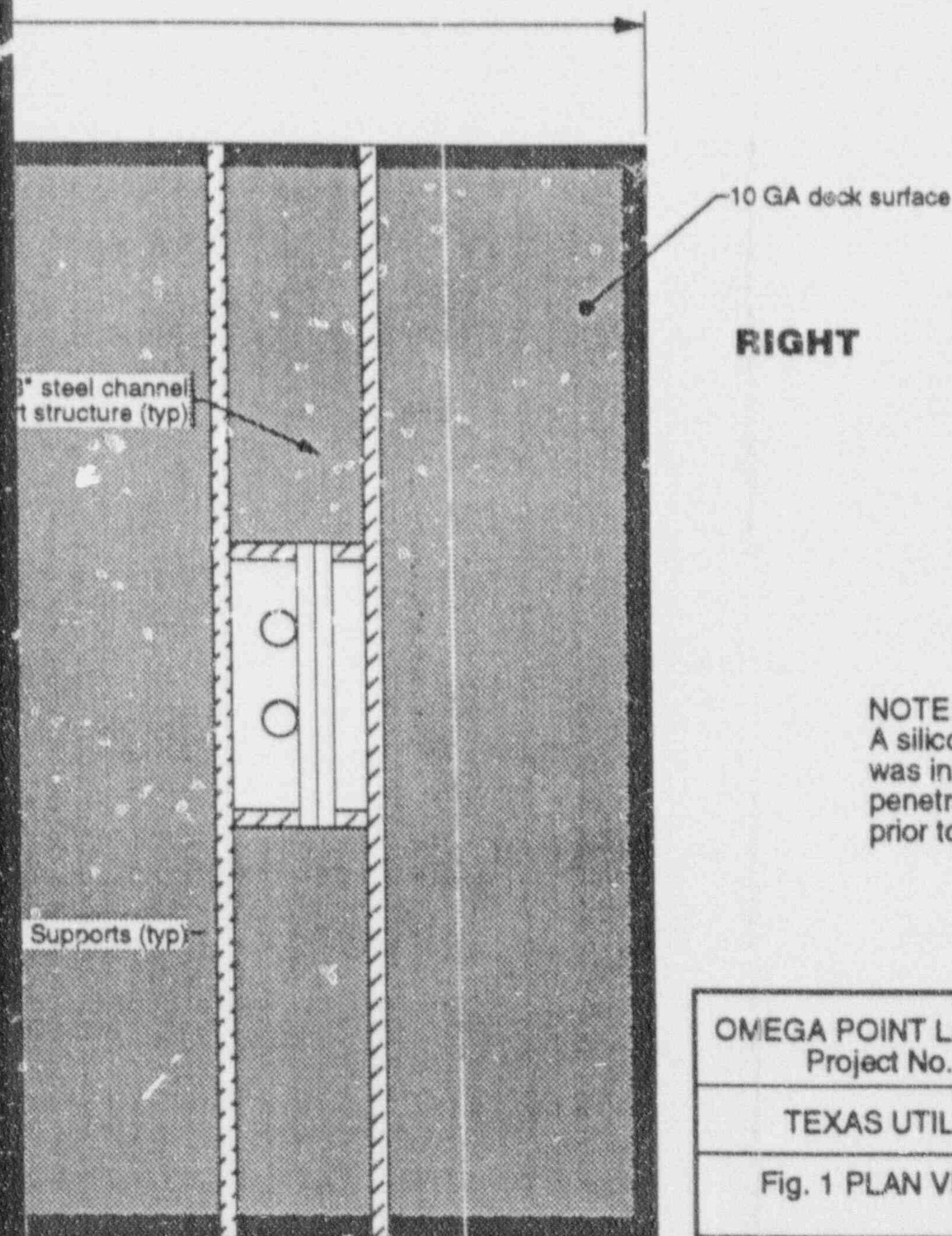


13'- 0"
8'- 0"
3" steel channel for blockout perimeter and deck support (typ)
Uni-Strut upper conduit support
3" ø Conduit
3" steel channel (deck perimeter)
FRONT



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NOTE:
A silicon foam firestop was installed into each penetration blockout prior to testing.

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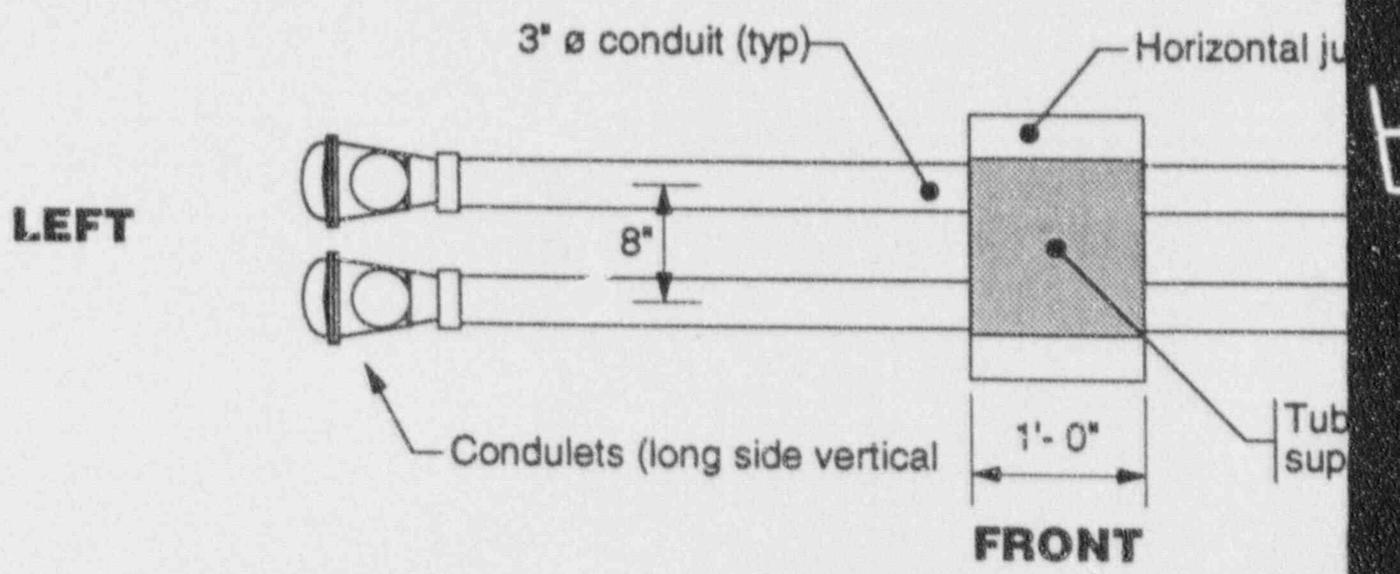
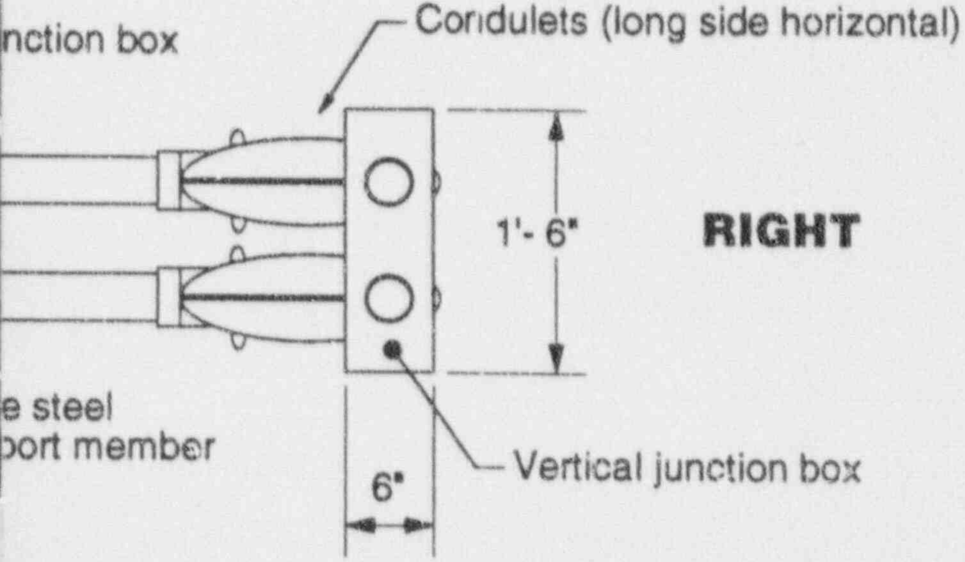
TEXAS UTILITES ELECTRIC
Fig. 1 PLAN VIEW - Above Deck

9302160274-01



LEFT
3" ø conduit (typ)
Horizontal ju
8"
Condulets (long side vertical
1'- 0"
Tub
sup
FRONT



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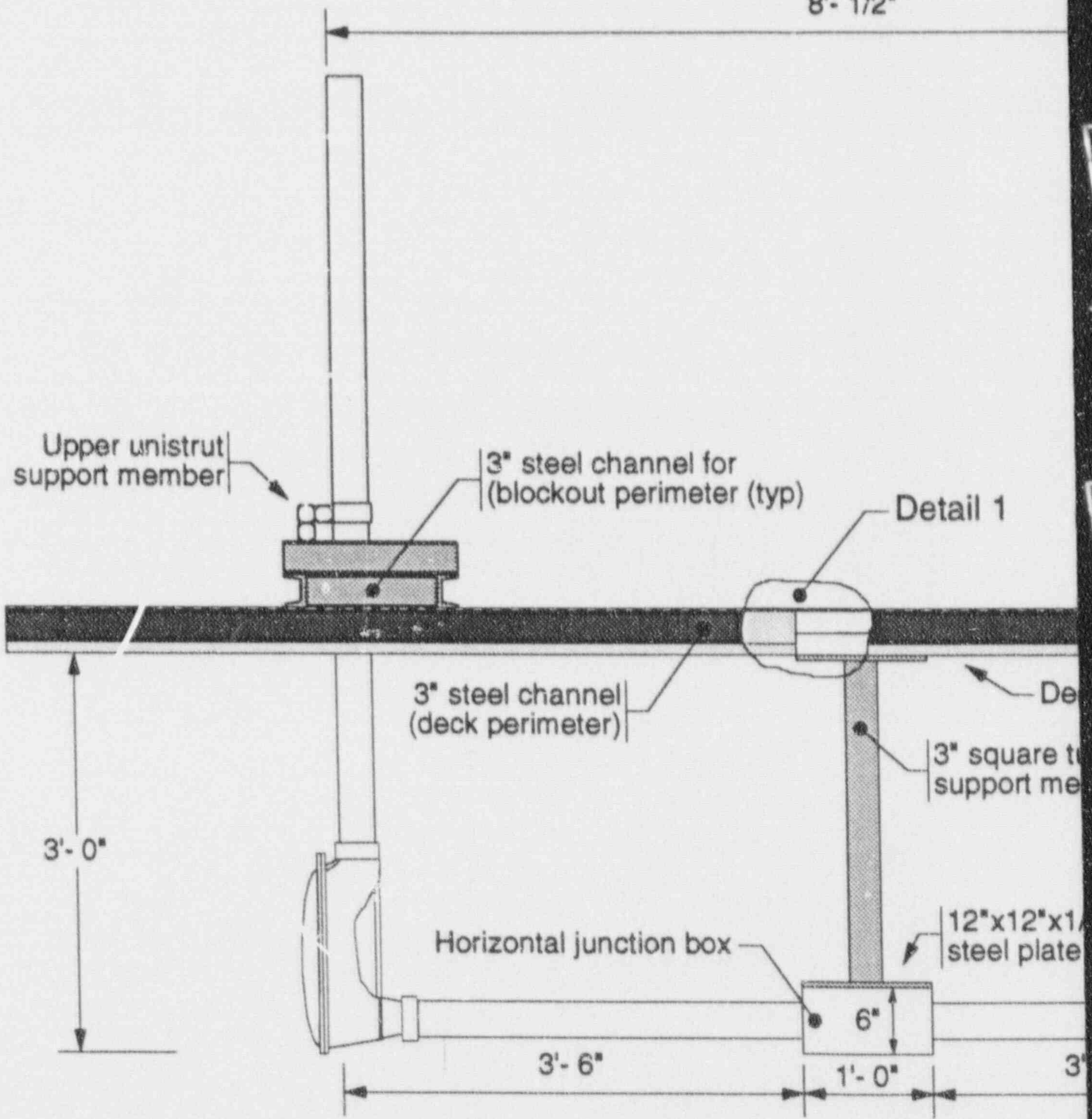
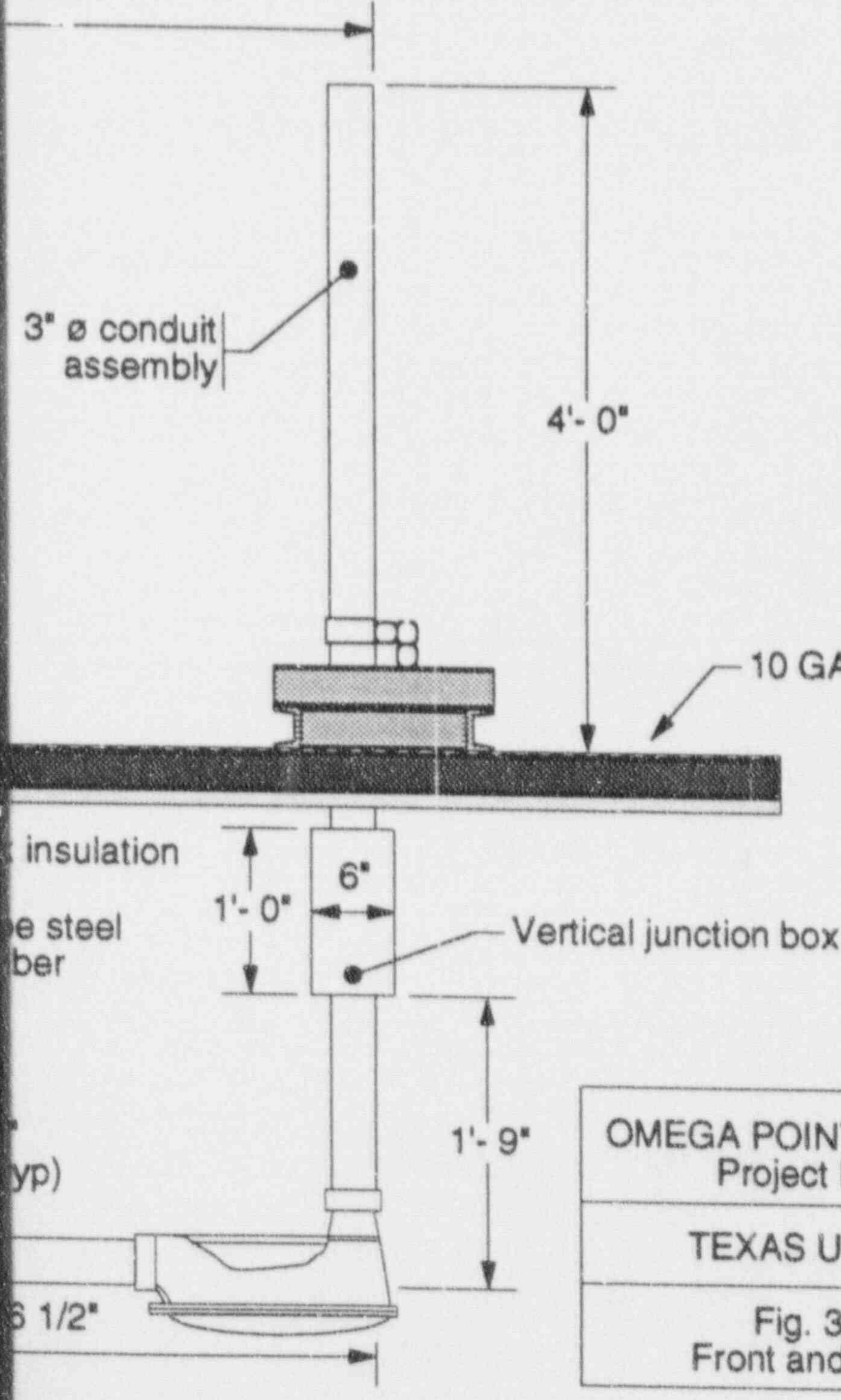
OMEGA POINT LABORATORIES, INC. Project No. 12340-94367c
TEXAS UTILITES ELECTRIC
Fig. 2 PLAN VIEW - Below Deck

9302160274 - 02



8'- 1/2"
Upper unistrut support member
3" steel channel for (blockout perimeter (typ)
Detail 1
3" steel channel (deck perimeter)
3'- 0"
Horizontal junction box
6"
3'- 6"
1'- 0"



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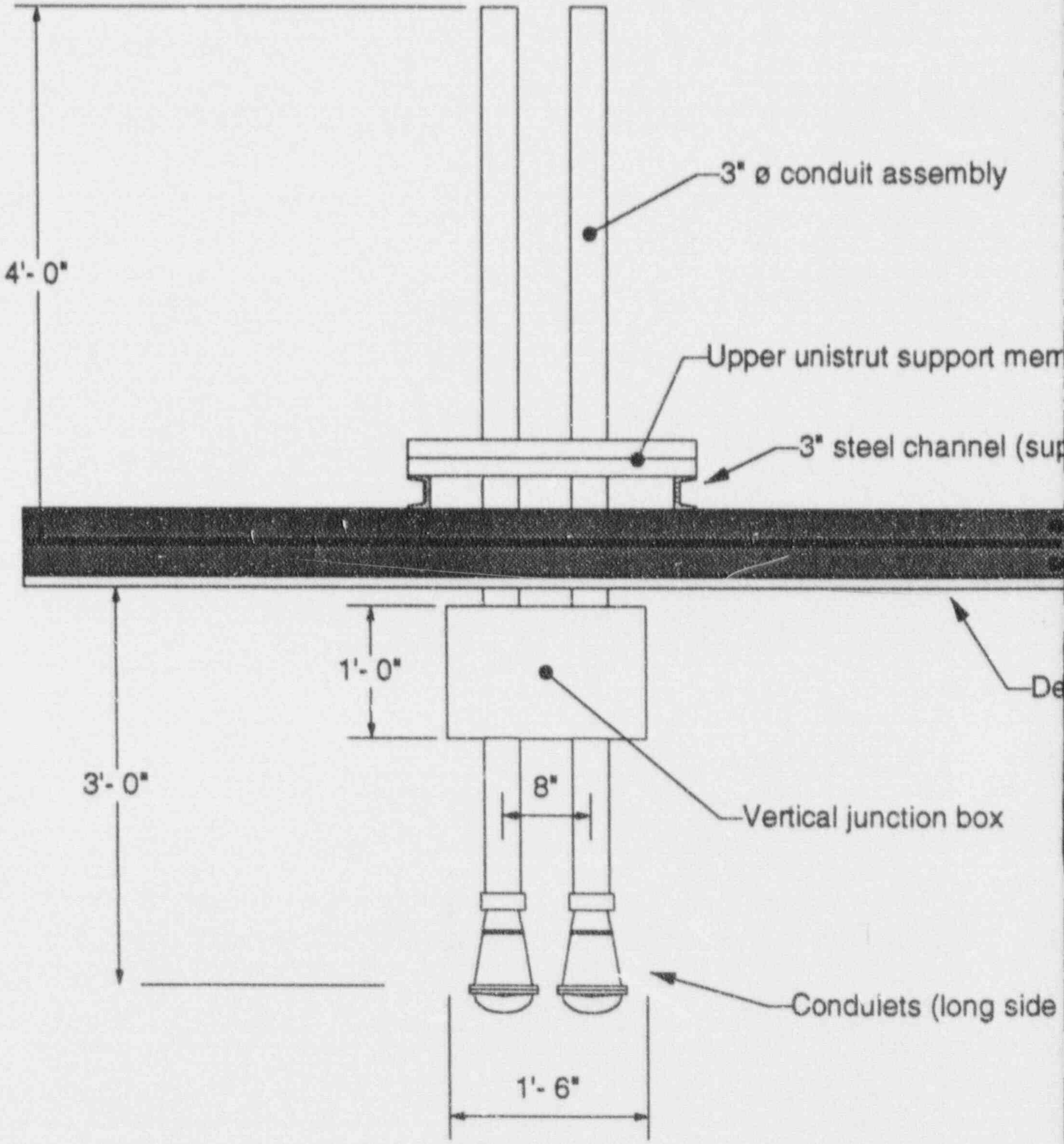
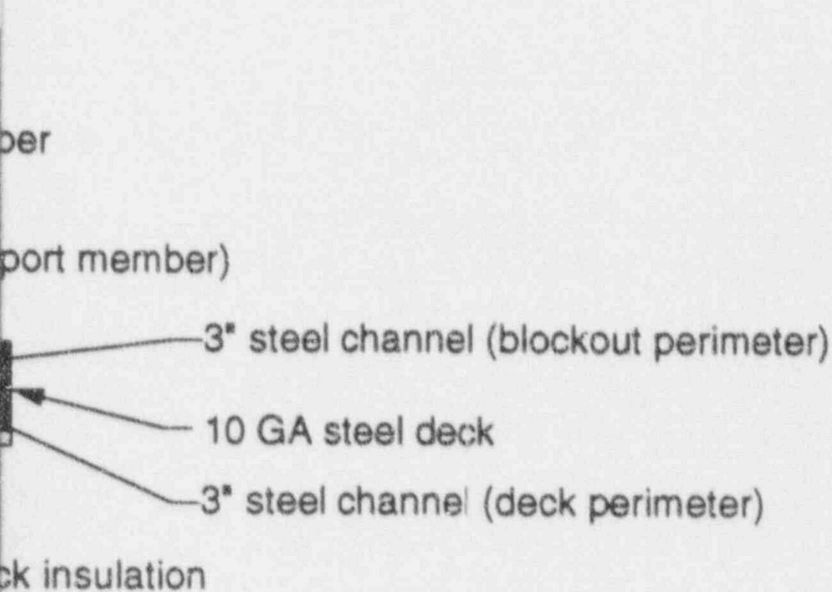
OMEGA POINT LABORATORIES, INC. Project No. 12340-94367c
TEXAS UTILITES ELECTRIC
Fig. 3 Elevation View Front and Rear 3" ø Conduits


3" ø conduit assembly
4'- 0"
Upper unistrut support mem
3" steel channel (sup
1'- 0"
De
3'- 0"
8"
Vertical junction box
Conduiets (long side
1'- 6"



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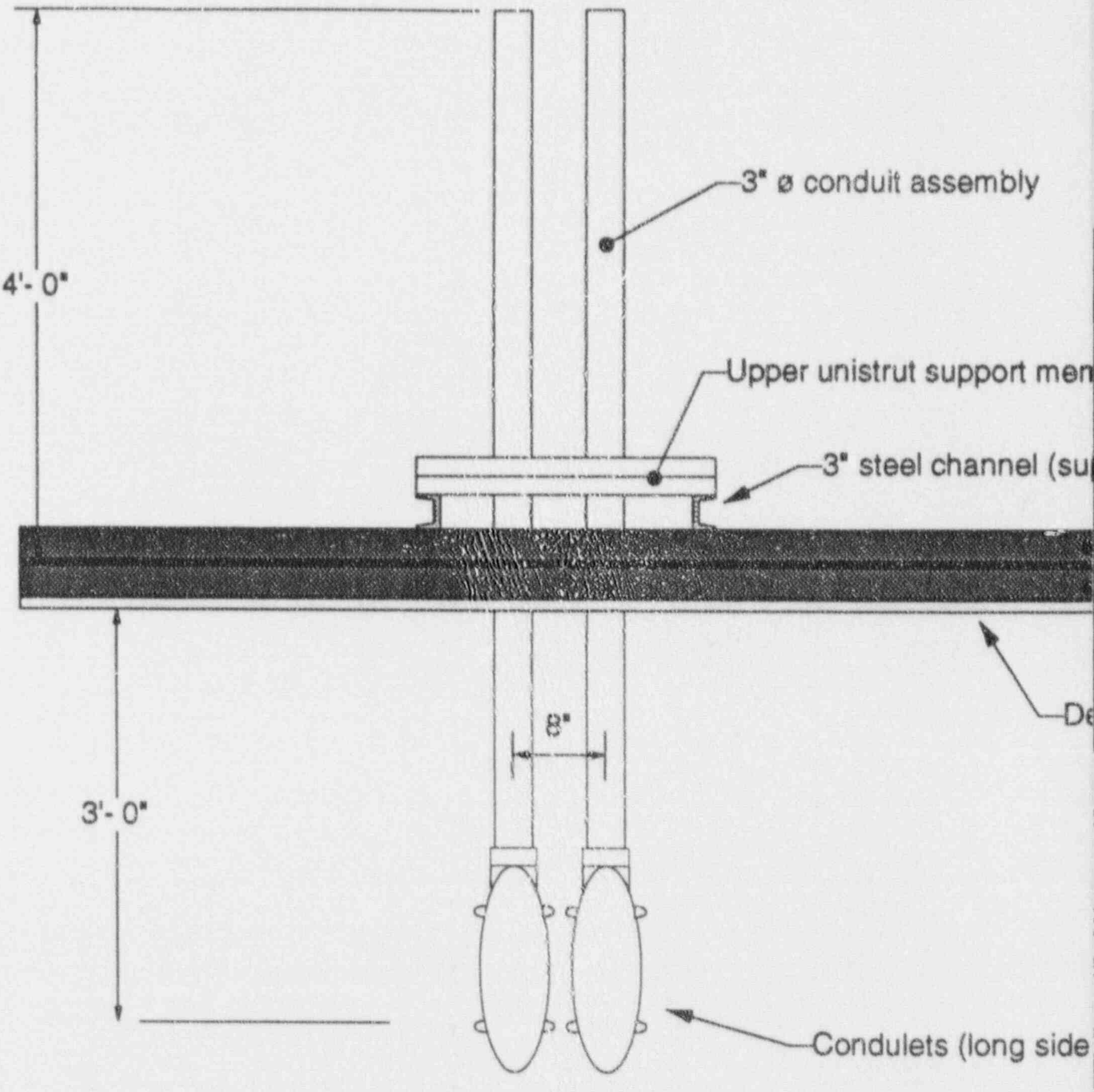
TEXAS UTILITES ELECTRIC
Fig. 4 RIGHT END VIEW

9302160274 -04



3" ø conduit assembly
4'- 0"
Upper unistrut support men
3" steel channel (su
De
8"
3'- 0"
Condulets (long side

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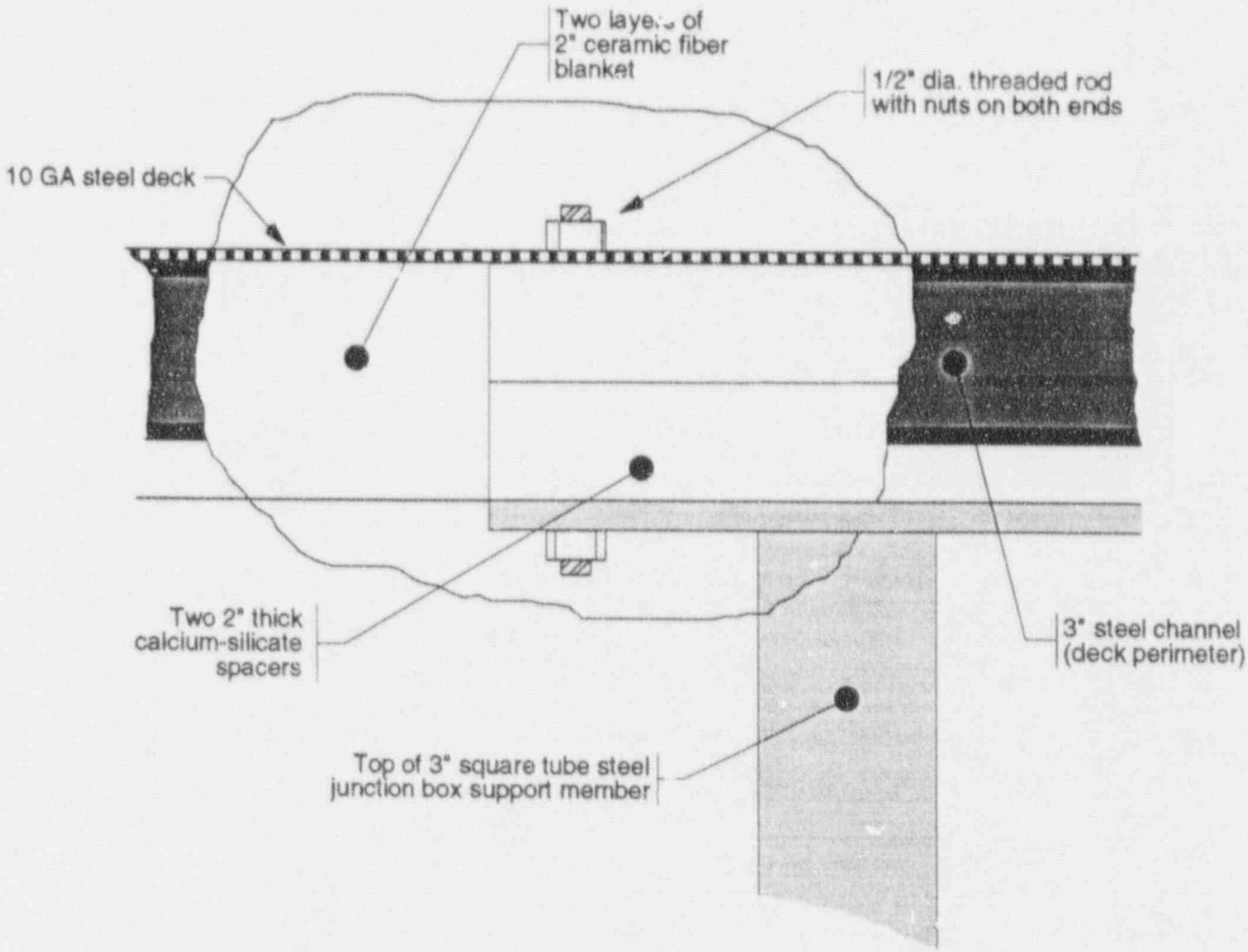
TEXAS UTILITES ELECTRIC
Fig. 5 LEFT END VIEW



DETAIL 1

OMEGA POINT LABORATORIES, INC. Project No. 12340-94367a
TEXAS UTILITIES ELECTRIC
Fig. 6 DETAIL 1 - Hanger Mount and Insulation

Appendix B

TEST PLAN

TEST PLAN - Rev. 8

ONE HOUR FIRE ENDURANCE TESTS OF ARTICLES
PROTECTED WITH THE THERMO-LAG®
FIRE BARRIER SYSTEM

1.0 SCOPE

This test plan describes the methods and guidelines to be utilized for the preparation of test specimens, installation of the THERMO-LAG® (hereafter referred to as "Thermo-Lag") Fire Barrier Systems, performance of fire endurance and hose stream tests, electrical cable circuit integrity, insulation resistance testing and temperature monitoring, and all applicable documentation of these tasks and the test results.

2.0 OBJECTIVE

The objective of these tests is to qualify a protective generic fire barrier system for redundant essential cables at TU Electric's Comanche Peak Steam Electric Station. Successful results of this test program will provide documented evidence that the generic fire barrier systems will satisfactorily withstand an ASTM E119-88 fire exposure for a period of one hour, followed by a hose stream test. The circuit integrity will be monitored continuously using digital data acquisition. These tests shall satisfy the requirements for fire testing the cable raceway fire barriers as detailed in the American Nuclear Insurers Bulletin B.7.2, 11/87, Attachment B entitled: "ANI/MAERP RA Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class IEEE Electrical Circuits", Revision 1, dated November 1987, and the NRC Letter dated October 29, 1992, (Ref.4.1.22) (attached), in the absence of other standards for these specific types of tests, standard practice shall be invoked. Variations in this test procedure from these methods, such as the hose stream test alternatives described in Section 8, will be documented in the final test report.

3.0 ACCEPTANCE CRITERIA

3.1 Temperature - Temperatures of all thermocouples will be monitored with each tray rail for cable trays averaged and outside of steel thermocouples for conduits averaged. In addition, thermocouples on one of each cable type (power, control, instrumentation) will be averaged. Acceptance criteria maximum temperatures will be 250° above the ambient initial temperature, for averages as listed above and 325° above the ambient initial temperature, for any single thermocouple.

3.2 Hose Stream Test/Barrier Inspection - A hose stream test with 30° fog nozzle at 75 psi minimum pressure and 75 gpm minimum flow will be applied to the test assembly from 5'-0" away for five minutes. Following the hose stream test, a visual inspection will be conducted to document any evidence of burnthrough or opening of the barrier by the hose stream. Acceptance criteria requires that no evidence of burnthrough or openings in the barrier are identified such that the raceway or cables are visible.

3.3 Cable Visual Inspection - Providing items 3.1 and 3.2 are satisfactory, cable visual inspection is not required. However, if either of these criteria are not met, the barrier material will be removed and the cables will be inspected visually for damage in accordance with the criteria described in Section 8.5. Documentation of cable visual condition will support cable functionality testing in 3.4.

3.4 Insulation Resistance Testing - Providing items 3.1 and 3.2 are satisfactory, insulation resistance (IR) testing is not required. However, if either of these criteria are not met, the barrier material will be removed and IR testing shall commence within thirty (30) minutes following the hose stream test. The acceptance criteria for IR testing is described in Section 7.11.1. Following completion of IR testing, cable visual inspection (item 3.3) shall be performed. During the barrier visual inspection and prior to thirty minutes following the hose stream test, insulation resistance testing will be conducted using the formula for acceptance criteria in the NRC Letter dated October 29, 1992. Providing the results meet those value, the test will be considered satisfactory.

3.5 Cable Circuit Integrity - American Nuclear Insurer's criteria and method for cable circuit monitoring for successful passage of the ASTM E119-88 Fire Endurance and Water Hose Stream Test as outlined in Sections 8 and 9 of this test plan.

4.0 REFERENCES

4.1 Documents

4.1.1 Federal Register/Volume 45, No. 225/Wednesday, November 19,1980 Fire Protection Program for Operating Nuclear Power Plants 10 CFR, Part 50, Appendix R.

4.1.2 American Nuclear Insurers Bulletin B.7.2.. 11/87, Attachment B entitled: "ANI/MAERP RA Standard Fire Endurance Test Method To Qualify A Protective Envelope

For Class IEEE Electrical Circuits", Revision I, dated November 1987.

4.1.3 ASTM E119-88 "Standard Methods of Fire Tests of Building Construction and Materials."

4.1.4 Thermal Science, Inc.'s Technical Note 20684, Revision V "THERMO-LAG 330 Fire Barrier System, Installation Procedures Manual, Power Generating Plant Application," including TSI letters of clarification thereto.

4.1.5 Specification CPES-M-2032, Rev. 0, "Procurement and Installation of Fire Barrier and Fireproofing Materials."

4.1.6 M2-1701, "Thermo-Lag Typical Details"

a. Sheet 01, Rev. CP-1
b. Sheet 02, Rev. CP-1
c. Sheet 03, Rev. CP-1
d. Sheet 03A, Rev. CP-1
e. Sheet 03B, Rev. CP-1
f. Sheet 04, Rev. CP-1
g. Sheet 04A, Rev. CP-1
h. Sheet 05, Rev. CP-1
i. Sheet 05A, Rev. CP-1
j. Sheet 06, Rev. CP-1
k. Sheet 07, Rev. CP-1
l. Sheet 08, Rev. CP-1
m. Sheet 09, Rev. CP-1
n. Sheet 10, Rev. CP-1
o. Sheet 11, Rev. CP-1
p. Sheet 12, Rev. CP-1
q. Sheet 13, Rev. CP-1
r. Sheet 14, Rev. CP-1
s. Sheet 15, Rev. CP-1

4.1.7 Construction/Quality Procedure CQP-CV-107, Rev. 0, "Application of Fire Barrier and Fireproofing Materials."

4.1.8 Specification CPES-M-1061, Rev. 0, "Fire-Rated, Radiation Shielding and Pressure Penetration Seals."

4.1.9 M2-1901, "Penetration Seals Typical Details"

a. Sheet 01, Rev. CP-1
b. Sheet 02, Rev. CP-1
c. Sheet 03, Rev. CP-1

d. Sheet 04, Rev. CP-1

4.1.10 Construction/Quality Procedure CQP-MS-125, Rev. 1, "Penetration Seals and Maintenance of Separation Gaps"

4.1.11 Installation Procedure IP-0044.CP, Rev. E, "Installation and Repair of 3-6548 Silicone RTV Foam Penetration Seals."

4.1.12 Quality/Construction Procedure QCP-0044.CP, Rev. F, "Installation Inspection of 3-6548 Silicone RTV Foam Penetration Seals."

4.1.13 Installation Procedure IP-0045.CP, Rev. D, "Installation and Repair of 45B Elastomer Penetration Seals."

4.1.14 Quality/Construction Procedure QCP-0045.CP, Rev. D, "Installation Inspection of 45B Penetration Seals."

4.1.15 Quality/Construction Procedure QCP-0049.CP, Rev. C, "Documentation of Penetration Seal Inspection."

4.1.16 Quality/Construction Procedure QCP-0067.CP, Rev. D, "Density Verification."

4.1.17 Specification CPES-E-2004, Rev. 15, "Electrical Installation."

4.1.18 Construction/Quality Procedure CQP-EL-222, Rev. 1, "Installation and Fabrication of Conduit Raceway Systems."

4.1.19 Construction/Quality Procedure CQP-EL-225, Rev. 2, "Cable Tray and Supports."

4.1.20 Prerequisite Test Procedure XCP-EE-01, Rev. 11, "Megger/HI Pot Testing."

4.1.21 IEEE Standard 634 (78) "Standard Cable Penetration Fire Stop Qualification Test."

4.1.22 NRC Letter to TU Electric dated October 29, 1992.

5.0 RESPONSIBILITIES

5.1 Texas Utilities Electric (TU Electric) and Associated Contractor Organizations

5.1.1 Establish the criteria, guidelines, drawings (draft quality), recommendations, etc., to govern the installation of the test items. Supply the test item pieces, including all hardware, electrical cables, conduit, tray systems, etc.

5.1.2 Establish the criteria, guidelines, drawings (draft quality), recommendations, etc., to govern the installation of the fire penetration seal systems as indicated on applicable drawings (Ref. 4.1.8 through 4.1.16).

5.1.3 Establish the criteria, guidelines, drawings (final, report-quality if needed), recommendations, etc., to govern the installation of the Thermo-Lag Fire Barrier System Materials to the test articles (Ref. 4.1.5 through 4.1.7).

5.1.4 Provide the specific Thermo-Lag and penetration seal installation procedures and work package documentation (Ref. 4.1.7 and 4.1.15).

5.1.5 Provide materials representative of existing or future site installations.

5.1.6 Provide the Thermo-Lag Fire Barrier System and penetration seal materials and installation tools and equipment.

5.1.7 Provide scheduling of personnel, equipment and material necessary to perform the installation and QC documentation of the fire barrier system materials utilizing the appropriate installation procedures.

5.1.8 Coordinate all phases of the fire test preparation with the testing organization including approval of variations from the standard American Nuclear Insurers Test Method.

5.1.9 Apply the fire barrier system and penetration seals to the test articles.

5.1.10 Supply QC and construction personnel to witness and document assembly and test article raceway configurations (Ref. 4.1.8 and 4.1.19).

5.1.11 Perform as a liaison with the testing organization and provide the testing organization with all applicable TU Electric Documents as identified in Section 4.1.

5.1.12 Provide all applicable quality control documentation for the fire barrier system materials, cables, and installation of the fire barrier system and penetration seal materials to each test article.

5.1.13 Provide equipment for performance of insulation resistance testing in accordance with TU Electric specifications and procedures (Ref. 4.1.17 and 4.1.20) as described in Section 7.11.

5.2 Omega Point Laboratories, Inc. (Laboratory)

5.2.1 Prepare the test furnace, deck and slab assemblies and provide all required test instrumentation in accordance with Appendix B Quality Assurance and Quality Control Programs and other applicable procedures.

5.2.2 Provide thermocouple calibration and instrumentation, storage temperature recorder, surface temperature probe and relative humidity instrumentation.

5.2.3 Assemble, install and document the installation of all trays, conduits, cables, etc. to be supplied by TU Electric. Provide computer-generated drawings of tray and conduit systems which clearly indicate dimensions, thermocouple locations, circuit integrity cable locations, etc.

5.2.4 Observe and document the installation of the Thermo-Lag Fire Barrier System Materials and penetration seals to the test articles, and attendant instrumentation on each test article.

5.2.5 Conduct the fire endurance and water hose stream tests, and also provide electrical cable circuitry integrity and continuity monitoring throughout the specified test time period.

5.2.6 Inspect and document the physical condition of all cables and Thermo-Lag fire barrier system for each test article following completion of water hose stream tests (where applicable).

5.2.7 Document the test parameters and provide a formal detailed written report of the test program and test results.

5.2.8 Provide VHS video and 35mm photographic coverage of the test project.

5.2.9 Provide insulation resistance testing of all circuits prior to and following fire endurance test as described in Section 7.11.

5.3 Laboratory Quality Assurance/Quality Control

5.3.1 Verify and document the quality control documentation of the fire barrier system materials used in the test program.

5.3.2 Perform and document inspections of the fire barrier system materials at various points during the installation process.

5.3.3 Verify and document that TU Electric's installation procedures are utilized in the installation of the fire barrier system and penetration seal materials.

5.3.4 Inspect and document the construction and instrumentation of the test articles.

5.3.5 Provide written calibration documentation of all thermocouples, measurement devices and data acquisition systems used in this test program.

6.0 SPECIAL PRECAUTIONS

6.1 Precautions For Installation Of The Fire Barrier System Materials

6.1.1 Observe specific precautions recommended by Thermal Science, Inc. and other's material safety data sheets.

6.2. Precautions For Conducting The Fire Endurance Test

6.2.1 Proper safety precautions shall be exercised to preclude personnel from direct exposure to the flame environment, hot objects, hazardous gases, and all other related hazards.

7.0 PREREQUISITES

7.1 General Test Configuration Requirements

The cable tray, conduit, cables and cable loading used in this test program shall be representative of those configurations used, and shall be specified and designed by TU Electric.

7.2 Traceability Requirements

To insure that the materials used in this test are representative of those in actual use at Comanche Peak Steam Electric Station (CPSES), all aspects of traceability as required by the Laboratory QA Program shall be applied.

The cables used in this test program shall be traceable to the respective cable manufacturer and shall be supplied by TU Electric with documentation of traceability.

All thermocouples used in this test program shall be traceable to the respective thermocouple manufacturer, with calibration certification.

7.3 Dimensioned Drawings

All test articles shall conform to the rough draft dimensioned drawings provided by TU Electric during assembly of the test articles. Final, dimensioned drawings will be prepared by the Laboratory.

7.4 Test Configuration

7.4.1 General

The test articles shall be sufficiently secured to the test deck by Laboratory personnel and sealed by TU Electric personnel, in accordance with instructions and drawings.

7.4.2 Cable Tray Test Articles

Ten (10) configurations (i.e. "Schemes") of steel ladder back cable trays supplied by TU Electric will be tested.

a. A 36" wide x 4" deep "U" shape configuration with horizontal tee assembly and protruding member (Scheme 1).

b. A 12" wide x 4" deep "U" shape (Scheme 3).

c. A 36" wide x 4" deep straight vertical configuration (Scheme 4).

d. A 30" wide x 4" deep "U" shape configuration with horizontal tee assembly and protruding member (Scheme 5).

e. A 24" wide x 4" deep "U" shape configuration with horizontal tee assembly (Scheme 6).

f. A 30" wide x 4" deep "U" shape (Scheme 8).

g. A 30" wide x 4" deep "U" shape (Scheme 12-1).

h. A 24" wide x 4" deep "U" shape configuration with horizontal tee assembly (Scheme 12-2).

i. A 12" wide x 4" deep "U" shape (Scheme 13-1).

j. A 30" wide x 4" deep "U" shape configuration with horizontal tee assembly (Scheme 14-1)

7.4.3 Conduit Test Articles

Seven (7) configurations (i.e. "Schemes") of rigid steel conduits supplied by TU Electric will be tested.

a. A "U" shape conduit configuration consisting of three (3) individual rigid steel conduits; 3/4" diameter, 1" diameter and 5" diameter, mounted to a central 24" x 18" x 8" junction box. This configuration will also contain three (3) protruding members (Scheme 2).

b. A "U" shape conduit configuration consisting of five (5) individual conduits; two 3/4" diameter, one 1-1/2" diameter, one 2" diameter and one 3" diameter. Each conduit will have two (2) lateral bends (Scheme 7).

c. A "U" shape conduit configuration consisting of three (3) individual rigid steel conduits; 3/4" diameter, 3" diameter and 5" diameter. Each conduit will have one (1) lateral bend and one (1) radial bend (Scheme 9-1).

d. A "U" shape conduit configuration consisting of three (3) individual rigid steel conduits; 3/4" diameter, 3" diameter and 5" diameter. Each conduit will have one (1) lateral bend and one (1) radial bend (Scheme 9-2).

e. A "U" shape conduit configuration consisting of three (3) individual rigid steel conduits; 3/4" diameter, 1-1/2" diameter and 2" diameter. Each conduit will have two (2) lateral bends (Scheme 9-3).

f. A "U" shape conduit configuration consisting of two (2) individual rigid steel conduits, both 3" diameter, mounted to one (1) horizontal 18" x 12" x 6" junction box and one (1) vertical 18" x 12" x 6" junction box. Each conduit will have two (2) lateral bends (Scheme 10-1).

g. A "U" shape conduit configuration consisting of two (2) individual rigid steel conduits, both 3" diameter, mounted to one (1) horizontal 18" x 12" x 6" junction box and one (1) vertical 18" x 12" x 6" junction box. Each conduit will have two (2) lateral bends (Scheme 10-2).

7.4.4 Air Drop Test Articles

One (1) configuration (i.e. "Scheme") of steel ladder back cable tray which transitions into four (4) rigid steel conduits supplied by TU Electric will be tested.

a. A "U" shape configuration consisting of a 24" wide x 4" deep cable tray, with 90° sweeping bend, which transitions into three (3) individual rigid steel conduits; 1" diameter, 2" diameter and 3" diameter, through individual "air drops" and one "air drop" of cabling which exits the top of the 24" wide x 4" deep cable tray and enters a vertical 5" diameter rigid steel conduit, which extends through the test deck (Scheme 11-1).

7.5 Cable Loading Requirements

Cable loading requirements* shall be as specified by TU Electric, and will approximately consist of the following percentage mix:

CABLE TRAYS AND 1-1/2" – 5" DIAMETER CONDUIT

33 1/3% 600 volt Power Cables
33 1/3% 600 volt Instrumentation Cables
33 1/3% 600 volt Control Cables

3/4" – 1" DIAMETER CONDUIT

Either 100% Control or Instrumentation Cable

* Actual tray and conduit full densities and cable diameters will be documented and included in the final test report.

7.6 Cable Installation

An itemized listing of cable types and quantities including density fill to be installed in the test articles will be prepared by the Laboratory and included in the final report. Cable location within the test articles shall be documented and included with data to be evaluated by the testing laboratory.

OMEGA POINT LABORATORIES

7.7 Thermocouple Installation

All thermocouples used in this test program shall be provided and installed by the Laboratory, with QC surveillance by Laboratory personnel. The thermocouple wires shall be calibrated (by Lot No.) prior to installation and/or use, and applicable quality control documentation for record purposes generated. All thermocouples will consist of 24 GA, type K, Chromel-Alumel (Special Limits of Error: ±1.1°C) electrically welded thermojunctions. Calibration will consist of manufacturer-supplied (and audited) certifications of calibrations at five temperatures of thermocouples taken from both ends of each purchased lot number.

All thermocouples shall be located on and within each test article in accordance with the following TU Electric requirements:

NOTE: Thermocouple locations which differ from the following criteria shall be documented in the final test report.

1) All cable trays shall be instrumented with thermocouples located on the outside, longitudinal centerline of each cable tray rail at 12 inch intervals along the portions of the cable tray that are below the deck and protected by the fire protective envelope. Each thermocouple shall be attached to the tray rail by the use of a small metal screw. For each tray rail, the maximum and average temperatures will be documented.

2) All conduits shall be instrumented with thermocouples located on the outside, top surface of the conduit at 12 inch intervals along the portions of the conduit that are below the deck and protected by the fire protective envelope. Each thermocouple shall be attached to the conduit by a double wrap of glass-fiber reinforced electrical tape or by electrical welding to the conduit steel. For each conduit, the maximum and average temperatures will be documented.

3) Electrical junction box (Scheme 1) shall be instrumented with a minimum of one thermocouple per 5 square feet of exterior surface, located on the inside surface of the item and attached using a small sheet metal screw or welded directly to the steel surface. A thermocouple shall be placed within one (1) inch of the penetration seal on the inside surface of the junction box.

4) Electrical junction boxes (Schemes 10-1 and 10-2) shall be instrumented with a minimum of one (1) thermocouple centered on the inside surface of each box face and one (1) thermocouple within 1" of where each conduit enters the junction box. Thermocouples shall be attached using a small sheet metal screw or welded directly to the steel surface. These thermocouples will be grouped with attached conduit

thermocouples and maximum and average temperatures will be documented.

5) Electrical cables (Schemes 1 through 8) shall be randomly selected in each assembly (one of each cable type: Power, Instrumentation and Control) and instrumented with thermocouples located at each 12 inch interval along each cable's length inside the exposed area of the test item. If insufficient cables are contained within a test item to instrument to that degree, a minimum of one cable, of the smallest size in that system, will be instrumented. Systems which contain more than a single layer of cables will have the instrumented cables positioned at the top surface of the cable bundle.

   Each thermocouple shall be attached to its appropriate cable by placing the thermojunction in direct contact with the outer insulation of the cable for a minimum of 3-1/2" and covering with a double wrap of glass-fiber reinforced electrical tape, unless otherwise documented in the final test report.

6) Electrical cables (Schemes 9-1 through 14-1) shall be randomly selected in each assembly (one of each cable type: Power, Instrumentation and Control) and instrumented with thermocouples located at each 6 inch interval along each cable's length inside the exposed area of the test item. If insufficient cables are contained within a test item to instrument to that degree, a minimum of one cable, of the smallest size in that system, will be instrumented.

   Each thermocouple shall be attached to its appropriate cable by placing the thermojunction in direct contact with the outer insulation of the cable for a minimum of 3-1/2" and covering with a double wrap of glass-fiber reinforced electrical tape, unless otherwise documented in the final test report.

7) Instrumented cables in cable tray Schemes 1, 3, 4 and 5 shall be positioned such that one passes down the longitudinal centerline and the other two shall be positioned between the center cable and the tray rails on each side, as documented in the final test report.

8) Instrumented cables in cable tray in Schemes 6, 8, 11-1, 12-1, 12-2, 13-1 and 14-1 shall be positioned such that one passes down the longitudinal centerline and the other two shall be positioned immediately next to the tray rails on each side, as documented in the final test report. Each line of thermocouples on a cable will be grouped and maximum and average temperatures will be documented.

9) Cables in conduits will have one instrumented cable in the center of the bundle, one cable half-way to the outside of the bundle and one instrumented cable on the outside of the bundle.

10) For air drop tests, cable bundles will be instrumented as described in paragraph 9 above, unless otherwise documented in the final test report, and those cables will have thermocouples every six inches through the remainder of the test assembly. Where these cables are located in the cable trays, one of the instrumented cables will be positioned (as described in paragraph 8 above) immediately next to each tray rail and one along the longitudinal centerline of the tray. All remaining thermocoupled cables will be distributed as evenly as possible. Each line of thermocouples on a cable will be grouped and maximum and average temperatures will be documented.

7.8 Installation of the Fire Barrier system to the Test Articles

Thermo-Lag Fire Barrier System materials shall be installed by TU Electric in accordance with applicable specifications, design drawings and procedures (Ref. 4.1.5, 4.1.6 and 4.1.7) such that the test articles are representative of CPSES plant installations except those test articles intended to qualify upgraded THERMO-LAG installation configurations. Details of the Thermo-Lag configurations including fasteners, orientation of structural ribs, etc., shall be documented in the final test report.

7.9 Fire Seal Installation

Upon completion of the fabrication and installation of the fire barrier systems to the test articles (or prior to, depending upon the situation), all openings in the test articles shall be sealed by TU Electric in accordance with applicable specifications, design drawings and procedures (Ref. 4.1.8 through 4.1.16). All openings in the test deck and slab assemblies not sealed by TU Electric shall be sealed by the laboratory.

Failure of the fire seal shall not necessarily constitute a failure of the protective envelope. The type of fire seal used shall be at the discretion of TU Electric.

7.10 Circuit Integrity Monitoring

All cables shall be energized to monitor circuit integrity (as required to check for a circuit failure) in accordance with Reference 4.1.2. Circuit failure is defined as circuit to circuit (conductor to conductor short); open circuit (conductor broken); and, circuit to ground (short circuits, conductors to ground). The cables shall be instrumented for each of the three parameters in accord with the following:

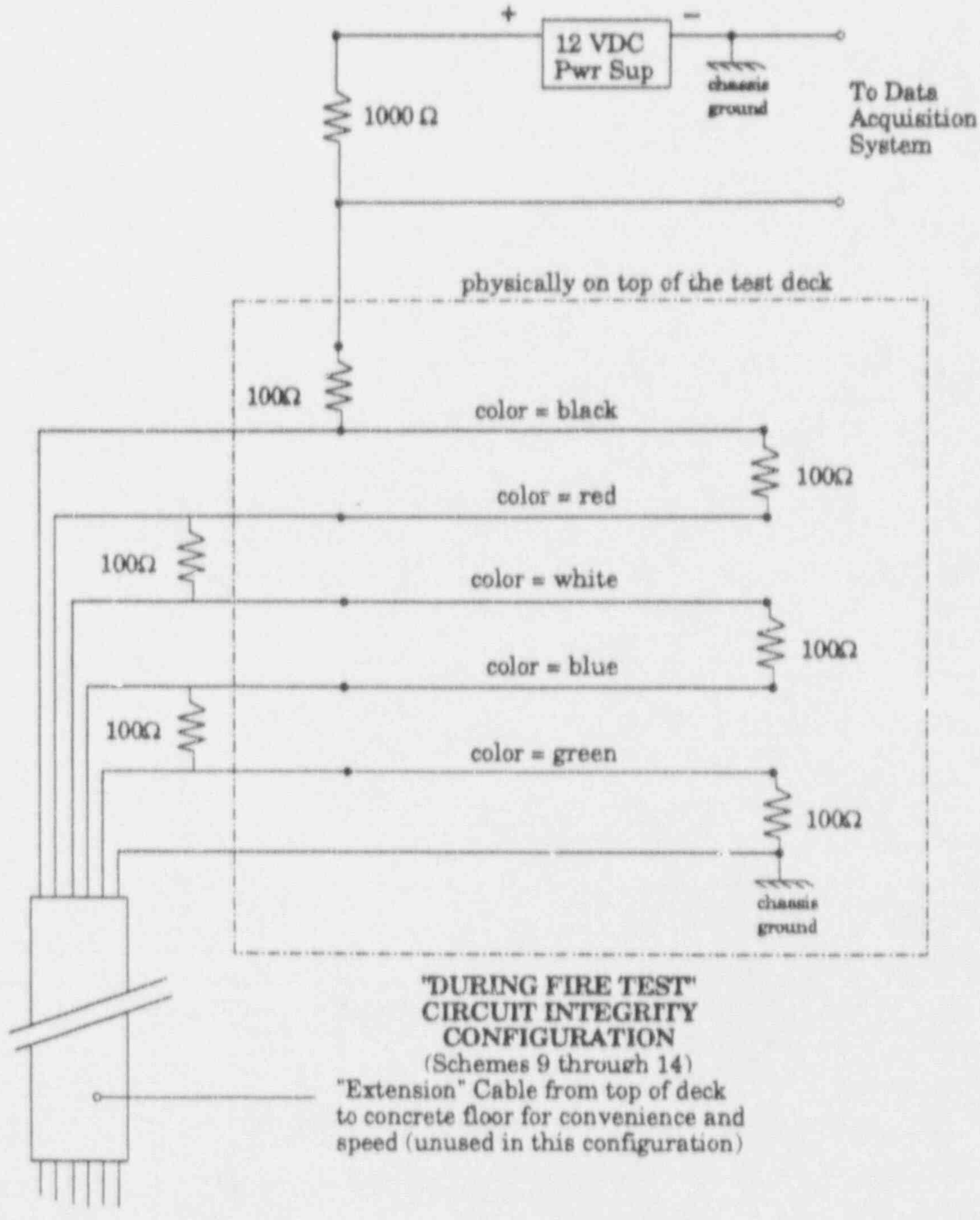
- All cables of a single type shall be connected into a single series circuit, which will allow any circuit failure to be detected. Cable failures will be identifiable as having been Power, Control or Instrumentation cable.

- Cable circuit integrity will be done by energizing each circuit with low voltage (5 - 12 VDC). The data acquisition system will monitor the voltage across the system and will register any drop in voltage.

  NOTE: Circuit integrity with low voltage is based on personal safety concerns and is consistent with standard test practice.

The purpose of the circuit integrity measurement is to enable the detection of the occurrence of a short between any two conductors or ground (the tray or conduit steel) or an open circuit. Since the failure of any conductor within the system would result in a failure of the protective envelope, it is not important to be able to determine exactly which conductor failed, but merely that it did fail. Consequently, all conductors of each type will be connected together in a single series circuit, with a 100Ω resistor between each end. Finally, a 1000Ω resistor will be installed between this circuit and a 12 volt DC power supply (wet cell battery) to act as a load resistor for the data acquisition system, and a 100Ω resistor will be connected between the end of the circuit and system ground.

The resultant circuit allows the measurement of a steady-state voltage drop across the entire circuit, which will drop accordingly as any combination of the 100Ω resistors are removed from the circuit by shorting of any conductors. With the total resistance of the circuit being 2000Ω, and the data acquisition system measuring across 1000Ω of the 2000Ω, the minimum voltage drop due to a loss of one of the 100Ω resistors would be approximately 0.316 volts, a level easily detected. An open anywhere in the circuit would cause the voltage to drop to zero. A typical circuit integrity monitoring design (one which would be used with a limited number of cables, which would be all connected into a single circuit) is shown below:

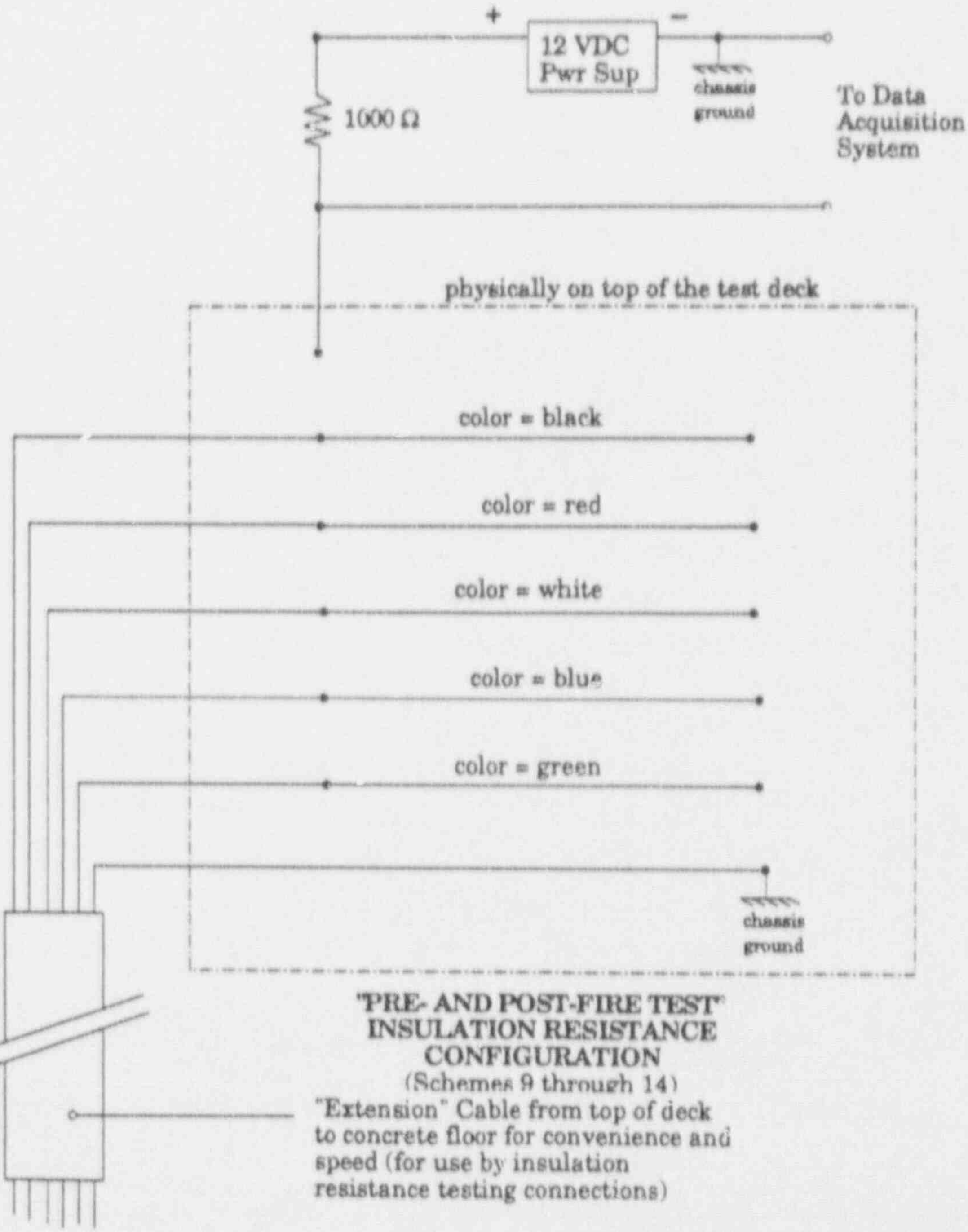


"DURING FIRE TEST"
CIRCUIT INTEGRITY
CONFIGURATION
(Schemes 9 through 14)

"Extension" Cable from top of deck to concrete floor for convenience and speed (unused in this configuration)

The monitored cables shall be scanned at least once each minute. Monitored cables shall be energized until the hose stream test is completed.

NOTE: All conduit and cable trays shall be separately grounded by connection of a 1/0 copper ground to the Laboratory's electrical chassis ground. Preceding and following the fire and hose stream tests, the cables will be tested for Insulation Resistance, with the circuits configured as follows:



"PRE- AND POST-FIRE TEST" INSULATION RESISTANCE CONFIGURATION
(Schemes 9 through 14)

The Insulation Resistance Test will be performed prior to the fire exposure test in accordance with 7.11.1 and the circuit configuration will then be changed to that necessary for following Circuit Integrity during the fire and hose stream tests. Following the hose stream test the circuit configuration will be returned to that required for the Insulation Resistance Test in accordance with 7.11.1. The insulation resistance test will begin within 30 minutes of completion of the hose stream test.

7.11 **Preburn Inspection**

7.11.1 The Laboratory shall perform insulation resistance testing of all circuits with a 500 v megohmmeter for instrumentation and 1500 v megohmmeter for power and control cables to establish reasonable assurance that wiring insulation was not damaged prior to or during installation. This will determine the insulation resistance from all conductor to conductor combinations, and each conductor to ground. Details of this testing will be discussed in each test report and documented on "Insulation Resistance Testing Data Sheets." The acceptance criteria for each "meggered" cable is based on the following formula:

$$\text{IR Acceptance Value } (M\Omega) \geq \frac{\left(\frac{1M\Omega}{kV} + 1\right) * 1000\,(ft)}{\text{Length}\,(ft)}$$

7.11.2 Prior to the commencement of the fire endurance test, a thorough check of each test assembly and associated equipment (including data recording equipment) shall be performed and documented by the testing laboratory.

7.11.3 TU Electric shall inspect the Thermo-Lag Fire Barrier System for surface defects, etc. prior to test.

7.11.4 Written approval of the construction, assembly, installation and instrumentation will be supplied by TU Electric and the Laboratory prior to performance of each fire exposure test (a sign-off sheet for this purpose will be supplied by the Laboratory).

7.11.5 Fire endurance testing of assemblies will not commence until Thermo-Lag Fire Barrier Materials attain a moisture meter reading that does not exceed 20% moisture content when using a meter with a scale of 0-100 (with 100 being 20% actual moisture content) such as a Delmhorst Model DP or equivalent.

8.0 PROCEDURE

8.1 **Fire Endurance Test**

8.1.1. The protected test article shall be exposed to the standard time/temperature curve found in ASTM E119 (88) for one hour.

8.1.2 The testing organization shall adapt their testing procedures to assure the fire test complies with the requirements established in all referenced portions of referenced standards. Any changes, revisions, or deviations required to comply with this requirement shall be documented and properly justified and included as a part of the final test report.

8.2 **Insulation Resistance Test**

8.2.1 The insulation resistance test shall be conducted in accordance with Section 7.11.1 prior to the fire test and following the hose stream test.

8.3 **Water Hose Stream Test**

8.3.1 For Schemes 1 through 5, immediately following the fire endurance test, accessible surfaces of the protected test article shall be subjected to the American Nuclear Insurer's preferred water hose stream test, as specified. The water hose stream shall be applied for a minimum of two and one half (2-1/2) minutes. Proper safety precautions shall be exercised. Only those personnel required to perform the hose stream test shall be allowed in the immediate area, and only then with appropriate breathing apparati.

8.3.2 For Scheme 7, no hose stream test will be conducted to facilitate post-fire test inspection of the test articles. Instead, a nondestructive quench of the articles will be utilized with a garden hose and a gentle spray.

8.3.3 For all remaining schemes, the hose stream test will be applied using a 30° angle spray nozzle with a minimum pressure at the nozzle of 75 psi at a distance of 5 feet, for a 5 minute duration. The minimum flow from the nozzle shall be 75 gpm (in accordance with Ref. 4.1.21.)

8.4 **Protective Envelope Inspection**

8.4.1 Following the Water Hose Stream Test a visual inspection will be conducted of the outer surface of the protective envelope including all material and seams. The condition of the envelope will be documented, including any locations where there is evidence of burn through or opening of the barrier, on a "Barrier Inspection Data Sheet."

8.5 **Cable Inspection**

8.5.1 Following the Protective Envelope Inspection and Post Fire Insulation Resistance Test, visual inspection of all cables for each test article shall be performed. The physical condition of all cables shall be detailed on "Cable Inspection Data Sheets" in the final test report and suitably photographed. The criteria utilized for visual inspection of cables shall include but is not necessarily limited to the following:

a) jacket swelling/blistering, splitting/cracking, discoloration or melting
b) shield exposed
c) conductor insulation exposed, degraded or discolored
d) bare copper conductor exposed
e) jacket hardening

9.0 DATA SYSTEMS

9.1 During the fire exposure period, the thermocouples will be scanned at one minute intervals or less. Data storage for reporting purposes will be at one minute intervals, although the furnace thermocouples will be scanned every 15 seconds, to allow close control of the furnace. A printer output and scanning of all other thermocouple data will also be done at intervals of one minute or less, but will not be included in the test report (however, this record will be filed in the QC document file at the Laboratory).

9.2 Monitored cables shall be energized during the water hose stream test or nondestructive quench as applicable.

10.0 FIRE TEST REPORT

10.1 The Laboratory will submit a report on the results of the test and thermocouple data.

10.2 The Laboratory will assemble the final test report, containing the collected data and required quality control documentation.

10.3 The test report shall be prepared in sufficient detail to summarize the total testing activity. The report shall include as a minimum:

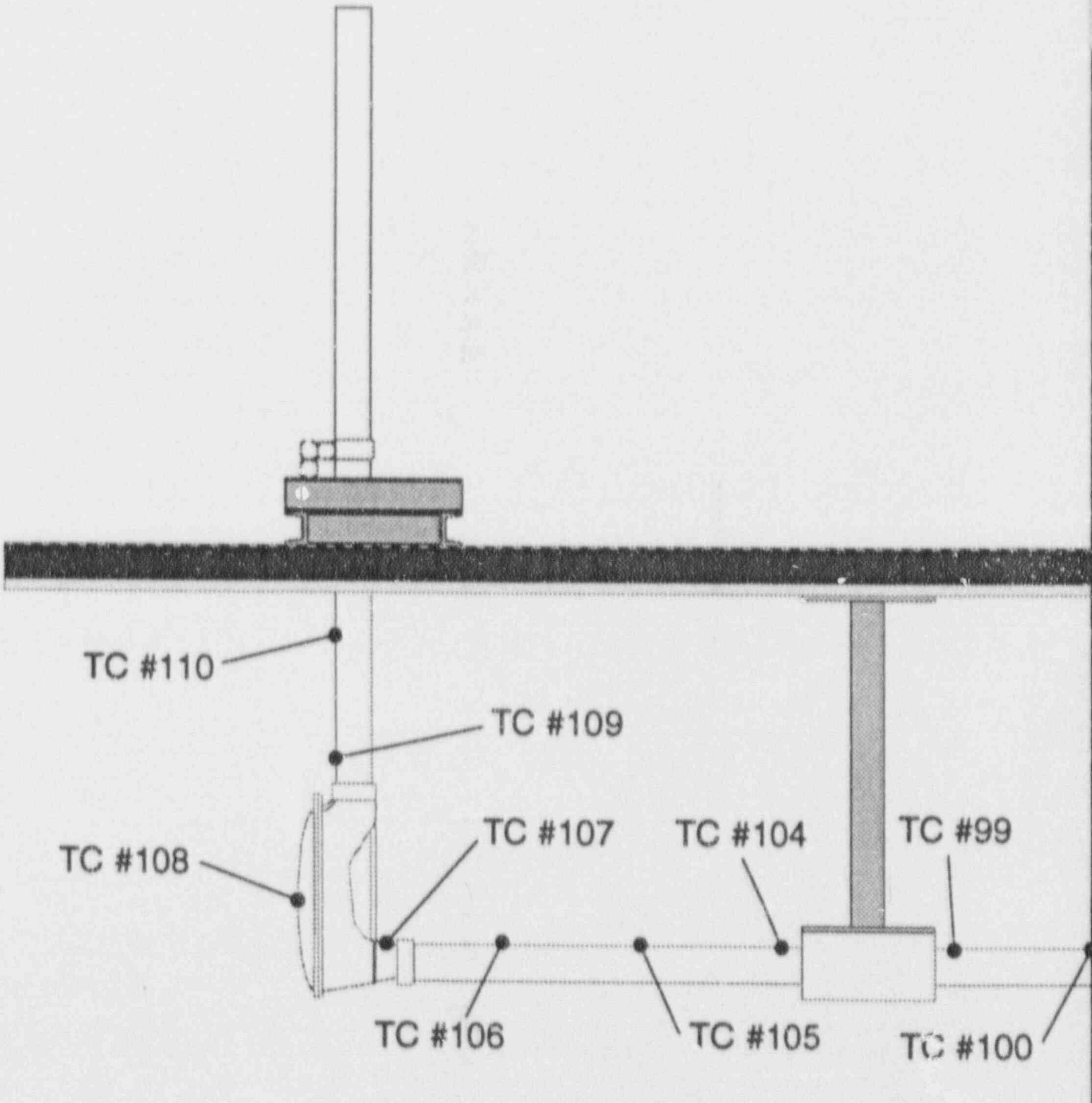
a) Date of the test
b) Location of the test
c) Description of the test furnace and test articles
d) Calibration documentation of all thermocouples
e) Qualification and certification for test personnel
f) Test procedures used
g) Acceptance criteria
h) Provide quality control records for:
    - Test article construction
    - Qualification and certification for installation and inspection personnel
    - Identification and installation of fire barrier material
    - Thermocouple locations
    - Cables, size, type, and location
    - Actual tray and conduit fill densities
i) Computer printout and graphic results of the fire endurance test
j) All raw data including circuit integrity monitoring
k) 35mm and VHS video photographic coverage of the test project
l) Provide a chronological log (Event Log) of all activities from receipt of materials through final test report
m) Insulation resistance test methodology and documentation
n) Post test protective envelope and cable inspection records and results

OMEGA POINT LABORATORIES

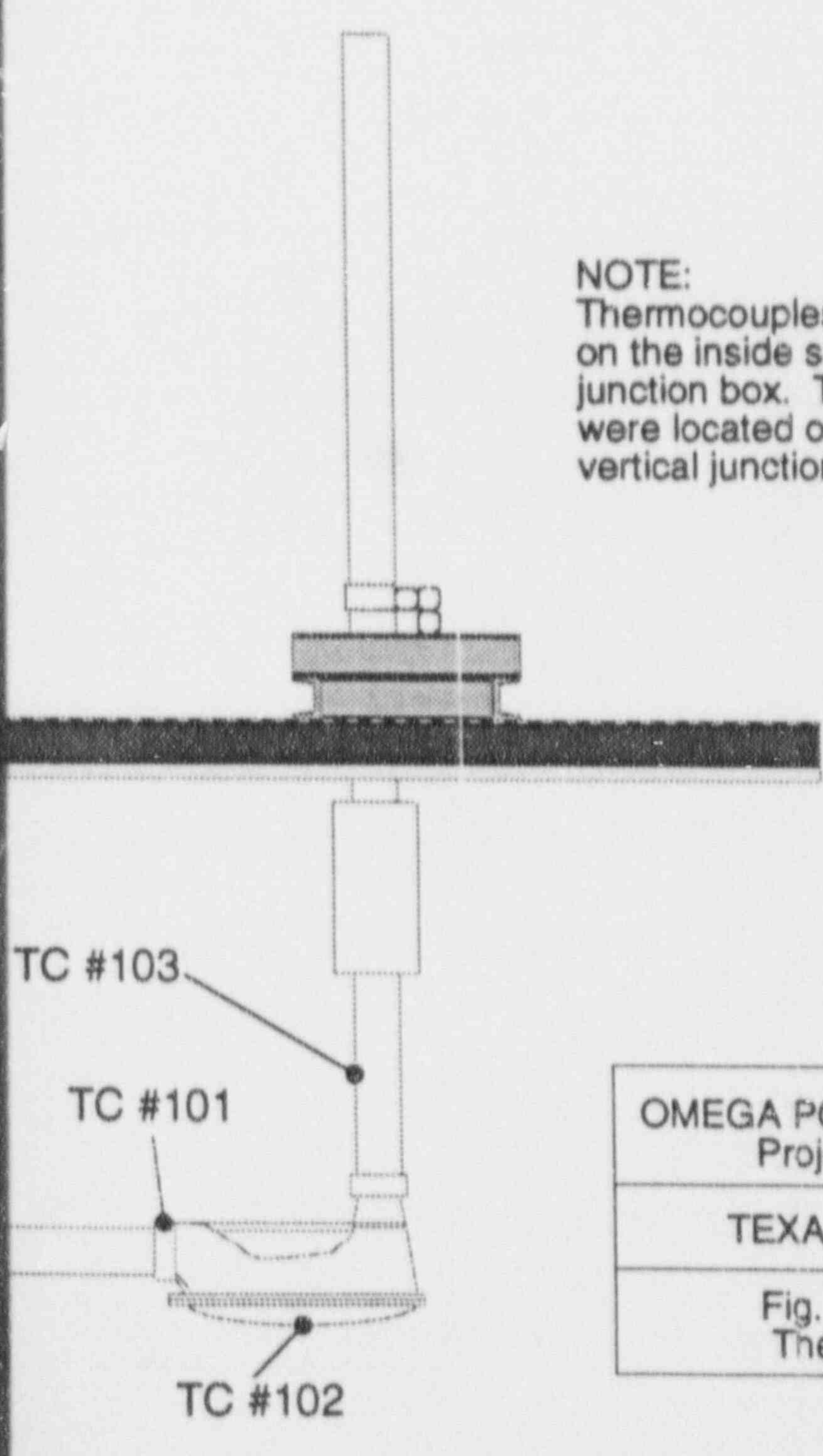
Appendix C

THERMOCOUPLE LOCATIONS

OMEGA POINT LABORATORIES

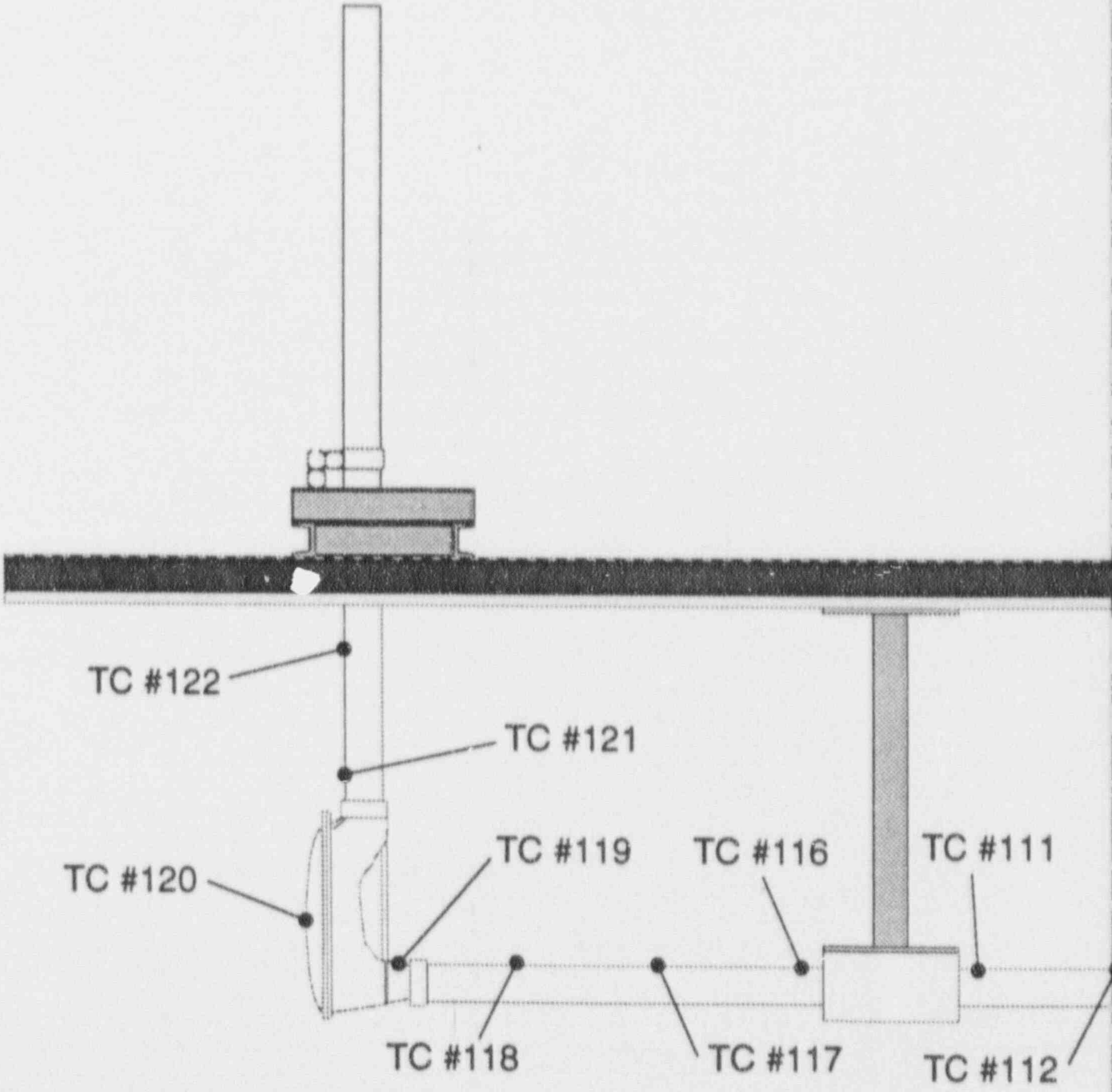


TC #110
TC #109
TC #108
TC #107
TC #104
TC #99
TC #106
TC #105
TC #100

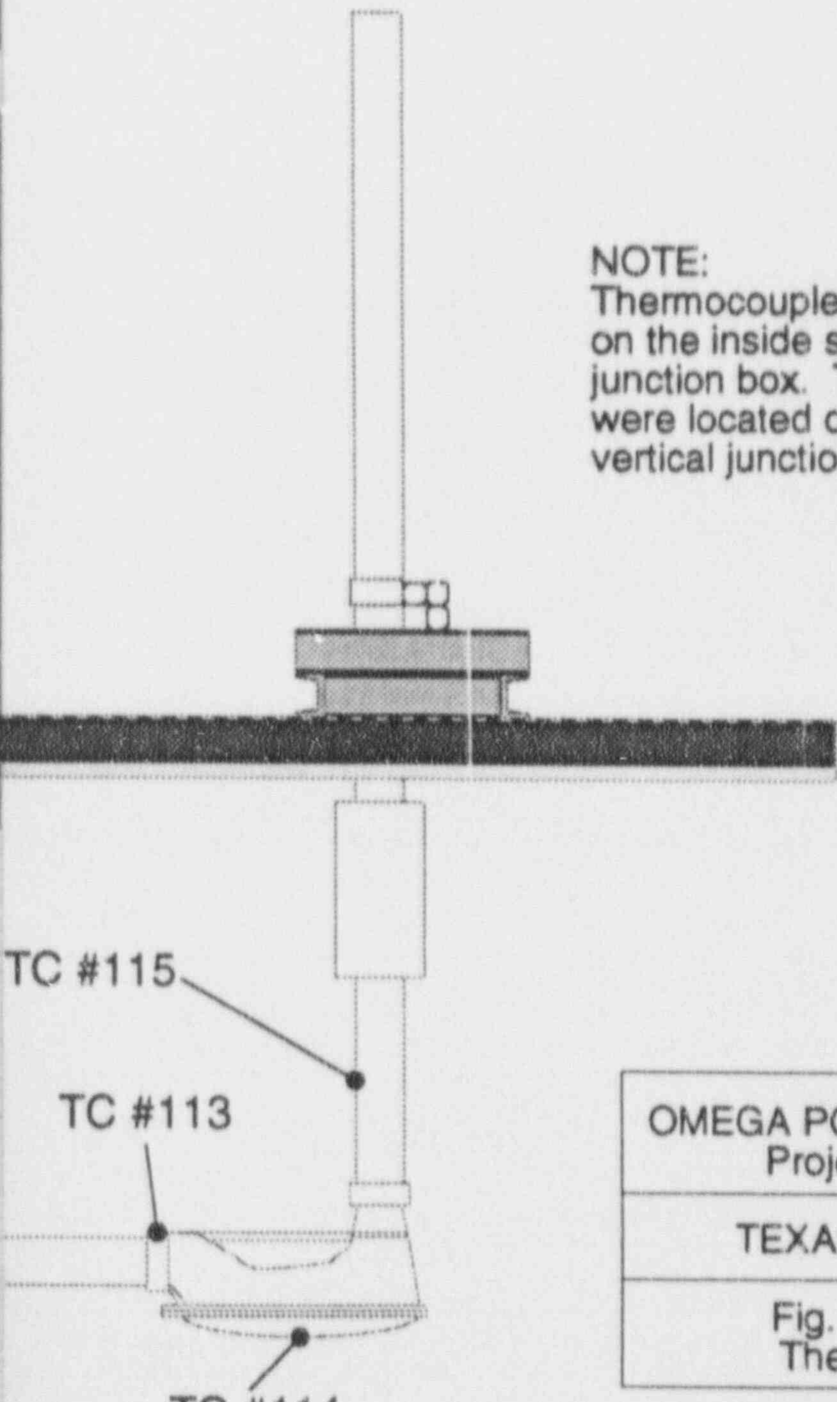


NOTE:
Thermocouples 40 through 49 were located on the inside surfaces of the horizontal junction box. Thermocouples 50 through 59 were located on the inside surfaces of the vertical junction box.

OMEGA POINT LABORATORIES, INC. Project No. 12340-94367c
TEXAS UTILITES ELECTRIC
Fig. 7 Front 3" ø Conduit Thermocouple Locations



TC #122
TC #121
TC #120
TC #119
TC #116
TC #111
TC #118
TC #117
TC #112



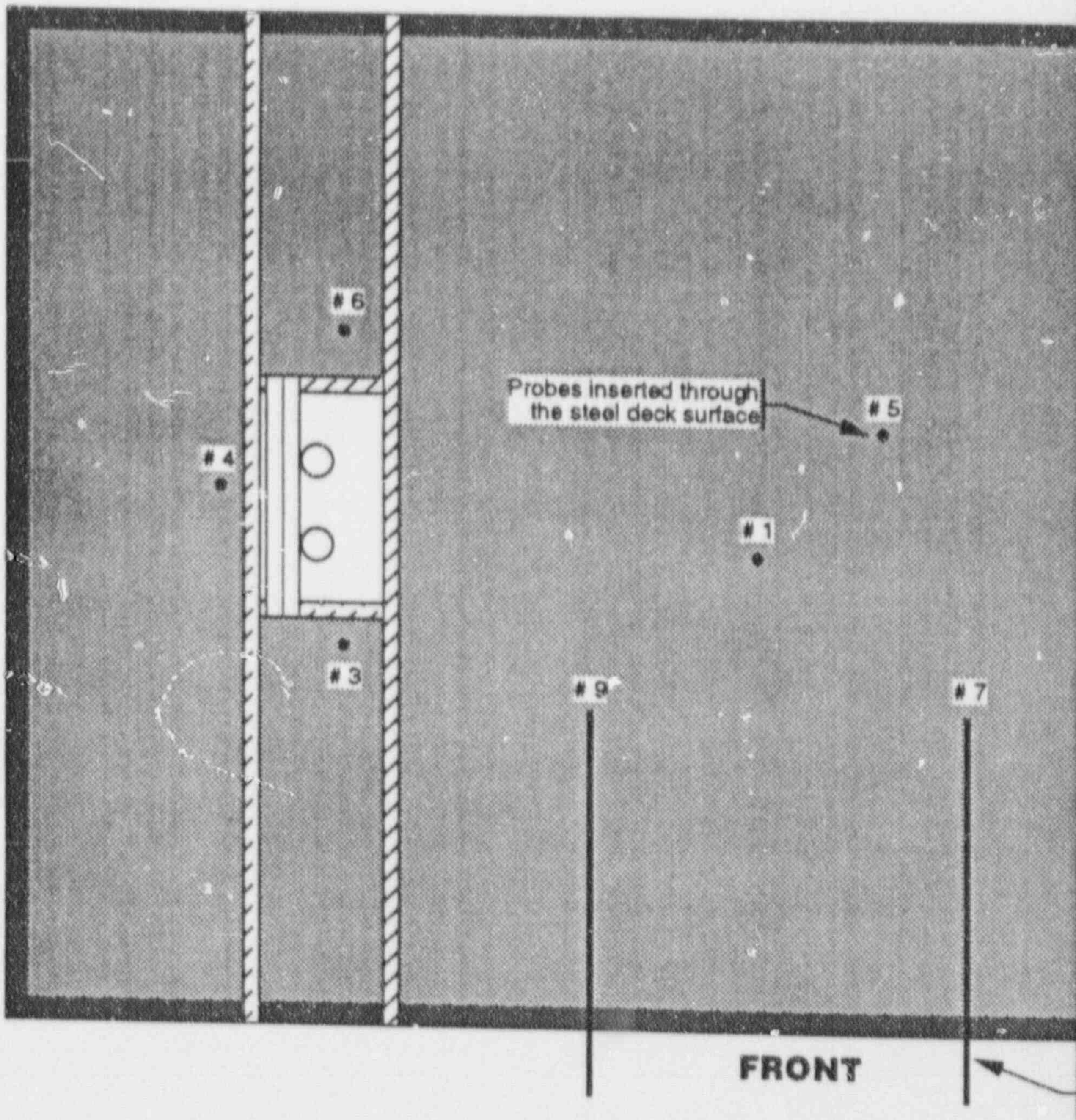
NOTE:
Thermocouples 40 through 49 were located on the inside surfaces of the horizontal junction box. Thermocouples 50 through 59 were located on the inside surfaces of the vertical junction box.

SI
APERTURE
CARD

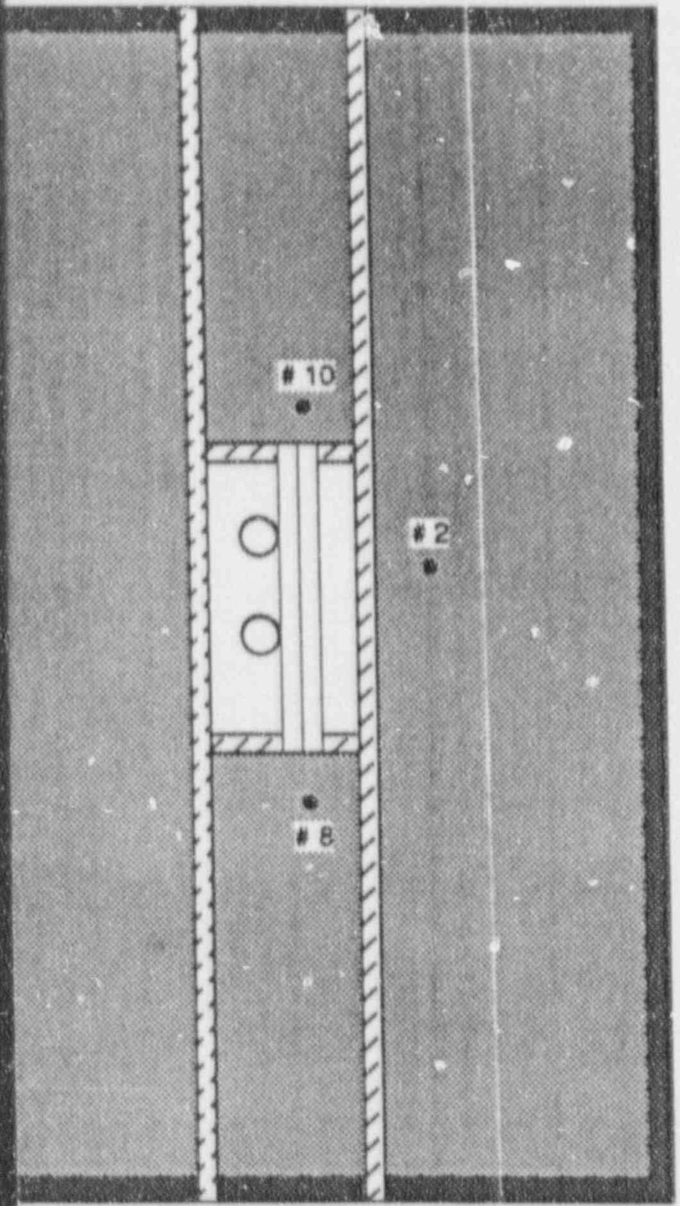
Also Available On
Aperture Card

OMEGA POINT LABORATORIES, INC. Project No. 12340-94367c
TEXAS UTILITES ELECTRIC
Fig. 8 Rear 3" ø Conduit Thermocouple Locations

9302160274 - 07



6
Probes inserted through
the steel deck surface
5
4
1
3
9
7
FRONT



Probes inserted through the front furnace wall

RIGHT

SI
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Aperture Card

OMEGA POINT LABORATORIES, INC. Project No. 12340-94367c
TEXAS UTILITES ELECTRIC
Fig. 9 Furnace Probe Locations

9302160274 -08

THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

Scheme #9-1: 94367A
Scheme #9-2: 94367B
Scheme #10-1: 94367C
Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Front

Power Cable

3C/#8 W-020

TC Number	Description of exact physical location
P1	Center of cable
P159	6" right of center
P2	12" right of center
P160	18" right of center
P3	24" right of center
P161	30" right of center
P4	36" right of center
P162	42" right of center
P5	48" right of center
P163	54" right of center
P6	60" right of center
P164	66" right of center
P7	72" right of center
P165	6" left of center
P8	12" left of center
P166	18" left of center
P9	24" left of center
P167	30" left of center
P10	36" left of center
P168	42" left of center
P11	48" left of center
P169	54" left of center
P12	60" left of center
P170	66" left of center
P13	72" left of center

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

PLEASE USE THE BACK OF THIS SHEET FOR DRAWINGS, IF NECESSARY

THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

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Scheme #9-2: 94367B
Scheme #10-1: 94367C
Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Front
Control Cable
7C/#12 W-047

TC Number	Description of exact physical location
[illegible]4	Center of cable
[illegible]1	6" right of center
C15	12" right of center
C172	18" right of center
C16	24" right of center
C173	30" right of center
C17	36" right of center
C174	42" right of center
C8	48" right of center
C175	54" right of center
C19	60" right of center
C176	66" right of center
C20	72" right of center
C177	6" left of center
C21	12" left of center
C178	18" left of center
C22	24" left of center
C179	30" left of center
C23	36" left of center
C180	42" left of center
C24	48" left of center
C181	54" left of center
C25	60" left of center
C182	66" left of center
C26	72" left of center

NOTE: TCs shall be numbered sequentially from 1 [illegible]wards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

PLEASE USE THE BACK OF THIS SHEET FOR DRAWINGS, IF NECESSARY

THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

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Scheme #9-2: 94367B
Scheme #10-1: 94367C
Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Front Instrumentation Cable 5C/#16 W-071

TC Number	Description of exact physical location
I27	Center of cable
I183	6" right of center
I28	12" right of center
I184	18" right of center
I29	24" right of center
I185	30" right of center
I30	36" right of center
I186	42" right of center
I31	48" right of center
I187	54" right of center
I32	60" right of center
I188	66" right of center
I33	72" right of center
I189	6" left of center
I34	12" left of center
I190	18" left of center
I35	24" left of center
I191	30" left of center
I36	36" left of center
I192	42" left of center
I37	48" left of center
I193	54" left of center
I38	60" left of center
I194	66" left of center
I39	72" left of center

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

PLEASE USE THE BACK OF THIS SHEET FOR DRAWINGS, IF NECESSARY

THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

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Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: Horizontal J-Box

Internal Steel Surfaces

TC Number	Description of exact physical location
E40	On left vertical J-Box side, 1" from conduit, between conduit and front side
E41	Centered on left vertical J-Box side between conduits
E42	On left vertical J-Box side, 1" from conduit, between conduit and rear side
E43	Centered on rear vertical J-Box side
E44	On right vertical J-Box side, 1" from conduit, between conduit and rear side
E45	Centered on right vertical J-Box side between conduits
E46	On right vertical J-Box side, 1" from conduit, between conduit and front side
E47	Centered on front vertical J-Box side
E48	Centered on top horizontal side of J-Box
E49	Centered on bottom horizontal side of J-Box (cover)

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.
PLEASE USE THE BACK OF THIS SHEET FOR DRAWINGS, IF NECESSARY

THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

Scheme #9-1: 94367A
Scheme #9-2: 94367B
Scheme #10-1: 94367C
Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: Vertical J-Box

Internal Steel Surfaces

TC Number	Description of exact physical location
E50	On bottom horizontal J-Box side, 1" from conduit, between conduit and front side
E51	Centered on bottom horizontal J-Box side between conduits
E52	On bottom horizontal J-Box side, 1" from conduit, between conduit and rear side
E53	Centered on rear vertical J-Box side
E54	On top horizontal J-Box side, 1" from conduit, between conduit and rear side
E55	Centered on top horizontal J-Box side between conduits
E56	On top horizontal J-Box side, 1" from conduit, between conduit and front side
E57	Centered on front vertical J-Box side
E58	Centered on left vertical side of J-Box
E59	Centered on right vertical side of J-Box (cover)

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
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Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Rear

Power Cable

3C/#8 W-020

TC Number	Description of exact physical location
P60	Center of cable
P123	6" right of center
P61	12" right of center
P124	18" right of center
P62	24" right of center
P125	30" right of center
P63	36" right of center
P126	42" right of center
P64	48" right of center
P127	54" right of center
P65	60" right of center
P128	66" right of center
P66	72" right of center
P129	6" left of center
P67	12" left of center
P130	18" left of center
P68	24" left of center
P131	30" left of center
P69	36" left of center
P132	42" left of center
P70	48" left of center
P133	54" left of center
P71	60" left of center
P134	66" left of center
P72	72" left of center

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
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Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Rear

Control Cable

7C/#12 W-047

TC Number	Description of exact physical location
C73	Center of cable
C135	6" right of center
C74	12" right of center
C136	18" right of center
C75	24" right of center
C137	30" right of center
C76	36" right of center
C138	42" right of center
C77	48" right of center
C139	54" right of center
C78	60" right of center
C140	66" right of center
C79	72" right of center
C141	6" left of center
C80	12" left of center
C142	18" left of center
C81	24" left of center
C143	30" left of center
C82	36" left of center
C144	42" left of center
C83	48" left of center
C145	54" left of center
C84	60" left of center
C146	66" left of center
C85	72" left of center

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
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Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Rear Instrumentation Cable

5C/#16 W-071

TC Number	Description of exact physical location
I86	Center of cable
I147	6" right of center
I87	12" right of center
I148	18" right of center
I88	24" right of center
I149	30" right of center
I89	36" right of center
I150	42" right of center
I90	48" right of center
I151	54" right of center
I91	60" right of center
I152	66" right of center
I92	72" right of center
I153	6" left of center
I93	12" left of center
I154	18" left of center
I94	24" left of center
I155	30" left of center
I95	36" left of center
I156	42" left of center
I96	48" left of center
I157	54" left of center
I97	60" left of center
I158	66" left of center
I98	72" left of center

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

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Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Front

Conduit Steel

TC Number	Description of exact physical location
E99	1" to right of center (horizontal) junction box, on top of conduit
E100	12" to right of previous TC, on top of conduit
E101	12" to right of previous TC, on top surface of condulet bell
E102	Centered on outside of condulet cover
E103	7-1/4" above top of condulet, on inside of conduit
E104	1" to left of center (horizontal) junction box, on top of conduit
E105	12" to left of previous TC, on top of conduit
E106	12" to left of previous TC, on top of conduit
E107	12" to left of previous TC, 1" to left of lower condulet bell, on top of condulet
E108	Centered on outside of condulet cover
E109	1" above top of condulet, on outside of conduit surface
E110	12" above previous TC on outside of conduit surface

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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THERMOCOUPLE PLACEMENT LOG - PROJECT NO. 94367

NOTE:
This Log is to be used to document the precise location of the thermocouples located on each test item. The assigned project number for each of the test assemblies are:

Scheme #9-1: 94367A
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Scheme #10-2: 94367D
Scheme #11-1: 94367E
Scheme #11-2: 94367F
Scheme #11-3: 94367G
Scheme #12-2: 94367H
Scheme #12-1: 94367I
Scheme #9-3: 94367J
Scheme #10-3: 94367K
Scheme #13-1: 94367L
Scheme #14-1: 94367M

Project #: 94367C

Scheme #: 10-1

Item: 3" Conduit-Rear

Conduit Steel

TC Number	Description of exact physical location
E111	1" to right of center (horizontal) junction box, on top of conduit
E112	12" to right of previous TC, on top of conduit
E113	12" to right of previous TC, on top surface of condulet bell
E114	Centered on outside of condulet cover
E115	7-1/4" above top of condulet, on inside of conduit
E116	1" to left of center (horizontal) junction box, on top of conduit
E117	12" to left of previous TC, on top of conduit
E118	12" to left of previous TC, on top of conduit
E119	12" to left of previous TC, 1" to left of lower condulet bell, on top of condulet
E120	Centered on outside of condulet cover
E121	1" above top of condulet, on outside of conduit surface
E122	12" above previous TC on outside of conduit surface

NOTE: TCs shall be numbered sequentially from 1 upwards for each deck assembly. Prefixes shall be added as follows: P (power cable), C (control cable), I (instrumentation cable) and E (engineering TC), for instance P1, E35, C46, etc.

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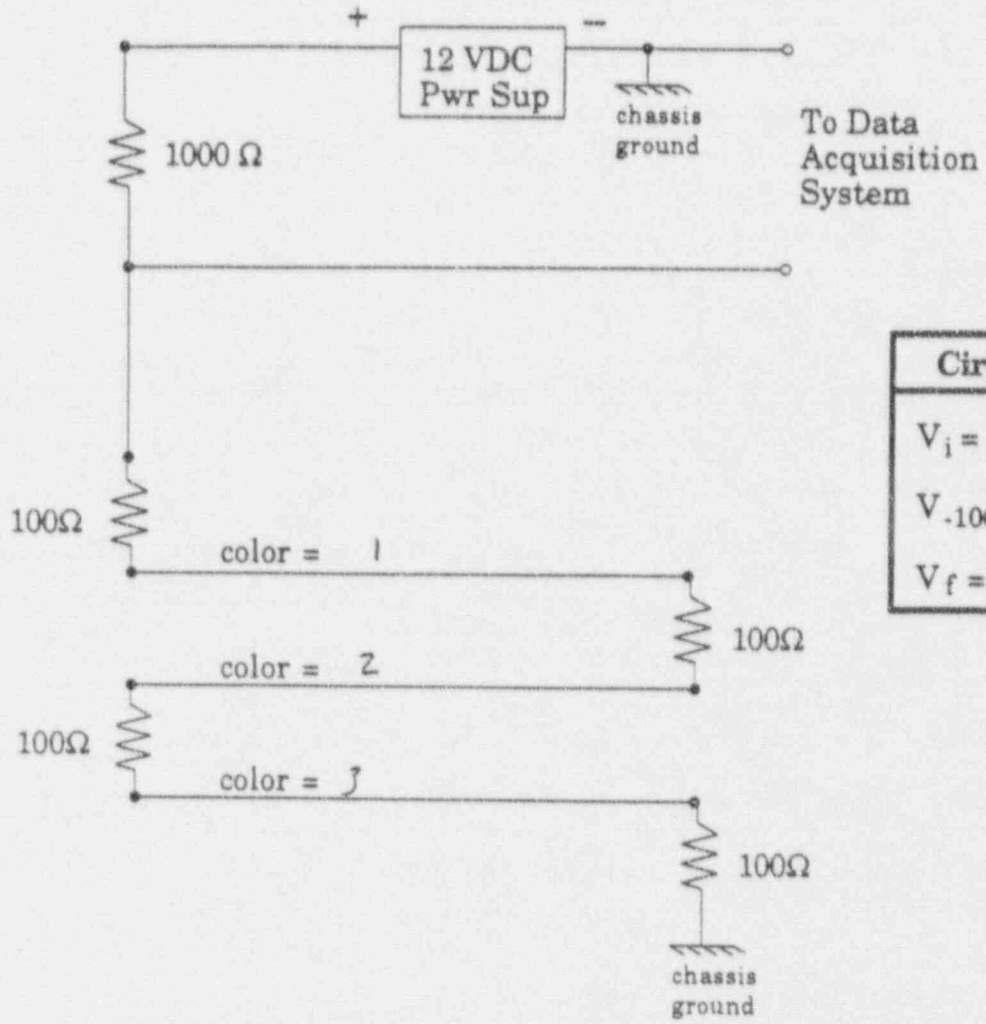
Appendix D

CIRCUIT INTEGRITY DETAILS

TEXAS UTILITIES ELECTRIC
PROJECT NO. ______________
CIRCUIT INTEGRITY CONNECTIONS



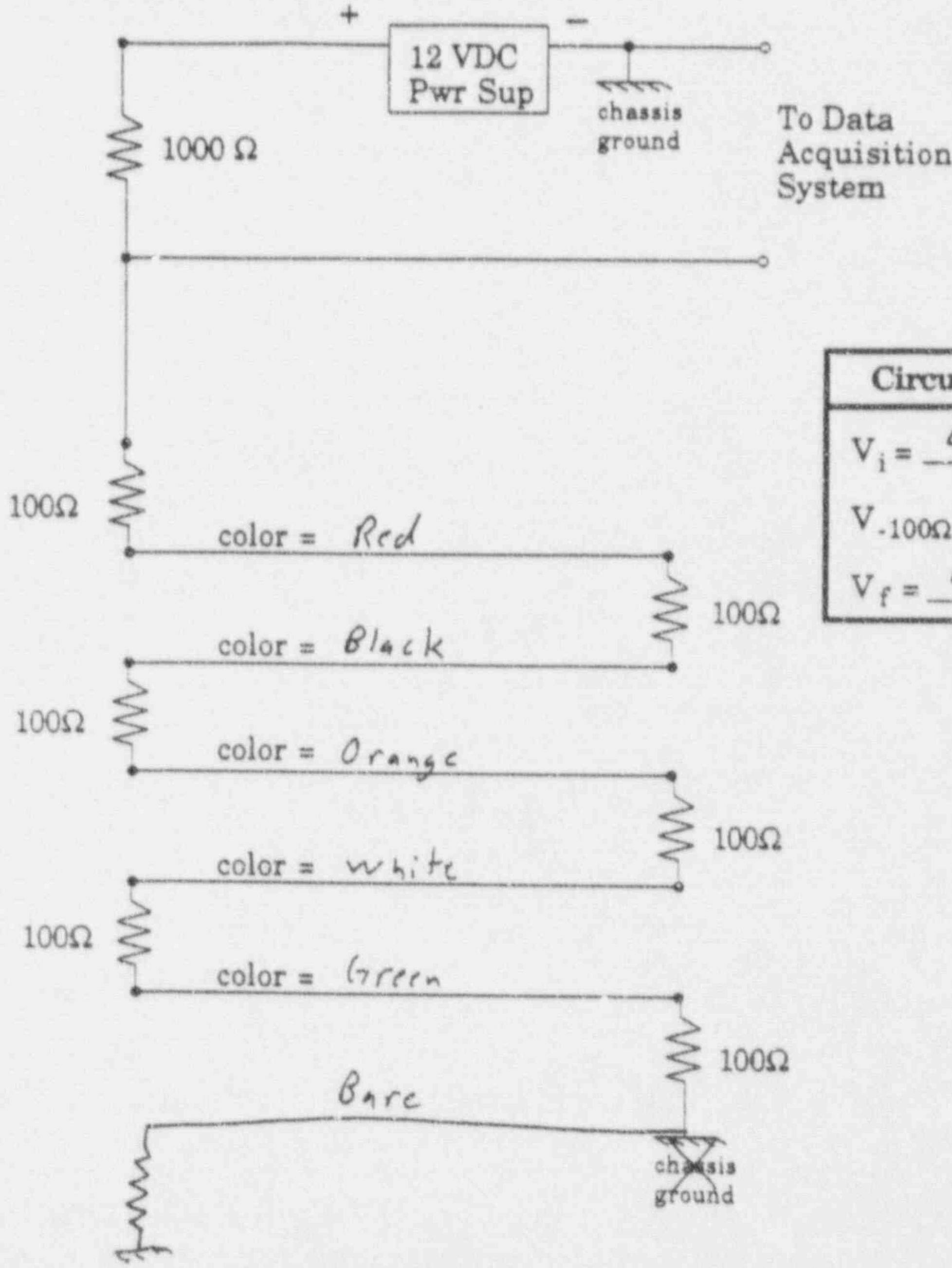
Circuit Integrity
V_i = ~~1.364~~ 2.970
$V_{-100\Omega}$ = 2.195
V_f = 2.964

Date Instrumented: 11-5-92
Technician: KH

Channel 1 - "A"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Front 3" Conduit
CABLE FUNCTION:	POWER
CABLE TYPE:	W-023
CABLE SIZE:	3C/#8 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ___________
CIRCUIT INTEGRITY CONNECTIONS



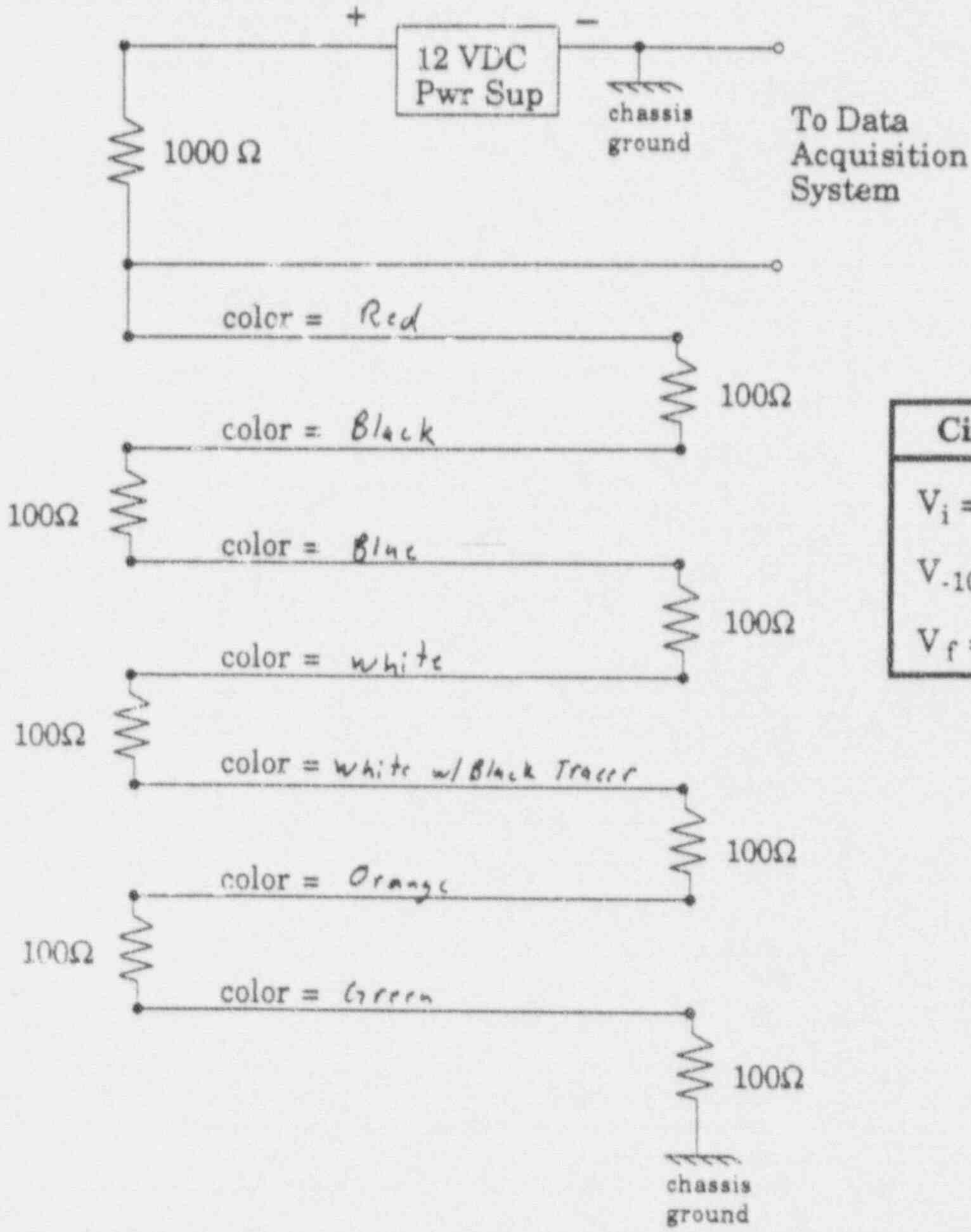
Circuit Integrity	
V_i =	4.702
$V_{-100\Omega}$ =	4.194
V_f =	4.692

Date Instrumented: 11-5-92
Technician: KH

Channel 2 - "8"

SCHEME #: 10
ASSEMBLY #: 1
ITEM: Front 3" Conduit
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-071
CABLE SIZE: 5C/#16 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



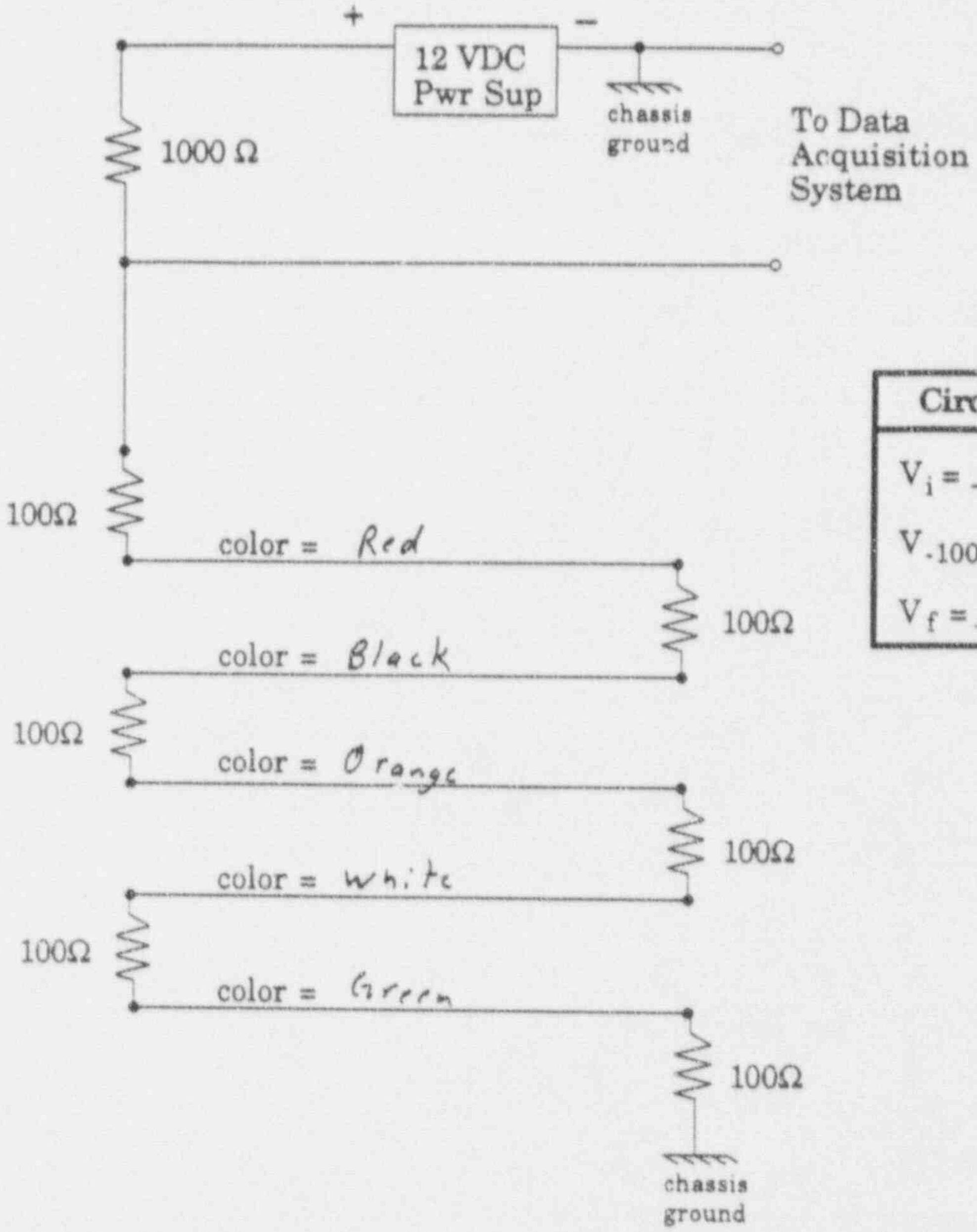
Circuit Integrity
V_i = 5.133
$V_{-100\Omega}$ = 4.681
V_f = 5.130

Channel 3 - "C"

Date Instrumented: 11-5-92
Technician: KCH

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Front 3" Conduit
CABLE FUNCTION:	CONTROL
CABLE TYPE:	W-047
CABLE SIZE:	7C/#12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



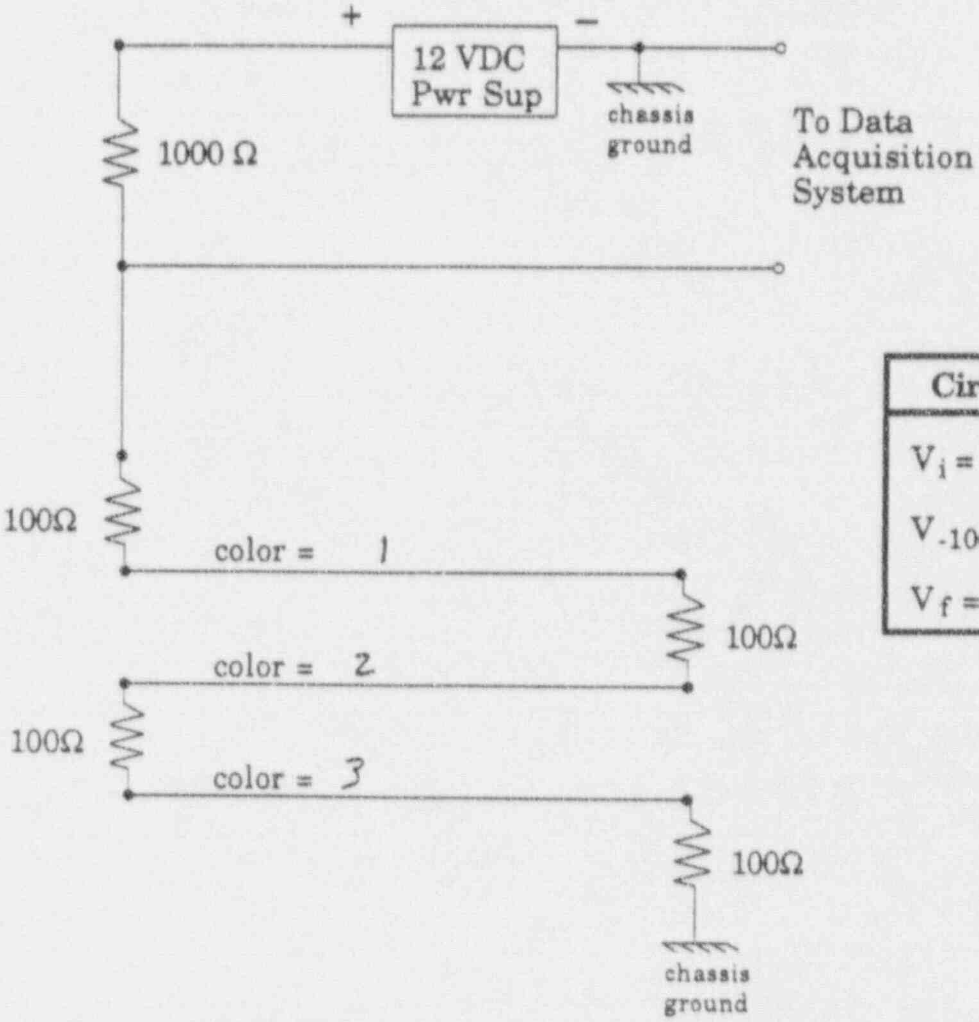
Circuit Integrity
V_i = 4.263
$V_{-100\Omega}$ = 3.687
V_f = 4.251

Date Instrumented:	11/5/92
Technician:	KCH

Channel 4-"D"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Front 1" Conduit
CABLE FUNCTION:	CONTROL
CABLE TYPE:	W-048
CABLE SIZE:	5C/#12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ______________
CIRCUIT INTEGRITY CONNECTIONS



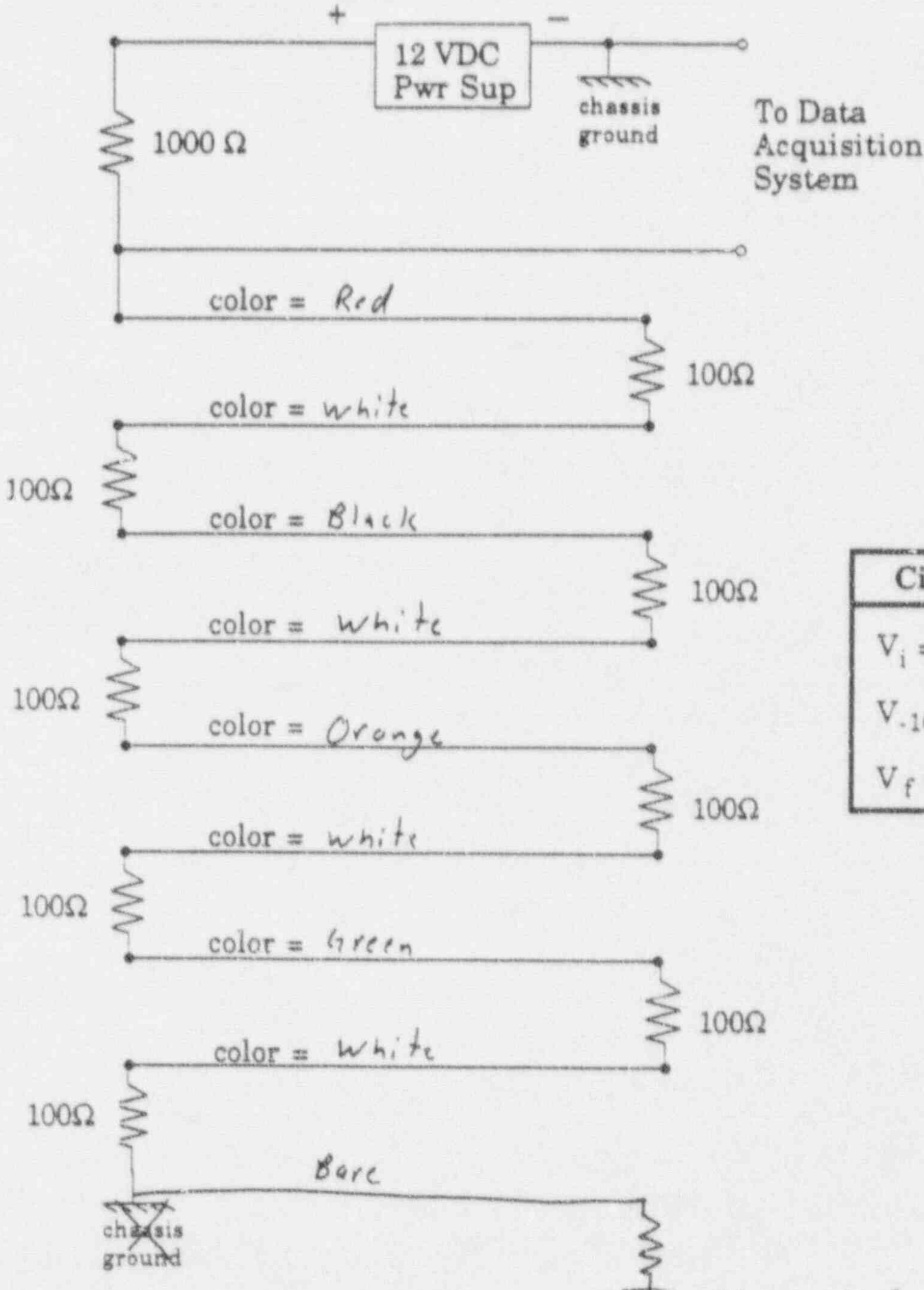
Circuit Integrity
V_i = ~~7.276~~ 2.978
$V_{-100\Omega}$ = 2.185
V_f = 2.961

Date Instrumented: 11/5/92
Technician: KH

Channel 5 - "E"

SCHEME #: 10
ASSEMBLY #: 1
ITEM: Front 3" Conduit
CABLE FUNCTION: POWER
CABLE TYPE: W-020
CABLE SIZE: 3C/#6 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



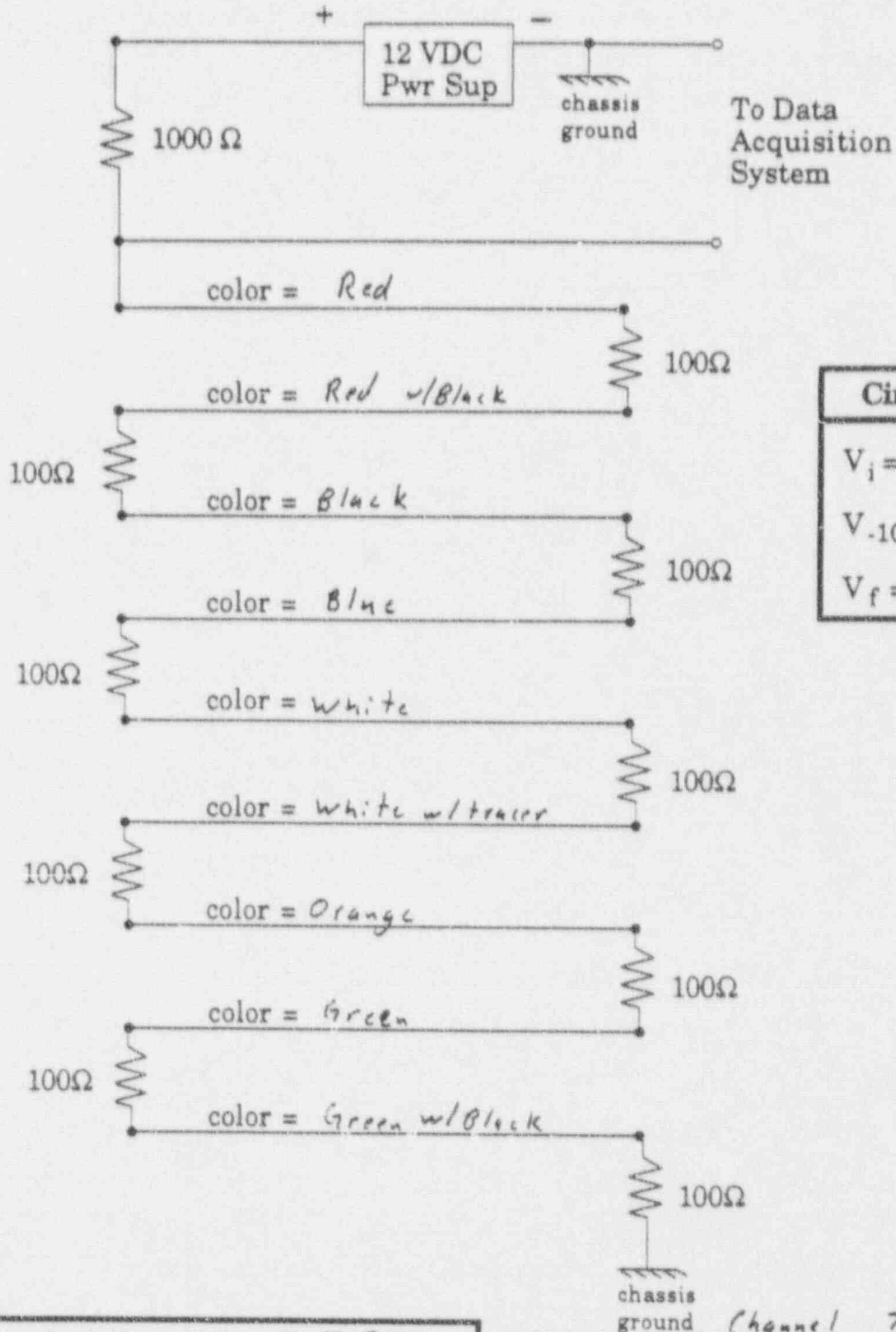
Circuit Integrity
V_i = 6.003
$V_{-100\Omega}$ = 5.639
V_f = 5.986

Channel 6 – "F"

Date Instrumented: 11-5-92
Technician: KCt

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Front 3" Conduit
CABLE FUNCTION:	INSTRUMENT
CABLE TYPE:	W-063
CABLE SIZE:	4 Shielded Twisted Pairs #16 AWG (8 Cond)

TEXAS UTILITIES ELECTRIC
PROJECT NO.__________
CIRCUIT INTEGRITY CONNECTIONS



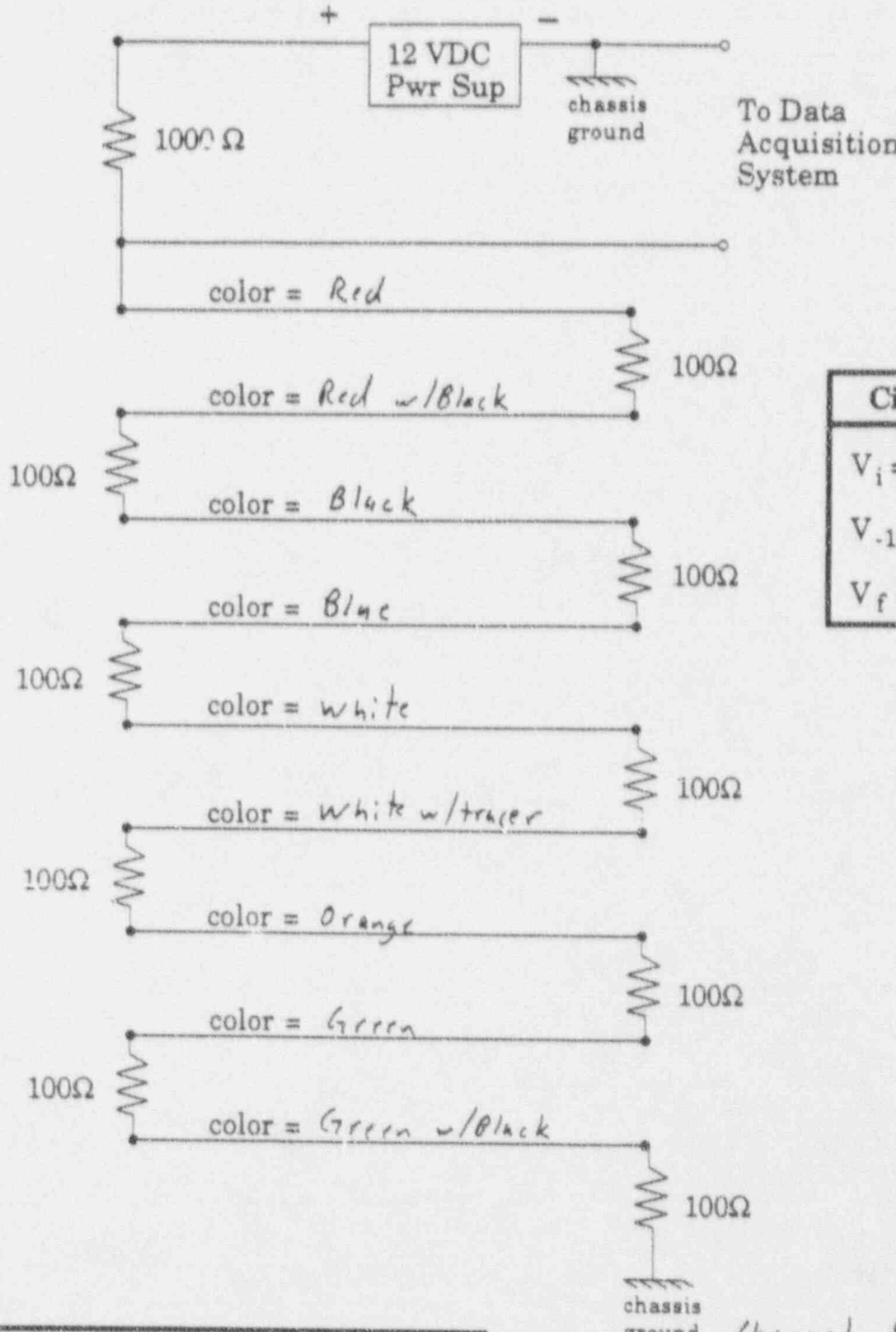
Circuit Integrity
V_i = 6.012
$V_{-100\Omega}$ = 5.645
V_f = 5.999

Channel 7 - "G"

Date Instrumented: 11-5-92
Technician: KH

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Front 1" Conduit
CABLE FUNCTION:	CONTROL
CABLE TYPE:	W-046
CABLE SIZE:	9/C #12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO.______________
CIRCUIT INTEGRITY CONNECTIONS



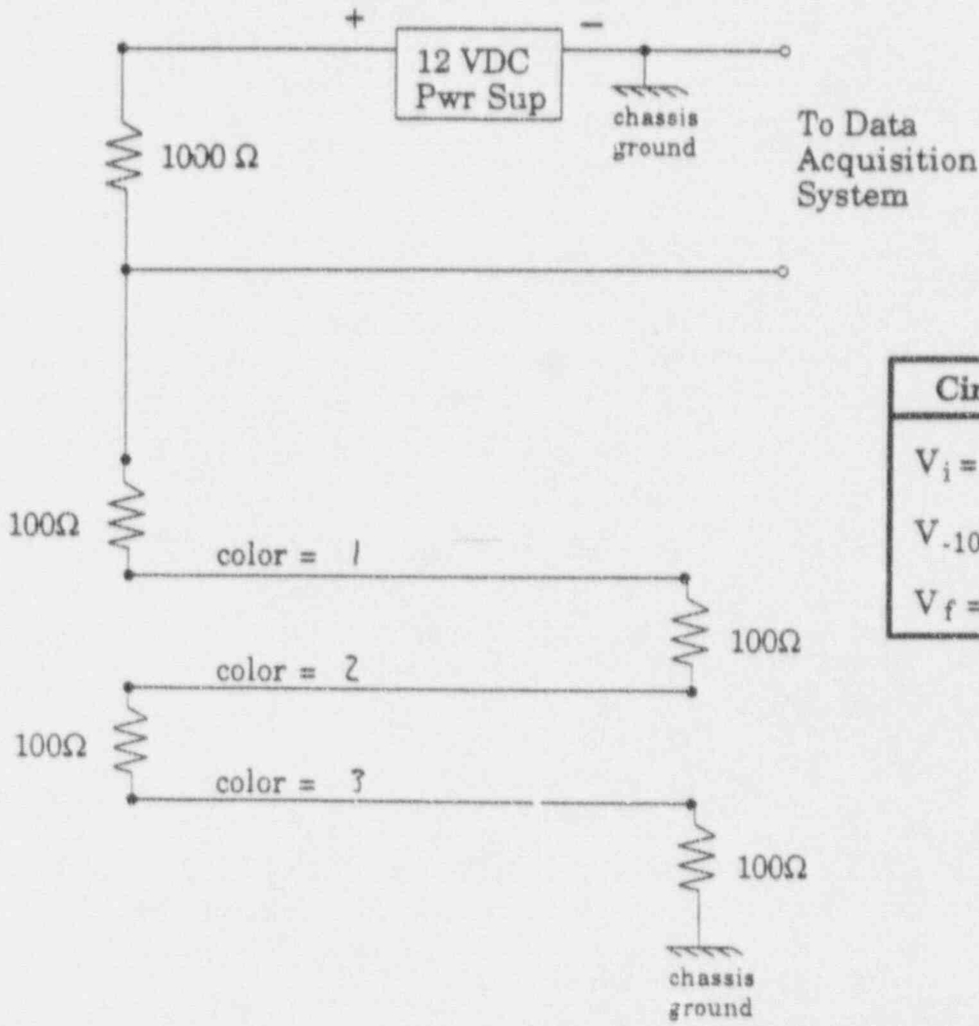
Circuit Integrity
V_i = 5.952
$V_{-100\Omega}$ = 5.586
V_f = 5.938

Date Instrumented: 11-5-92
Technician: KCT

Channel 8 – "H"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Rear 3" Conduit
CABLE FUNCTION:	CONTROL
CABLE TYPE:	W-046
CABLE SIZE:	9/C #12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ______________
CIRCUIT INTEGRITY CONNECTIONS



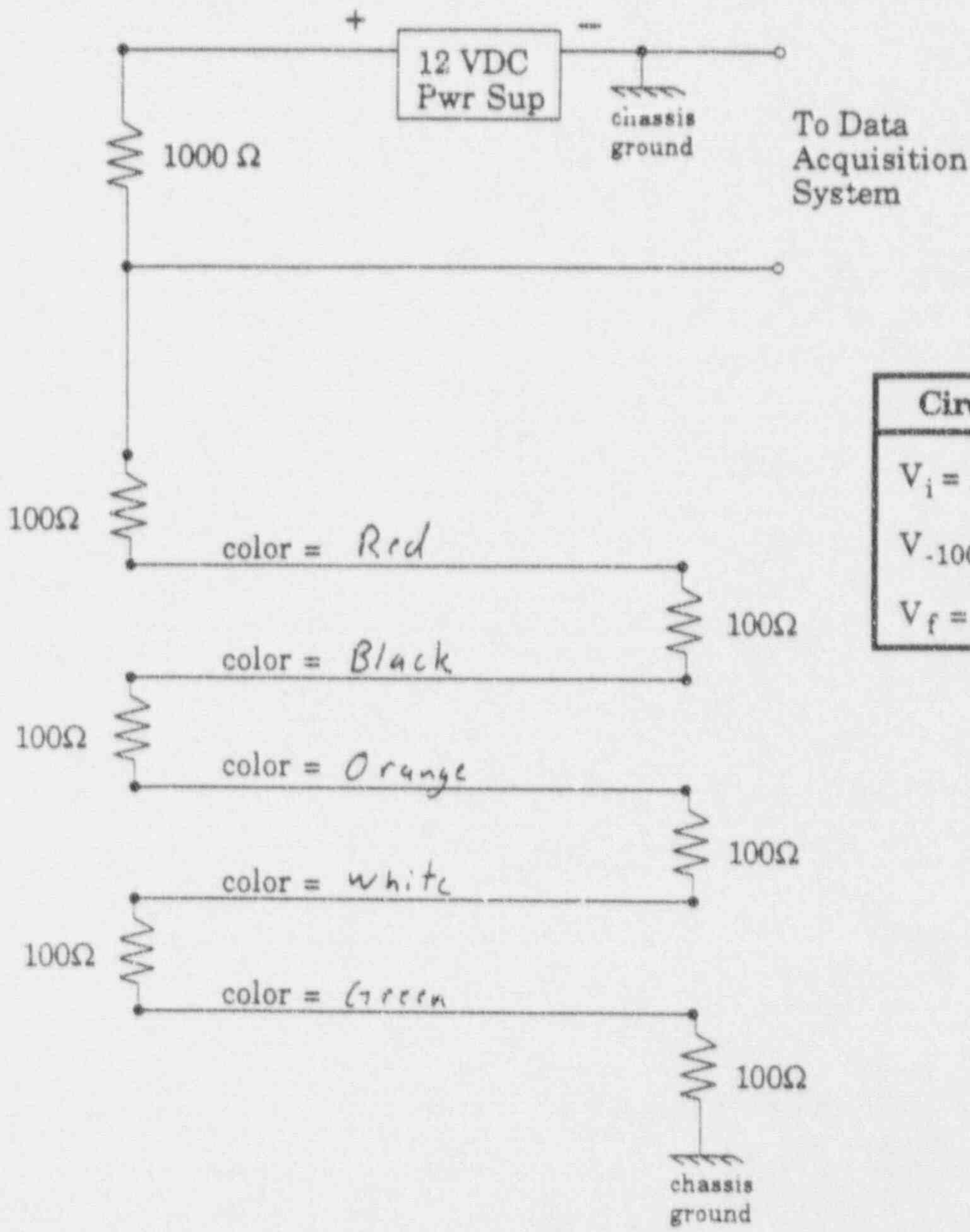
Circuit Integrity
V_i = 2.988
$V_{-100\Omega}$ = 2.204
V_f = 2.975

Date Instrumented: 11-5-92
Technician: KCH

Channel 9 - "J"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Rear 3" conduit
CABLE FUNCTION:	POWER
CABLE TYPE:	W-020
CABLE SIZE:	3C/#6 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



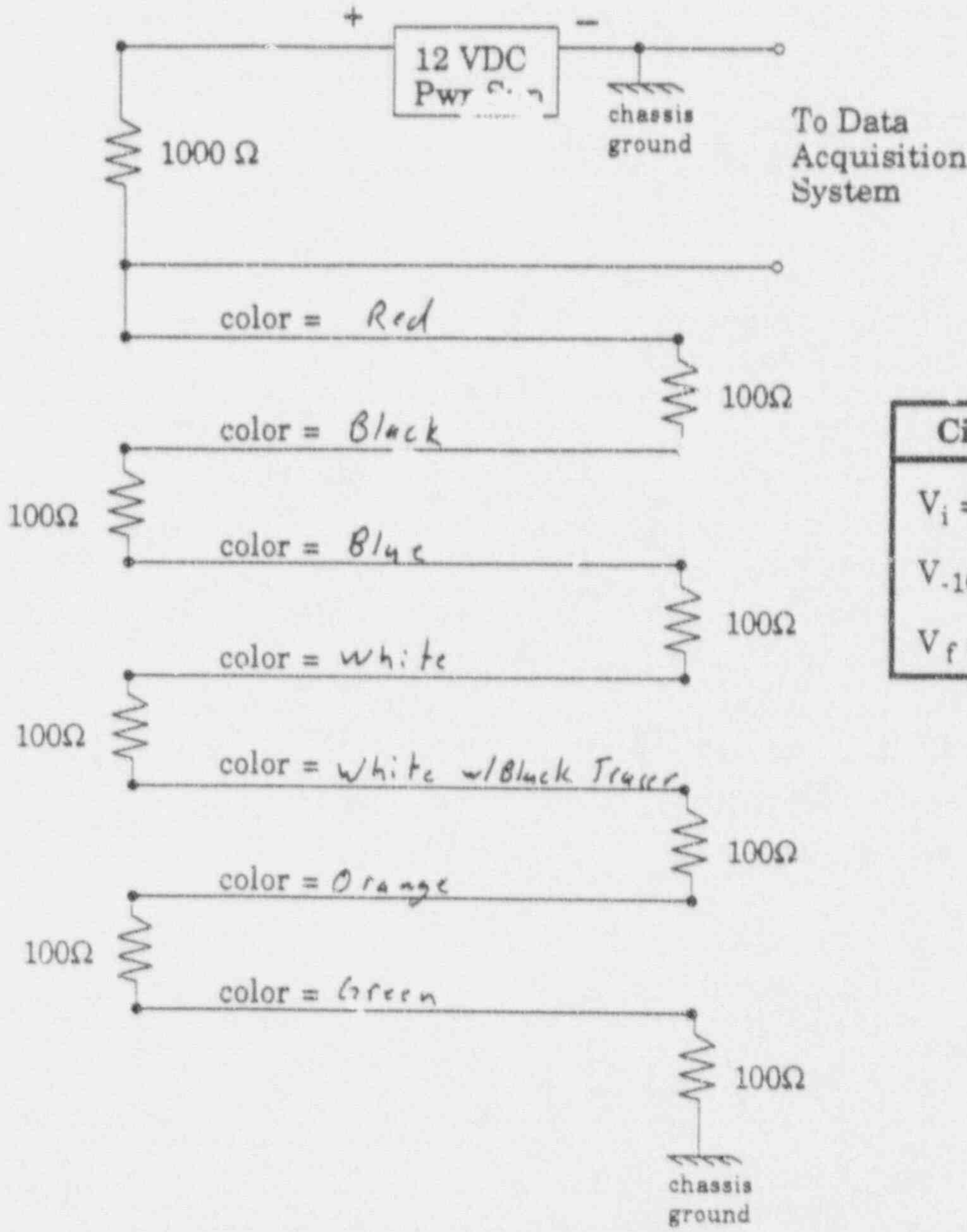
Circuit Integrity
V_i = 4.230
$V_{-100\Omega}$ = 3.650
V_f = 4.220

Date Instrumented: 11-5-92
Technician: KH

Channel 10 - "K"

SCHEME #: 10
ASSEMBLY #: 1
ITEM: Rear 3" Conduit
CABLE FUNCTION: CONTROL
CABLE TYPE: W-048
CABLE SIZE: 5C/#12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



Circuit Integrity

V_i = 5.147

$V_{-100\Omega}$ = 4.700

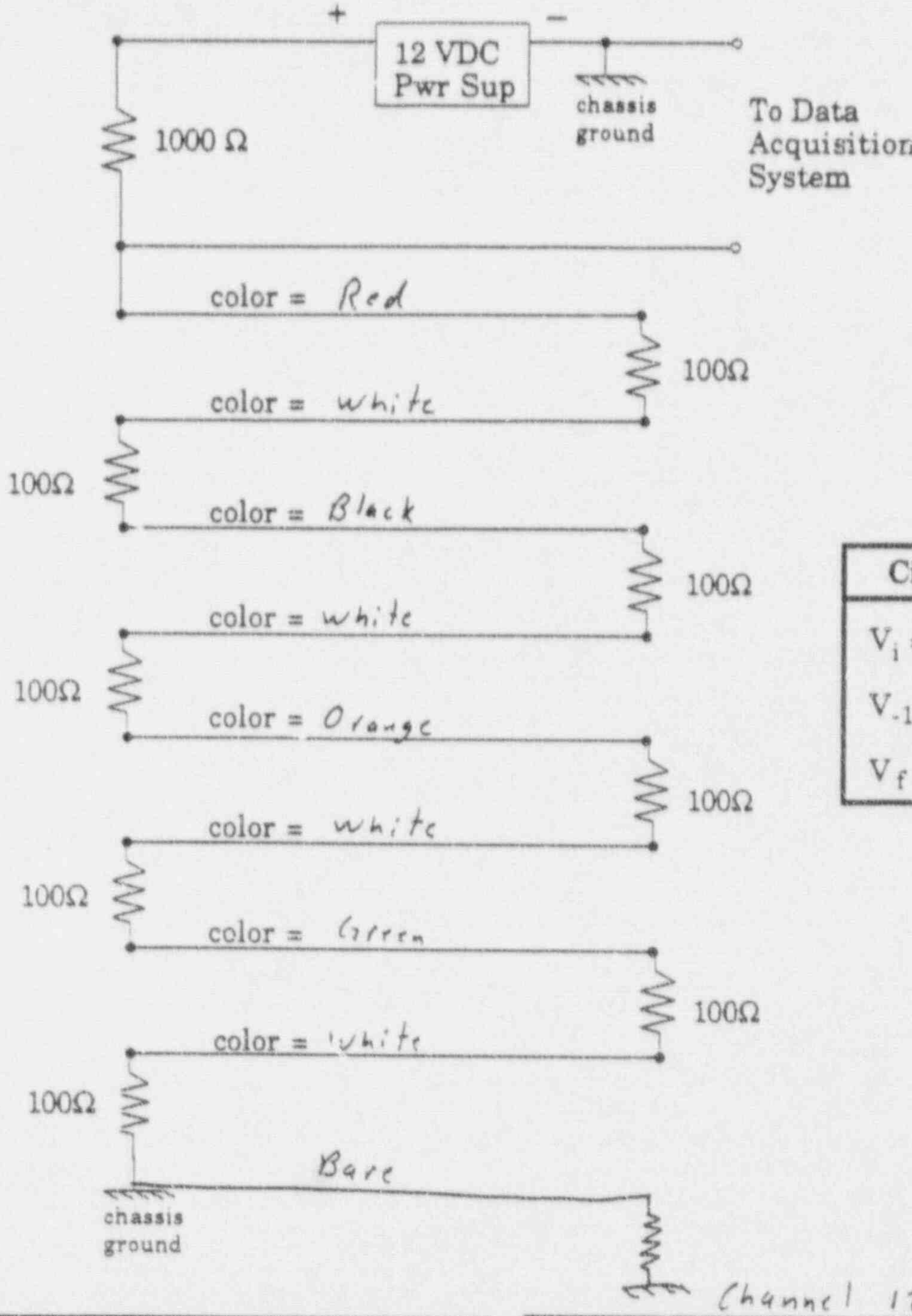
V_f = 5.135

Date Instrumented: 11-5-92
Technician: KH

Channel 11 - "L"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Rear 3" Conduit
CABLE FUNCTION:	CONTROL
CABLE TYPE:	W-047
CABLE SIZE:	7C/#12 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



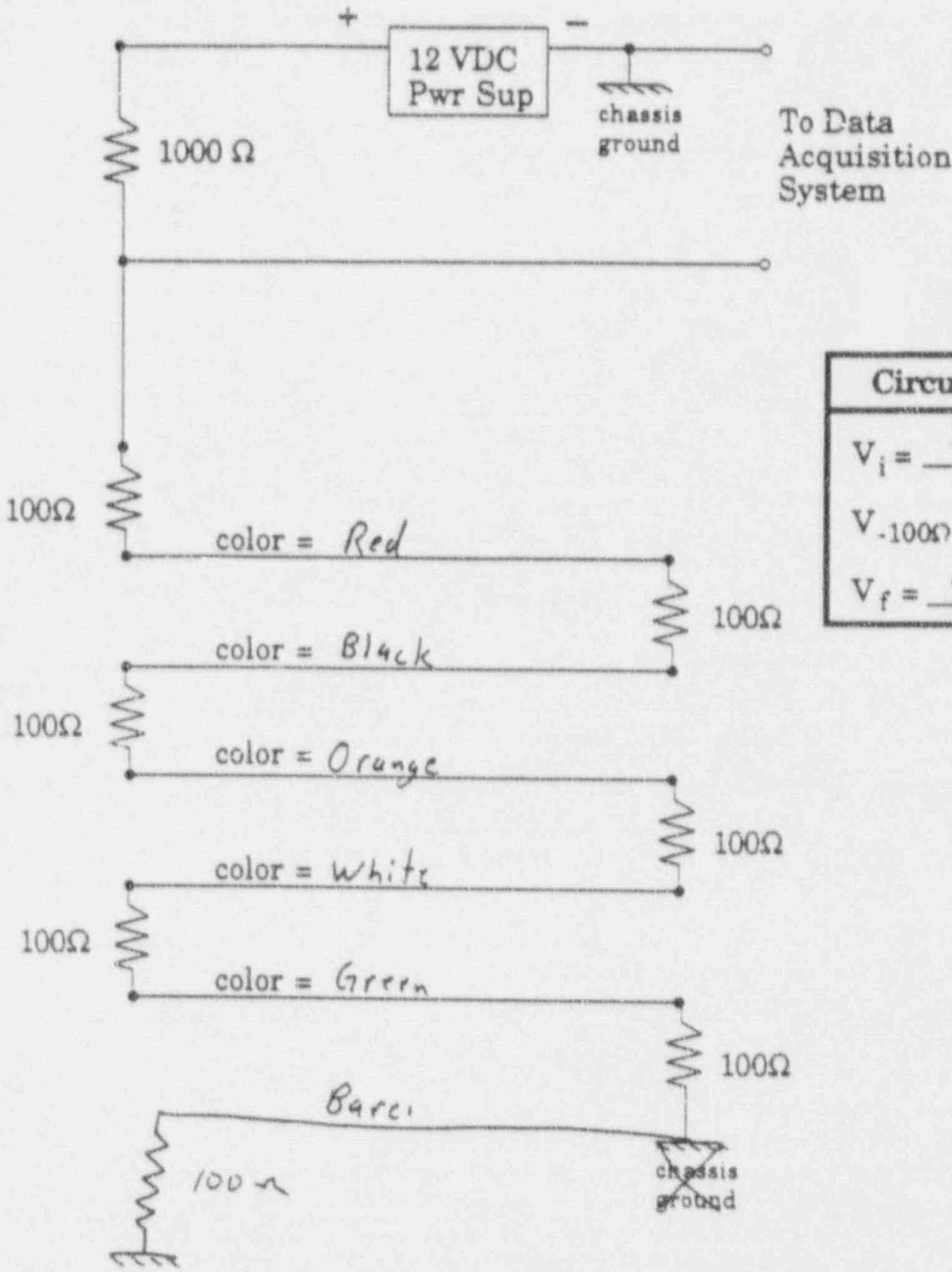
Channel 12 - "M"

Circuit Integrity
V_i = 5.963
$V_{-100\Omega}$ = 5.598
V_f = 5.946

Date Instrumented: 11-5-92
Technician: KCT

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Rear 3" Conduit
CABLE FUNCTION:	INSTRUMENT
CABLE TYPE:	W-063
CABLE SIZE:	4 Shielded Twisted Pairs #16 AWG (8 Cond)

TEXAS UTILITIES ELECTRIC
PROJECT NO. ____________
CIRCUIT INTEGRITY CONNECTIONS



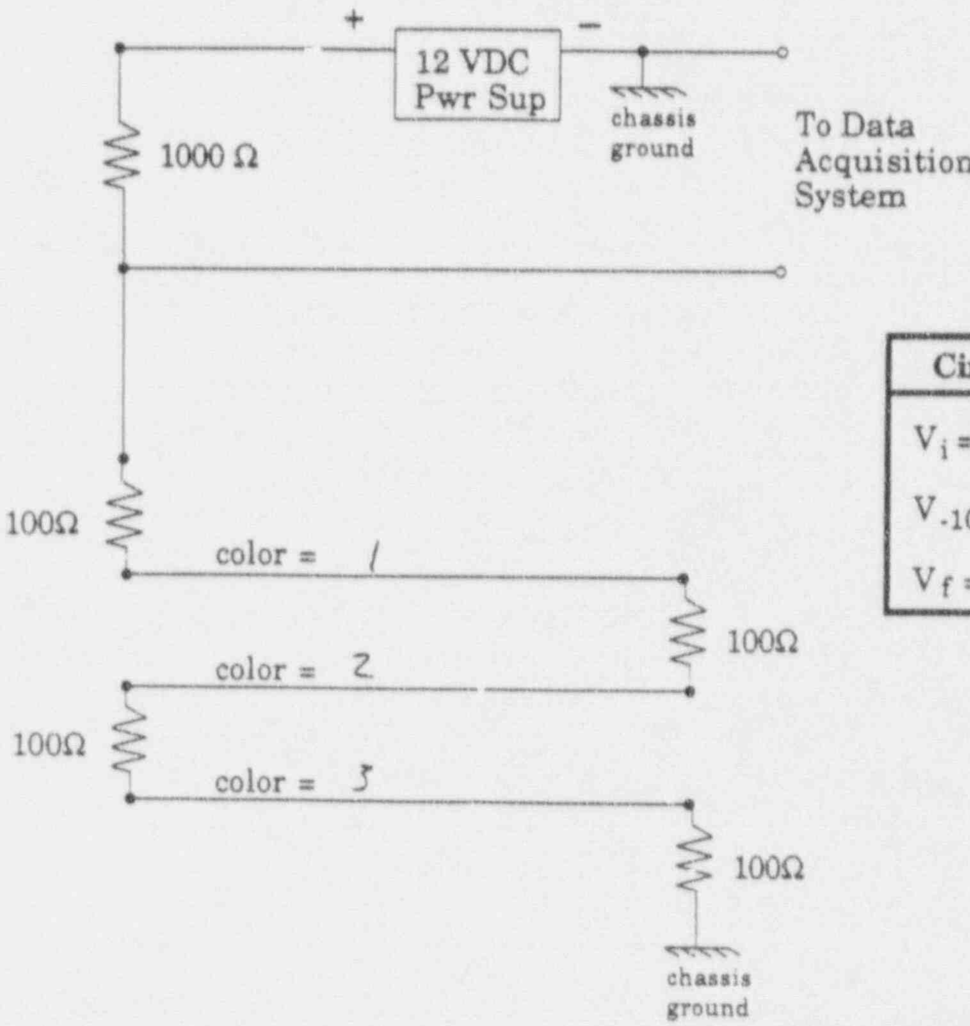
Circuit Integrity
V_i = 4.659
$V_{-100\Omega}$ = 4.162
V_f = 4.649

Date Instrumented: 11-5-97
Technician: KLT

Channel 13 - "N"

SCHEME #:	10
ASSEMBLY #:	1
ITEM:	Rear 3" Conduit
CABLE FUNCTION:	INSTRUMENT
CABLE TYPE:	W-071
CABLE SIZE:	5C/#16 AWG

TEXAS UTILITIES ELECTRIC
PROJECT NO. _ ___________
CIRCUIT INTEGRITY CONNECTIONS



Circuit Integrity	
V_i = ~~1.243~~ 2.979	
$V_{-100\Omega}$ = 2.206	
V_f = ~~2.971~~ 2.971	

Date Instrumented: 11-5-92
Technician: KH

Channel 14 – "P"

SCHEME #: 10
ASSEMBLY #: 1
ITEM: Rear 3" Conduit
CABLE FUNCTION: POWER
CABLE TYPE: W-023
CABLE SIZE: 3C/#8 AWG

Appendix E

INSULATION RESISTANCE DETAILS

OMEGA POINT LABORATORIES

Megger 10-1

	Extension Length		Cable Length	Total	(MΩ) Megger Accept. Criteria
W-023 A Fr.	14'10"	⊗	(1 x 23')	37'-10"	42.29
W-071 B Fr	15' 0"	⊗	(3 x 23')	84'-0"	19.05
W-047 C Fr.	14' 6"	⊗	(1 x 23')	37'-6"	42.66
W-048 D Fr.	20' 9"	⊗	(1 x 23')	43'-9"	36.57
W-020 E Fr.	16' 0"	⊗	(1 x 23')	39'-0"	41.02
W-063 F Fr.	15' 0"	⊗	(1 x 23')	38'-0"	42.10
W-046 G Fr.	19' 8"	⊗	(1 x 23')	42'-8"	37.50
W-046 H R	21' 6"	⊗	(1 x 23')	44'-6"	35.95
W-020 J R	19' 10"	⊗	(1 x 23')	42'-10"	37.35
W-048 K R	15' 3"	⊗	(1 x 23')	38'-3"	41.83
W-047 L R	14' 10"	⊗	(1 x 23')	37'-10"	42.29
W-063 M R	15' 3"	⊗	(1 x 23')	38'-3"	41.83
W-071 N R	19' 9"	⊗	(3 x 23')	88'-9"	18.03
W-023 P R	14' 6"	⊗	(1 x 23')	37'-6"	42.66

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE

A

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT): ______
IR ACCEPTANCE VALUE: ______

Reads are in Megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
Red No. 1 to white No. 2	750K	30K	Y
No. 1 to No. 3	750K	30K	Y
No. 1 to Ground	50K	15K	Y
No. 2 to No. 3	750K	30K	Y
No. 2 to Ground	40K	15K	Y
No. 3 to Ground	40K	14K	Y

Date Pre-Test IRT: 11-5-92
Technician: [signature]
Date Post-Test IRT: 11-5-92
Technician: [signature]

* IRT = Insulation Resistance Test

SCHEME #: ~~9~~ 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~ POWER
CABLE TYPE: W-023
CABLE SIZE: 3/C #8 AWG
ENERGIZE TO: 1500 VDC

Calibration
Tag# IC-1140
Date 930427

Same machine was used for both tests

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

Page 1 of 1
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE
B

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in Meg Ohms

CIRCUIT TESTED	PRE-TEST IR X1	POST-TEST IR X 1	ACCEPTANCE
Black to Pink	>50K	40 K	Y
Black to Orange	>50K	40K	Y
Black to White	>50K	40K	Y
Black to Green	>50K	>50K	Y
Black to Ground	>50K	25K	Y
Pink to Orange	>50K	>50K	Y
Pink to White	>50K	50K	Y
Pink to Green	>50K	>50K	Y
Pink to Ground	>50K	50K	Y
Orange to White	>50K	>50K	Y
Orange to Green	>50K	>50K	Y
Orange to Ground	>50K	45K	Y
White to Green	>50K	>50K	Y
White to Ground	>50K	30K	Y
Green to Ground	>50K	50K	Y
SHIELD to GROUND	25K	100K	Y
BLACK to SHIELD	>50K	20K	Y
PINK to SHIELD	>50K	50K	Y
ORANGE TO SHIELD	>50K	50K	Y
WHITE TO SHIELD	>50K	40K	Y
GREEN TO SHIELD	>50K	>50K	Y

Date Pre-Test IRT: 11/5/93
Technician: CH CAH
Date Post-Test IRT: 11/5/93
Technician: CH CAH

* IRT = Insulation Resistance Test

SCHEME #: 2 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-071
CABLE SIZE: 5/C #16 AWG
ENERGIZE TO: 500 VDC

Calibration data:
Tag No. IC-1137
Cal. due Date: 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE C

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT): ______
IR ACCEPTANCE VALUE: ______

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x3	POST-TEST IR x3	ACCEPTANCE
Black to Red	>50K	40K	Y
Black to Blue	>50K	40K	Y
Black to White	>50K	32K	Y
Black to White/Black	>50K	40K	Y
Black to Orange	>50K	40K	Y
Black to Green	>50K	45K	Y
Black to Ground	50K	25K	Y
Red to Blue	>50K	45K	Y
Red to White	>50K	50K	Y
Red to White/Black	>50K	50K	Y
Red to Orange	>50K	50K	Y
Red to Green	>50K	>50K	Y
Red to Ground	50K	25K	Y
Blue to White	>50K	50K	Y
Blue to White/Black	>50K	45K	Y
Blue to Orange	>50K	50K	Y
Blue to Green	>50K	50K	Y
Blue to Ground	50K	25K	Y
White to White/Black	>50K	50K	Y
White to Orange	>50K	50K	Y
White to Green	>50K	50K	Y
White to Ground	50K	25K	Y
White/Black to Orange	>50K	50K	Y
White/Black to Green	>50K	>50	Y
White/Black to Ground	50K	30K	Y
Orange to Green	>50K	50K	Y
Orange to Ground	50K	22K	Y
Green to Ground	50K	40K	Y

Date Pre-Test IRT: 11-5-92
Technician: [initials] 11-5-92
Date Post-Test IRT: 11-5-92
Technician: [initials] 11-5-92

SCHEME #: 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~
CABLE TYPE: W-047
CABLE SIZE: 7/C #12 AWG
ENERGIZE TO: 1500 VDC

* IRT = Insulation Resistance Test

CALIBRATION
TAG NO. IC-1140
DATE 930427

Both tests, the same machine was used.

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

Page 1 of 1

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: D

PROJECT NO: 94367C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x3	POST-TEST IR x 3	ACCEPTANCE
Black to Pink	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to White	>50K	>50K	Y
Black to Green	>50K	>50K	Y
Black to Ground	50K	50K	Y
Pink to Orange	>50K	>50K	Y
Pink to White	>50K	>50K	Y
Pink to Green	>50K	>50K	Y
Pink to Ground	50K	50K	Y
Orange to White	>50K	>50K	Y
Orange to Green	>50K	>50K	Y
Orange to Ground	50K	50K	Y
White to Green	>50K	>50K	Y
White to Ground	50K	50K	Y
Green to Ground	50K	50K	Y

Date Pre-Test IRT: 11-5-92
Technician: SP [illegible]
Date Post-Test IRT: 11/5/92
Technician: CH CAH

* IRT = Insulation Resistance Test

SCHEME #: 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~ POWER
CABLE TYPE: W-048
CABLE SIZE: 5/C #12 AWG
ENERGIZE TO: 1500 VDC

Pre test
Calibration
Tag # IC-1140
Date 930427

Post test
Tag # IC-1137
Cal. Due Date: 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

Page 1 of 1
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: ~~A~~ AE

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in Megohms

CIRCUIT TESTED	PRE-TEST IR X 3	POST-TEST IR X3	ACCEPTANCE
No. 1 (Red) to No. 2 (W)	>50K	30K	Y
No. 1 to No. 3	>50K	35K	Y
No. 1 to Ground	50K	15K	Y
No. 2 to No. 3	>50K	35K	Y
No. 2 to Ground	50K	15K	Y
No. 3 to Ground	50K	18K	Y

Date Pre-Test IRT: 11-5-92
Technician: [illegible]
Date Post-Test IRT: 11-5-92
Technician: [illegible]

* IRT = Insulation Resistance Test

SCHEME #: ~~9~~ 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~ POWER
CABLE TYPE: W-020
CABLE SIZE: 3/C #6 AWG
ENERGIZE TO: 1500 VDC

Calibration
Tag # IC-1140
Date 930427

Same machine was used for both tests.

TEXAS UTILITIES ELECTRIC INSULATION RESISTANCE MEASUREMENT DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: F

PROJECT NO: 94367C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x1	POST-TEST IR x1	ACCEPTANCE
Red to White (red)	>50K	>50K	Y
Red to Black	>50K	>50K	Y
Red to White (black)	>50K	>50K	Y
Red to Green	>50K	>50K	Y
Red to White (green)	>50K	>50K	Y
Red to Orange	>50K	>50K	Y
Red to White (orange)	>50K	>50K	Y
Red to Shield	>50K	>50K	Y
Shield to Ground	50K	~~>50K~~ 10K CH	Y
White (red) to Black	>50K	>50K	Y
White (red) to White (black)	>50K	>50K	Y
White (red) to Green	>50K	>50K	Y
White (red) to White (green)	>50K	>50K	Y
White (red) to Orange	>50K	>50K	Y
White (red) to White (orange)	>50K	>50K	Y
White (red) to Shield	>50K	>50K	Y
Black to White (black)	>50K	>50K	Y
Black to Green	>50K	>50K	Y
Black to White (green)	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to White (orange)	>50K	>50K	Y
Black to Shield	>50K	35K	Y
White (black) to Green	>50K	>50K	Y
White (black) to White (green)	>50K	>50K	Y
White (black) to Orange	>50K	>50K	Y
White (black) to White (orange)	>50K	>50K	Y
White (black) to Shield	>50K	>50K	Y
Green to White (green)	>50K	>50K	Y
Green to Orange	>50K	>50K	Y

(MORE ON NEXT SHEET)

Date Pre-Test IRT: 11/5/93
Technician: CH CAH
Date Post-Test IRT: 11/5/93
Technician: CH CAH

SCHEME #: ~~A~~ 10-1
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-063
CABLE SIZE: 4 pr #16 AWG
ENERGIZE TO: 500 VDC

* IRT = Insulation Resistance Test

Calibration data:
Tag No. IC-1137
Cal Due Date: 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

Page 2 of 2
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE
F

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X 1	POST-TEST IR X 1	ACCEPTANCE
Green to White (orange)	>50K	>50K	Y
Green to Shield	>50K	>50K	Y
White (green) to Orange	>50K	>50K	Y
White (green) to White (orange)	>50K	>50K	Y
White (green) to Shield	>50K	>50K	Y
Orange to White (orange)	>50K	>50K	Y
Orange to Shield	>50K	>50K	Y
White (orange) to Shield	>50K	>50K	Y

Date Pre-Test IRT: 11/5/92
Technician: CH CAH
Date Post-Test IRT: 11/5/92
Technician: CH CAH

SCHEME #: 10-1
ASSEMBLY #: I
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-063
CABLE SIZE: 4 pr #16 AWG
ENERGIZE TO: 500 VDC

* IRT = Insulation Resistance Test

Calibration data:
Tag No. IC-1137
Cal Due Date: 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: G

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT): ____
IR ACCEPTANCE VALUE: ____

Reads are megohms

CIRCUIT TESTED	PRE-TEST IR X 3	POST-TEST IR X3	ACCEPTANCE
Black to White	>50K	50K SJZ	Y
Black to Red	>50K	50K SJZ	Y
Black to Blue	>50K	50K SJZ	Y
Black to Orange	>50K	50K SJZ	Y
Black to Green	>50K	>50K SJZ	Y
Black to White/Black	>50K	50K SJZ	Y
Black to Red/Black	>50K	45K SJZ	Y
Black to Green/Black	>50K	50K	Y
Black to Ground	50K	40K	Y
Red to Blue	>50K	35K	Y
Red to Orange	>50K	40K	Y
Red to Green	>50K	40K	Y
Red to White/Black	>50K	40K	Y
Red to Red/Black	>50K	40K	Y
Red to Green/Black	>50K	33K	Y
Red to Ground	50K	21K	Y
Blue to Orange	>50K	35K	Y
Blue to Green	>50K	40K	Y
Blue to White/Black	>50K	40K	Y
Blue to Red/Black	>50K	40K	Y
Blue to Green/Black	>50K	35K	Y
Blue to Ground	50K	22K	Y
Orange to Green	>50K	38K	Y
Orange to White/Black	>50K	40K	Y
Orange to Red/Black	>50K	45K	Y
Orange to Green/Black	>50K	40K	Y
Orange to Ground	50K	21K	Y
Green to White/Black	>50K	50K	Y
Green to Red/Black	>50K	50K	Y

(MORE ON NEXT PAGE)

Date Pre-Test IRT: 11-5-92
Technician: SJZ
Date Post-Test IRT: 11-5-92
Technician: SJZ

SCHEME #: 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: CONTROL
CABLE TYPE: W-046
CABLE SIZE: 9/C #12 AWG
ENERGIZE TO: 1500 VDC

* IRT = Insulation Resistance Test

Calibration Tag # IC-1140 Date 930427

Same machine was used on both test

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: G

PROJECT NO: 94367 C
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
Green to Green/Black	>50K	45K	Y
Green to Ground	50K	21K	Y
White/Black to Red/Black	>50K	40K	Y
White/Black to Green/Black	>50K	40K	Y
White/Black to Ground	50K	20K	Y
Red/Black to Green/Black	>50K	40K	Y
Red/Black to Ground	50K	20K	Y
Green/Black to Ground	50K	21K	Y

Date Pre-Test IRT: 11-5-92
Technician: [signature]
Date Post-Test IRT: 11-5-92
Technician: [signature]

* IRT = Insulation Resistance Test

SCHEME #: 10
ASSEMBLY #: 1
ITEM: FRONT 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~
CABLE TYPE: W-046
CABLE SIZE: 9/C #12 AWG
ENERGIZE TO: 1500 VDC

Calibration Tag # IC-1140 Date 930427

Same Machine was used for both test

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: H

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
Black to White	>50K	>50K	Y
Black to Red	>50K	>50K	Y
Black to Blue	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to Green	>50K	>50K	Y
Black to White/Black	>50K	>50K	Y
Black to Red/Black	>50K	>50K	Y
Black to Green/Black	>50K	>50K	Y
Black to Ground	50K	50K	Y
Red to Blue	>50K	>50K	Y
Red to Orange	>50K	>50K	Y
Red to Green	>50K	>50K	Y
Red to White/Black	>50K	>50K	Y
Red to Red/Black	>50K	>50K	Y
Red to Green/Black	>50K	>50K	Y
Red to Ground	50K	50K	Y
Blue to Orange	>50K	>50K	Y
Blue to Green	>50K	>50K	Y
Blue to White/Black	>50K	>50K	Y
Blue to Red/Black	>50K	>50K	Y
Blue to Green/Black	>50K	>50K	Y
Blue to Ground	50K	50K	Y
Orange to Green	>50K	>50K	Y
Orange to White/Black	>50K	>50K	Y
Orange to Red/Black	>50K	>50K	Y
Orange to Green/Black	>50K	>50K	Y
Orange to Ground	50K	50K	Y
Green to White/Black	>50K	>50K	Y
Green to Red/Black	>50K	>50K	Y

(MORE ON NEXT PAGE)

Date Pre-Test IRT: 11-5-92
Technician: [illegible]
Date Post-Test IRT: 11-5-92
Technician: [illegible]

SCHEME #: 910
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: CONTROL
CABLE TYPE: W-046
CABLE SIZE: 9/C #12 AWG
ENERGIZE TO: 1500 VDC

* IRT = Insulation Resistance Test

Calibration
Tag # IC-1140
Date 930427

Sam machine was used for both tests.

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

Page 2 of 2
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: H

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
Green to Green/Black	750K	750K	Y
Green to Ground	50K	50K	Y
White/Black to Red/Black	750K	750K	Y
White/Black to Green/Black	750K	750K	Y
White/Black to Ground	50K	50K	Y
Red/Black to Green/Black	750K	750K	Y
Red/Black to Ground	50K	50K	Y
Green/Black to Ground	50K	50K	Y

Date Pre-Test IRT: 11-5-92
Technician: [illegible]
Date Post-Test IRT: 11-5-92
Technician: [illegible]

* IRT = Insulation Resistance Test

SCHEME #: 910
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: CONTROL
CABLE TYPE: W-046
CABLE SIZE: 9/C #12 AWG
ENERGIZE TO: 1500 VDC

Calibration
Tag # 1C-1140
Date 930427

Same machine was used for both tests.

TEXAS UTILITIES ELECTRIC INSULATION RESISTANCE MEASUREMENT DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: J

PROJECT NO: 94367
TEST NO: 1C-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
Red W No. 1 to No. 2	> 50K	40K	Y
No. 1 to No. 3	> 50K	40K	Y
No. 1 to Ground	50K	18K	Y
No. 2 to No. 3	> 50K	40K	Y
No. 2 to Ground	50K	15K	Y
No. 3 to Ground	50K	18K	Y

Date Pre-Test IRT: 11-5-92
Technician: [signature]
Date Post-Test IRT: 11-5-92
Technician: [signature]

* IRT = Insulation Resistance Test

SCHEME #: 910
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~ POWER
CABLE TYPE: W-020
CABLE SIZE: 3/C #6 AWG
ENERGIZE TO: 1500 VDC

Calibration
Tag No 1C-1140
Date 930427

Same Machine was used for both tests.

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: K

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X 3	ACCEPTANCE
Black to Pink	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to White	>50K	>50K	Y
Black to Green	>50K	>50K	Y
Black to Ground	50K	50K	Y
Pink to Orange	>50K	>50K	Y
Pink to White	>50K	>50K	Y
Pink to Green	>50K	>50K	Y
Pink to Ground	50K	50K	Y
Orange to White	>50K	>50K	Y
Orange to Green	>50K	>50K	Y
Orange to Ground	50K	50K	Y
White to Green	>50K	>50K	Y
White to Ground	50K	50K	Y
Green to Ground	50K	50K	Y

Date Pre-Test IRT: 11-5-92
Technician: [illegible]
Date Post-Test IRT: 11/5/92
Technician: CH CAH

* IRT = Insulation Resistance Test

Pre T Calibration
Tag # 1C-1140
Date 930427

Post test:
Tag No. IC-1137

SCHEME #: 10
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: CONTROL
CABLE TYPE: W-048
CABLE SIZE: 5/C #12 AWG
ENERGIZE TO: 1500 VDC

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

Page 1 of 1

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE
L

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT): —
IR ACCEPTANCE VALUE: —

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x3	POST-TEST IR x 3	ACCEPTANCE
Black to Red	>50k	50K	Y
Black to Blue	>50K	>50K	Y
Black to White	>50K	>50K	Y
Black to White/Black	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to Green	>50K	>50K	Y
Black to Ground	>50K	50K	Y
Red to Blue	>50K	>50K	Y
Red to White	>50K	>50K	Y
Red to White/Black	>50K	>50K	Y
Red to Orange	>50K	>50K	Y
Red to Green	>50K	>50K	Y
Red to Ground	>50K	50K	Y
Blue to White	>50K	>50K	Y
Blue to White/Black	>50K	>50K	Y
Blue to Orange	>50K	>50K	Y
Blue to Green	>50K	>50K	Y
Blue to Ground	>50K	>50K	Y
White to White/Black	>50K	>50K	Y
White to Orange	>50K	>50K	Y
White to Green	>50K	>50K	Y
White to Ground	>50K	>50K	Y
White/Black to Orange	>50K	>50K	Y
White/Black to Green	>50K	>50K	Y
White/Black to Ground	>50K	>50K	Y
Orange to Green	>50K	>50K	Y
Orange to Ground	50K	50K	Y
Green to Ground	>50K	>50K	Y

Date Pre-Test IRT: 11/5/92
Technician: HWS CAH
Date Post-Test IRT: 11/5/92
Technician: CH CAH

SCHEME #: ~~8~~ 10
ASSEMBLY #: L
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: CONTROL
CABLE TYPE: W-047
CABLE SIZE: 7/C #12 AWG
ENERGIZE TO: 1500 VDC

* IRT = Insulation Resistance Test

Calibration
Tag # IC-~~[illegible]~~ 1137
Date 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

Page 1 of 2
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE
M

PROJECT NO: 94367 CABLE LENGTH (FT):
TEST NO: 10-1 IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x1	POST-TEST IR X 1	ACCEPTANCE
Red to White (red)	>50K	>50K	Y
Red to Black	>50K	>50K	Y
Red to White (black)	>50K	>50K	Y
Red to Green	>50K	>50K	Y
Red to White (green)	>50k	>50k	Y
Red to Orange	>50K	>50K	Y
Red to White (orange)	>50K	>50K	Y
Red to Shield	>50K	>50K	Y
Shield to Ground	>50K	25K	Y
White (red) to Black	>50K	>50K	Y
White (red) to White (black)	>50k	>50K	Y
White (red) to Green	>50K	>50K	Y
White (red) to White (green)	>50K	>50K	Y
White (red) to Orange	>50k	>50K	Y
White (red) to White (orange)	>50K	>50K	Y
White (red) to Shield	>50k	>50K	Y
Black to White (black)	>50k	>50K	Y
Black to Green	>50K	>50K	Y
Black to White (green)	>50K	>50K	Y
Black to Orange	>50K	>50K	Y
Black to White (orange)	>50K	>50K	Y
Black to Shield	>50K	>50K	Y
White (black) to Green	>50K	>50K	Y
White (black) to White (green)	>50k	>50K	Y
White (black) to Orange	>50K	>50K	Y
White (black) to White (orange)	>50k	>50K	Y
White (black) to Shield	>50K	>50K	Y
Green to White (green)	>50k	>50K	Y
Green to Orange	>50K	>50K	Y

(MORE ON NEXT SHEET)

Date Pre-Test IRT: 11/5/92
Technician: HWS CAH
Date Post-Test IRT: 11/5/92
Technician: CH CAH

SCHEME #: Q10
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-063
CABLE SIZE: 4 pr #16 AWG
ENERGIZE TO: 500 VDC

* IRT = Insulation Resistance Test

IC-1137

Due Date: 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT

DATA SHEET

Page 2 of 2
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: M

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reeds are in megohms

CIRCUIT TESTED	PRE-TEST IR x1	POST-TEST IR	ACCEPTANCE
Green to White (orange)	>50K	>50K	Y
Green to Shield	>50K	>50K	Y
White (green) to Orange	>50K	>50K	Y
White (green) to White (orange)	>50K	>50K	Y
White (green) to Shield	>50K	>50K	Y
Orange to White (orange)	>50K	>50K	Y
Orange to Shield	>50K	>50K	Y
White (orange) to Shield	>50K	>50K	Y

Date Pre-Test IRT: 11/5/92
Technician: HWS CAH
Date Post-Test IRT: 11/5/92
Technician: CH CAH

* IRT = Insulation Resistance Test

SCHEME #: ~~9~~ 10
ASSEMBLY #: 1
ITEM: ~~REAR~~ 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-063
CABLE SIZE: 4 pr #16 AWG
ENERGIZE TO: 500 VDC

IC-1137

DocDate 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

Page 1 of 1
This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE
N

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR x1	POST-TEST IR x1	ACCEPTANCE
Black to Pink	>50K	15 K	Y
Black to Orange	>50K	12.5K	Y
Black to White	>50K	10 K	Y
Black to Green	>50k	17.5K	Y
Black to Ground	>50K	7 K	Y
Pink to Orange	>50K	20 K	Y
Pink to White	>50K	17.5 K	Y
Pink to Green	>50K	20K	Y
Pink to Ground	>50K	15K	Y
Orange to White	>50K	19K	Y
Orange to Green	>50K	23 K	Y
Orange to Ground	>50K	12.5 K	Y
White to Green	>50K	20 K	Y
White to Ground	>50K	9K	Y
Green to Ground	>50K	20K	Y
Black to Shield	>50k	9k	Y
Pink to Shield	>50K	16K	Y
Orange to Shield	>50K	14K	Y
White to Shield	>50K	10K	Y
Green to Shield	>50K	20K	Y

Date Pre-Test IRT: 11/5/92
Technician: HWS CAH
Date Post-Test IRT: 11/5
Technician: CH CAH

* IRT = Insulation Resistance Test

SCHEME #: 10
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: INSTRUMENT
CABLE TYPE: W-071
CABLE SIZE: 5/C #16 AWG
ENERGIZE TO: 500 VDC

IC-1137
Due Date 930427

TEXAS UTILITIES ELECTRIC
INSULATION RESISTANCE MEASUREMENT
DATA SHEET

This individual cable has been labeled with the letter shown in the box to the right, to simplify rapid identification.

CABLE CODE: P

PROJECT NO: 94367
TEST NO: 10-1

CABLE LENGTH (FT):
IR ACCEPTANCE VALUE:

Reads are in megohms

CIRCUIT TESTED	PRE-TEST IR X3	POST-TEST IR X3	ACCEPTANCE
No. 1 to No. 2 (R W)	>50K	25K	Y
No. 1 to No. 3 (B)	>50K	28K	Y
No. 1 to Ground	50K	15K	Y
No. 2 to No. 3	>50K	30K	Y
No. 2 to Ground	50K	15K	Y
No. 3 to Ground	50K	14K	Y

Date Pre-Test IRT: 11-5-92
Technician: [illegible]
Date Post-Test IRT: 11-5-92
Technician: [illegible]

* IRT = Insulation Resistance Test

SCHEME #: 10
ASSEMBLY #: 1
ITEM: REAR 3" CONDUIT
CABLE FUNCTION: ~~CONTROL~~ POWER
CABLE TYPE: W-023
CABLE SIZE: 3/C #8 AWG
ENERGIZE TO: 1500 VDC

Calibration Tag # IC-1140
Date 930427

Same machine was used for both tests

Appendix G

TABULAR TEST DATA

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	E119 Std (°F)	Furnace Avg (°F)	Ckt Int # 1 (Volts)	Ckt Int # 2 (Volts)	Ckt Int # 3 (Volts)	Ckt Int # 4 (Volts)
0	68	61	2.970	4.692	5.122	4.252
1	254	154	2.970	4.691	5.122	4.252
2	440	5[illegible]	2.970	4.691	5.122	4.252
3	627	765	2.970	4.691	5.121	4.252
4	813	765	2.970	4.691	5.121	4.252
5	1000	729	2.970	4.691	5.121	4.252
6	1060	796	2.970	4.691	5.121	4.252
7	1120	1105	2.970	4.691	5.121	4.252
8	1180	1247	2.969	4.691	5.121	4.252
9	1240	1188	2.969	4.691	5.121	4.252
10	1300	1134	2.969	4.691	5.121	4.252
11	1327	1284	2.969	4.691	5.121	4.252
12	1346	1349	2.969	4.691	5.120	4.251
13	1364	1308	2.970	4.691	5.121	4.252
14	1380	1311	2.969	4.691	5.121	4.252
15	1395	1423	2.969	4.691	5.121	4.252
16	1410	1503	2.969	4.691	5.121	4.252
17	1423	1436	2.969	4.691	5.121	4.252
18	1436	1370	2.969	4.691	5.121	4.252
19	1448	1373	2.969	4.691	5.121	4.251
20	1459	1474	2.969	4.691	5.120	4.251
21	1470	1523	2.968	4.691	5.121	4.252
22	1480	1476	2.968	4.691	5.121	4.252
23	1490	1422	2.968	4.691	5.121	4.252
24	1499	1445	2.968	4.692	5.121	4.252
25	1508	1578	2.968	4.692	5.121	4.252
26	1517	1513	2.968	4.692	5.121	4.252
27	1525	1465	2.968	4.692	5.120	4.251
28	1533	1514	2.968	4.691	5.120	4.251
29	1541	1585	2.968	4.691	5.120	4.251
30	1548	1571	2.968	4.692	5.120	4.251
31	1555	1535	2.968	4.691	5.120	4.251
32	1562	1527	2.968	4.692	5.121	4.252
33	1569	1548	2.968	4.692	5.120	4.251
34	1576	1566	2.968	4.692	5.120	4.251
35	1582	1580	2.968	4.693	5.121	4.252
36	1588	1590	2.967	4.692	5.120	4.251
37	1594	1590	2.968	4.693	5.121	4.252
38	1600	1591	2.967	4.693	5.120	4.251
39	1606	1597	2.967	4.692	5.120	4.251
40	1612	1600	2.967	4.692	5.120	4.251

OMEGA POINT LABORATORIES

Time (min)	E119 Std (°F)	Furnace Avg (°F)	Ckt Int # 1 (Volts)	Ckt Int # 2 (Volts)	Ckt Int # 3 (Volts)	Ckt Int # 4 (Volts)
41	1617	1603	2.968	4.693	5.121	4.252
42	1622	1610	2.968	4.693	5.121	4.252
43	1627	1619	2.968	4.693	5.121	4.252
44	1633	1626	2.968	4.693	5.121	4.252
45	1638	1632	2.967	4.693	5.121	4.251
46	1642	1636	2.967	4.693	5.122	4.252
47	1647	1641	2.968	4.693	5.121	4.252
48	1652	1645	2.967	4.693	5.121	4.251
49	1656	1652	2.967	4.693	5.121	4.251
50	1661	1660	2.967	4.693	5.121	4.251
51	1665	1666	2.967	4.693	5.121	4.251
52	1669	1672	2.966	4.693	5.120	4.251
53	1674	1672	2.967	4.693	5.121	4.251
54	1678	1672	2.967	4.693	5.121	4.252
55	1682	1679	2.967	4.694	5.121	4.251
56	1686	1689	2.966	4.693	5.121	4.251
57	1690	1693	2.966	4.693	5.121	4.250
58	1693	1685	2.965	4.692	5.120	4.250
59	1697	1686	2.965	4.692	5.120	4.249
60	1701	1691	2.966	4.694	5.121	4.250
61			2.965	4.693	5.120	4.250
62			2.965	4.693	5.120	4.250
63			2.965	4.692	5.120	4.250
64			2.964	4.694	5.119	4.251
65			2.963	4.693	5.120	4.250
66			2.964	4.693	5.120	4.250
67			2.965	4.693	5.121	4.251
68			2.965	4.693	5.121	4.251
69			2.965	4.693	5.121	4.252
70			2.966	4.693	5.121	4.251
71			2.966	4.693	5.121	4.252
72			2.966	4.693	5.121	4.252
73			2.965	4.693	5.120	4.251
74			2.965	4.692	5.120	4.251
MAX						

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Ckt Int # 5 (Volts)	Ckt Int # 6 (Volts)	Ckt Int # 7 (Volts)	Ckt Int # 8 (Volts)	Ckt Int # 9 (Volts)	Ckt Int # 10 (Volts)
0	2.971	5.990	6.000	5.939	2.978	4.219
1	2.970	5.990	5.999	5.939	2.978	4.219
2	2.970	5.990	5.999	5.939	2.978	4.219
3	2.971	5.990	5.999	5.939	2.978	4.219
4	2.970	5.990	5.999	5.939	2.978	4.219
5	2.970	5.990	5.999	5.938	2.978	4.219
6	2.971	5.990	5.999	5.939	2.978	4.219
7	2.970	5.990	5.999	5.939	2.978	4.219
8	2.970	5.990	5.999	5.938	2.977	4.219
9	2.971	5.990	5.999	5.939	2.978	4.220
10	2.969	5.989	5.999	5.938	2.977	4.219
11	2.969	5.989	5.998	5.938	2.977	4.219
12	2.969	5.988	5.998	5.938	2.977	4.219
13	2.970	5.989	5.999	5.939	2.977	4.219
14	2.970	5.989	5.999	5.939	2.977	4.219
15	2.970	5.989	5.999	5.939	2.977	4.219
16	2.970	5.989	5.999	5.939	2.977	4.219
17	2.970	5.989	5.999	5.939	77	4.219
18	2.969	5.988	5.999	5.939	2.977	4.219
19	2.969	5.988	5.999	5.939	2.977	4.219
20	2.968	5.988	5.999	5.938	2.977	4.219
21	2.969	5.988	5.999	5.939	2.977	4.219
22	2.969	5.988	5.999	5.939	2.977	4.219
23	2.969	5.988	5.998	5.939	2.977	4.219
24	2.969	5.988	5.998	5.939	2.977	4.220
25	2.969	5.988	5.998	5.939	2.977	4.220
26	2.968	5.987	5.998	5.939	2.977	4.220
27	2.968	5.987	5.998	5.939	2.977	4.219
28	2.968	5.987	5.998	5.938	2.976	4.219
29	2.967	5.987	5.998	5.938	2.976	4.219
30	2.968	5.987	5.998	5.938	2.976	4.219
31	2.967	5.987	5.998	5.938	2.976	4.219
32	2.968	5.987	5.998	5.939	2.977	4.220
33	2.967	5.987	5.999	5.938	2.976	4.219
34	2.967	5.987	5.999	5.938	2.976	4.219
35	2.968	5.987	5.999	5.939	2.977	4.220
36	2.967	5.986	5.999	5.938	2.975	4.219
37	2.967	5.987	5.999	5.939	2.976	4.220
38	2.967	5.986	5.999	5.938	2.975	4.220
39	2.967	5.986	5.999	5.938	2.975	4.220
40	2.967	5.986	5.999	5.938	2.975	4.220

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Ckt Int # 5 (Volts)	Ckt Int # 6 (Volts)	Ckt Int # 7 (Volts)	Ckt Int # 8 (Volts)	Ckt Int # 9 (Volts)	Ckt Int # 10 (Volts)
41	2.967	5.986	5.999	5.939	2.976	4.220
42	2.967	5.986	5.999	5.939	2.976	4.220
43	2.967	5.986	5.999	5.939	2.976	4.220
44	2.967	5.986	5.999	5.939	2.976	4.220
45	2.967	5.986	5.999	5.939	2.976	4.220
46	2.967	5.986	5.999	5.939	2.977	4.220
47	2.966	5.986	5.999	5.939	2.976	4.221
48	2.966	5.985	5.999	5.939	2.976	4.220
49	2.966	5.985	5.999	5.939	2.975	4.220
50	2.966	5.985	5.999	5.939	2.975	4.220
51	2.966	5.985	5.999	5.939	2.975	4.220
52	2.965	5.985	5.999	5.938	2.975	4.220
53	2.965	5.985	5.998	5.939	2.975	4.221
54	2.965	5.985	5.999	5.939	2.975	4.220
55	2.965	5.984	5.999	5.939	2.975	4.221
56	2.965	5.984	5.999	5.939	2.975	4.221
57	2.964	5.984	5.998	5.939	2.975	4.221
58	2.964	5.984	5.998	5.938	2.974	4.220
59	2.963	5.984	5.998	5.937	2.974	4.219
60	2.964	5.984	5.998	5.939	2.975	4.220
61	2.964	5.984	5.998	5.939	2.975	4.220
62	2.964	5.984	5.998	5.938	2.975	4.220
63	2.963	5.984	5.998	5.937	2.974	4.219
64	2.955	5.976	5.998	5.938	2.967	4.223
65	2.957	5.978	5.998	5.937	2.970	4.221
66	2.959	5.980	5.998	5.938	2.972	4.221
67	2.960	5.983	5.999	5.938	2.974	4.221
68	2.961	5.984	5.999	5.938	2.975	4.221
69	2.962	5.984	6.000	5.939	2.975	4.221
70	2.961	5.984	5.999	5.938	2.975	4.221
71	2.962	5.984	6.000	5.938	2.975	4.221
72	2.962	5.984	5.999	5.938	2.975	4.221
73	2.962	5.985	5.999	5.939	2.976	4.220
74	2.962	5.986	5.998	5.938	2.975	4.220

MAX

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Ckt Int # 11 (Volts)	Ckt Int # 12 (Volts)	Ckt Int # 13 (Volts)	Ckt Int # 14 (Volts)	Front 3" Conduit Power Cable Ave (°F)
0	5.135	5.951	4.647	2.978	63
1	5.135	5.951	4.647	2.978	63
2	5.135	5.951	4.647	2.978	63
3	5.135	5.950	4.648	2.978	63
4	5.135	5.950	4.647	2.978	63
5	5.134	5.950	4.647	2.977	63
6	5.135	5.950	4.648	2.978	63
7	5.135	5.950	4.647	2.978	63
8	5.134	5.950	4.647	2.977	63
9	5.135	5.950	4.647	2.977	63
10	5.134	5.949	4.647	2.977	63
11	5.134	5.949	4.646	2.976	63
12	5.134	5.949	4.646	2.976	63
13	5.134	5.948	4.647	2.976	63
14	5.134	5.948	4.647	2.976	64
15	5.134	5.948	4.647	2.975	64
16	5.135	5.948	4.647	2.976	64
17	5.134	5.948	4.647	2.975	64
18	5.135	5.948	4.647	2.975	65
19	5.134	5.948	4.647	2.975	65
20	5.134	5.948	4.647	2.975	65
21	5.135	5.948	4.647	2.975	66
22	5.135	5.948	4.648	2.975	66
23	5.134	5.948	4.648	2.975	67
24	5.135	5.948	4.648	2.975	68
25	5.135	5.948	4.648	2.975	68
26	5.135	5.947	4.648	2.974	69
27	5.134	5.947	4.648	2.974	70
28	5.135	5.947	4.648	2.974	71
29	5.134	5.947	4.647	2.974	72
30	5.135	5.947	4.648	2.974	73
31	5.134	5.947	4.647	2.973	74
32	5.[illegible]5	5.947	4.648	2.974	75
33	5.135	5.947	4.648	2.973	77
34	5.136	5.947	4.648	2.974	78
35	5.136	5.947	4.648	2.973	79
36	5.135	5.946	4.648	2.973	81
37	5.136	5.947	4.648	2.973	82
38	5.135	5.946	4.648	2.973	84
39	5.135	5.946	4.648	2.973	85
40	5.135	5.946	4.648	2.973	87

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Ckt Int # 11 (Volts)	Ckt Int # 12 (Volts)	Ckt Int # 13 (Volts)	Ckt Int # 14 (Volts)	Front 3" Conduit Power Cable Ave (°F)
41	5.136	5.947	4.648	2.972	89
42	5.136	5.946	4.649	2.973	91
43	5.136	5.946	4.649	2.972	92
44	5.136	5.946	4.649	2.972	94
45	5.136	5.946	4.649	2.972	96
46	5.136	5.946	4.650	2.973	98
47	5.136	5.946	4.650	2.971	100
48	5.136	5.946	4.649	2.971	102
49	5.136	5.945	4.649	2.971	104
50	5.136	5.946	4.649	2.971	107
51	5.135	5.944	4.648	2.970	109
52	5.136	5.944	4.649	2.970	112
53	5.136	5.945	4.649	2.971	114
54	5.136	5.945	4.649	2.970	117
55	5.136	5.944	4.649	2.970	120
56	5.136	5.944	4.649	2.969	123
57	5.136	5.944	4.649	2.969	127
58	5.135	5.943	4.649	2.969	129
59	5.134	5.944	4.648	2.969	132
60	5.136	5.944	4.649	2.969	135
61	5.136	5.944	4.649	2.969	
62	5.135	5.944	4.649	2.969	
63	5.134	5.944	4.648	2.969	
64	5.138	5.941	4.650	2.960	
65	5.137	5.941	4.649	2.963	
66	5.135	5.943	4.649	2.967	
67	5.136	5.944	4.650	2.968	
68	5.135	5.945	4.649	2.969	
69	5.135	5.945	4.650	2.970	
70	5.135	5.945	4.649	2.970	
71	5.135	5.945	4.649	2.970	
72	5.135	5.945	4.649	[illegible].970	
73	5.135	5.946	4.649	2.971	
74	5.135	5.946	4.649	2.971	
MAX					135

OMEGA POINT LABORATORIES

Time (min)	Front 3" Conduit Power Cable Max (°F)	Front 3" Conduit Control Cable Ave (°F)	Front 3" Conduit Control Cable Max (°F)	Front 3" Conduit Instrument Cable Ave (°F)
0	64	63	64	63
1	64	63	64	63
2	64	63	64	63
3	64	63	64	63
4	64	63	64	63
5	64	63	64	63
6	64	63	65	63
7	64	63	65	63
8	64	64	67	63
9	64	64	68	64
10	64	64	69	64
11	65	64	71	64
12	65	65	73	65
13	66	65	75	65
14	67	66	77	66
15	68	67	80	66
16	68	67	82	67
17	70	68	84	68
18	71	69	87	69
19	72	70	90	70
20	74	71	92	71
21	75	73	95	72
22	77	74	98	73
23	78	75	101	74
24	80	77	103	76
25	82	78	106	77
26	84	80	109	79
27	86	82	112	81
28	88	83	115	82
29	91	85	117	84
30	93	87	120	86
31	95	89	122	88
32	98	91	125	90
33	100	93	127	92
34	103	95	130	94
35	106	98	132	97
36	108	100	134	99
37	111	102	137	101
38	114	104	139	104
39	117	107	142	106
40	120	109	144	109

OMEGA POINT LABORATORIES

Time (min)	Front 3" Conduit Power Cable Max (°F)	Front 3" Conduit Control Cable Ave (°F)	Front 3" Conduit Control Cable Max (°F)	Front 3" Conduit Instrument Cable Ave (°F)
41	123	111	148	111
42	126	114	152	114
43	128	116	155	116
44	131	119	159	119
45	134	121	163	121
46	137	124	167	124
47	140	127	171	127
48	143	129	175	129
49	146	132	180	132
50	148	135	184	135
51	151	138	189	138
52	154	141	193	141
53	157	144	198	144
54	160	147	203	147
55	163	150	208	150
56	168	153	213	153
57	171	157	218	156
58	172	160	223	159
59	173	163	228	162
60	174	166	233	165
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
MAX	174	166	233	165

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Front 3" Conduit Instrument Cable Max (°F)	Front 3" Conduit Conduit Steel Ave (°F)	Front 3" Conduit Conduit Steel Max (°F)	Rear 3" Conduit Power Cable Ave (°F)
0	64	63	66	63
1	64	63	66	63
2	64	63	66	63
3	64	64	66	63
4	64	64	66	63
5	64	65	68	63
6	64	66	71	63
7	64	68	76	63
8	65	70	81	63
9	65	72	86	63
10	67	75	91	63
11	68	78	97	64
12	70	81	103	64
13	73	86	110	64
14	75	91	116	65
15	78	96	123	65
16	81	103	133	66
17	84	111	148	66
18	88	123	159	67
19	91	135	173	68
20	95	147	201	68
21	98	158	218	69
22	102	169	240	70
23	105	183	262	71
24	109	197	291	72
25	113	212	318	74
26	117	230	367	75
27	120	252	430	76
28	124	276	492	77
29	128	299	547	79
30	133	344	629	80
31	137	400	670	81
32	141	448	812	83
33	145	500	896	85
34	148	519	882	86
35	151	533	915	88
36	154	553	952	90
37	157	562	924	91
38	160	563	948	93
39	163	558	923	95
40	166	552	884	97

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Front 3" Conduit Instrument Cable Max (°F)	Front 3" Conduit Conduit Steel Ave (°F)	Front 3" Conduit Conduit Steel Max (°F)	Rear 3" Conduit Power Cable Ave (°F)
41	169	556	875	99
42	172	555	848	101
43	175	549	811	103
44	178	540	780	106
45	181	524	781	108
46	184	511	795	110
47	187	502	792	112
48	190	500	819	115
49	193	512	911	117
50	196	522	982	119
51	200	531	1028	122
52	203	544	1086	125
53	207	554	1141	127
54	210	576	1132	130
55	214	569	1066	133
56	217	549	976	136
57	221	538	899	139
58	225	510	850	142
59	228	502	824	145
60	232	494	808	148
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
MAX	232	576	1141	148

OMEGA POINT LABORATORIES

Time (min)	Rear 3" Conduit Power Cable Max (°F)	Rear 3" Conduit Control Cable Ave (°F)	Rear 3" Conduit Control Cable Max (°F)	Rear 3" Conduit Instrument Cable Ave (°F)
0	64	63	64	63
1	64	63	64	63
2	64	63	64	63
3	64	63	64	63
4	64	63	64	63
5	64	63	64	63
6	64	63	64	63
7	64	63	64	63
8	64	63	64	63
9	64	63	64	64
10	65	63	64	64
11	66	63	64	64
12	68	63	64	65
13	70	63	65	65
14	71	63	65	66
15	73	64	66	67
16	76	64	67	67
17	78	64	68	68
18	80	64	69	69
19	82	65	71	70
20	84	65	73	72
21	87	66	74	73
22	89	66	76	74
23	91	67	78	76
24	94	67	80	77
25	96	68	82	79
26	98	69	85	80
27	101	70	87	82
28	103	71	89	84
29	106	72	92	85
30	108	73	94	87
31	110	74	96	89
32	112	75	99	91
33	115	76	101	93
34	117	77	104	95
35	119	79	106	97
36	122	80	109	99
37	124	81	111	102
38	127	83	114	104
39	130	84	116	106
40	132	86	119	109

OMEGA POINT LABORATORIES

Time (min)	Rear 3" Conduit Power Cable Max (°F)	Rear 3" Conduit Control Cable Ave (°F)	Rear 3" Conduit Control Cable Max (°F)	Rear 3" Conduit Instrument Cable Ave (°F)
41	135	88	121	111
42	138	89	124	113
43	141	91	126	116
44	144	93	128	118
45	147	95	131	121
46	150	96	133	123
47	153	98	136	126
48	157	100	138	128
49	160	102	141	131
50	164	104	144	134
51	168	106	146	136
52	172	108	149	139
53	176	110	152	142
54	180	113	155	145
55	184	115	158	148
56	188	117	161	151
57	193	120	164	154
58	198	122	168	157
59	202	125	171	160
60	206	127	174	163
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
MAX	206	127	174	163

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Rear 3" Conduit Instrument Cable Max (°F)	Rear 3" Conduit Conduit Steel Ave (°F)	Rear 3" Conduit Conduit Steel Max (°F)	Horizontal Junction Box Ave (°F)
0	64	63	64	63
1	64	63	64	63
2	64	63	64	63
3	64	64	64	63
4	64	64	65	63
5	64	65	68	63
6	64	66	72	63
7	64	68	77	63
8	64	70	82	63
9	65	73	88	63
10	66	75	94	63
11	68	79	102	63
12	69	82	111	64
13	71	87	118	64
14	73	91	126	64
15	75	96	133	64
16	78	102	142	65
17	80	106	150	65
18	83	110	158	66
19	86	116	166	67
20	89	121	176	68
21	92	129	187	69
22	94	139	205	70
23	97	148	223	71
24	100	157	230	72
25	103	166	244	73
26	107	177	258	75
27	110	187	273	76
28	113	198	286	78
29	116	209	305	80
30	119	220	335	81
31	122	230	367	83
32	125	236	385	85
33	128	250	405	88
34	130	262	411	90
35	133	285	445	93
36	135	318	472	96
37	138	337	499	99
38	141	380	557	103
39	144	394	613	107
40	148	399	604	110

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Rear 3" Conduit Instrument Cable Max (°F)	Rear 3" Conduit Conduit Steel Ave (°F)	Rear 3" Conduit Conduit Steel Max (°F)	Horizontal Junction Box Ave (°F)
41	151	410	647	115
42	154	421	669	119
43	158	434	649	122
44	161	440	667	126
45	165	444	642	129
46	169	457	668	133
47	173	462	672	136
48	177	474	718	140
49	181	482	712	143
50	185	491	722	147
51	189	480	698	151
52	193	458	672	154
53	198	442	654	157
54	202	431	639	160
55	207	435	654	162
56	211	436	640	164
57	216	440	638	166
58	221	433	619	168
59	226	425	606	170
60	232	418	594	172
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
MAX	232	491	722	172

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Horizontal Junction Box Max (°F)	Vertical Junction Box Ave (°F)	Vertical Junction Box Max (°F)	TC # 1 (°F)	TC # 2 (°F)
0	63	64	65	63	63
1	63	64	65	62	63
2	63	64	65	63	63
3	63	64	65	63	63
4	63	64	65	63	63
5	63	64	65	63	63
6	63	64	65	63	63
7	63	64	65	63	63
8	64	64	65	63	63
9	64	64	65	63	63
10	64	64	65	63	63
11	64	64	65	62	63
12	65	64	65	63	63
13	65	64	65	62	63
14	66	64	65	62	63
15	67	65	65	63	64
16	68	65	66	63	64
17	69	65	67	63	65
18	70	66	68	63	65
19	72	66	69	63	66
20	73	67	70	63	66
21	75	68	74	63	67
22	76	68	77	63	68
23	78	69	78	63	69
24	80	70	79	63	70
25	81	71	81	64	71
26	83	72	84	64	72
27	85	73	85	64	74
28	87	74	87	65	75
29	89	75	89	65	76
30	91	76	91	66	78
31	94	78	93	66	79
32	96	79	95	67	81
33	98	80	98	68	82
34	101	82	100	68	84
35	104	83	103	69	86
36	109	85	105	70	88
37	114	87	107	71	90
38	118	88	110	72	92
39	121	90	113	74	93
40	125	92	115	75	95

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Horizontal Junction Box Max (°F)	Vertical Junction Box Ave (°F)	Vertical Junction Box Max (°F)	TC # 1 (°F)	TC # 2 (°F)
41	129	94	117	77	97
42	133	96	120	78	99
43	137	98	122	80	101
44	141	100	125	82	103
45	146	103	132	84	105
46	149	105	138	86	107
47	149	108	145	89	110
48	151	111	153	92	112
49	153	114	161	96	114
50	157	117	167	100	116
51	164	120	174	105	119
52	167	123	181	110	121
53	170	127	187	114	124
54	171	129	191	119	127
55	172	133	195	123	130
56	172	136	197	127	133
57	175	140	197	131	137
58	179	142	198	135	140
59	182	144	198	139	143
60	186	146	197	143	147
61					
62					
63					
64					
65					
66					
67					
68					
69					
70					
71					
72					
73					
74					
MAX	186	146	198	143	147

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 3 (°F)	TC # 4 (°F)	TC # 5 (°F)	TC # 6 (°F)	TC # 7 (°F)	TC # 8 (°F)	TC # 9 (°F)	TC # 10 (°F)	TC # 11 (°F)
0	63	63	63	63	64	63	63	63	63
1	63	63	63	63	64	63	63	63	63
2	62	63	63	63	64	63	63	63	63
3	63	63	63	63	64	63	63	63	63
4	62	63	63	63	64	63	63	63	63
5	63	63	63	63	64	63	63	63	63
6	63	63	63	63	64	63	63	63	63
7	62	63	63	63	64	63	63	63	63
8	63	63	63	63	64	63	63	63	63
9	63	63	63	63	64	63	63	63	63
10	63	63	63	63	64	63	63	63	63
11	63	63	63	63	64	63	63	63	63
12	63	63	63	63	64	63	63	63	63
13	63	63	63	63	64	63	63	63	63
14	64	63	63	63	64	63	63	63	63
15	64	63	63	64	64	63	63	64	63
16	65	63	63	64	64	63	64	64	63
17	65	63	63	64	64	63	64	65	63
18	66	63	63	64	64	64	64	65	63
19	66	63	63	65	64	64	65	66	64
20	67	63	63	65	64	64	65	66	64
21	68	63	64	65	64	64	66	67	64
22	69	64	64	66	64	65	67	68	64
23	70	64	64	66	64	65	68	69	65
24	71	64	64	67	64	66	69	70	65
25	72	64	65	67	64	67	70	71	65
26	73	65	65	68	64	67	71	72	66
27	75	65	65	68	64	68	72	73	66
28	76	66	66	69	64	69	73	74	67
29	78	66	67	70	64	70	75	75	68
30	79	67	67	71	64	71	76	76	69
31	81	68	68	72	65	72	78	78	69
32	82	68	69	72	65	73	79	79	70
33	84	69	70	73	65	74	81	80	71
34	85	70	70	74	65	75	83	82	72
35	87	71	72	75	66	76	84	84	73
36	89	72	73	76	66	78	86	85	74
37	91	73	74	77	66	79	88	87	76
38	93	75	75	79	6[illegible]	81	90	89	77
39	94	76	77	80	67	83	92	90	78
40	97	78	78	81	67	85	94	92	80

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 3 (°F)	TC # 4 (°F)	TC # 5 (°F)	TC # 6 (°F)	TC # 7 (°F)	TC # 8 (°F)	TC # 9 (°F)	TC # 10 (°F)	TC # 11 (°F)
41	99	79	80	82	68	86	96	94	81
42	101	81	81	84	68	88	99	96	83
43	103	82	83	85	68	90	101	98	85
44	105	84	85	87	69	92	103	100	87
45	107	85	86	88	69	94	105	102	88
46	109	87	88	90	70	96	108	105	90
47	111	89	90	91	71	98	110	107	92
48	114	91	91	93	71	100	113	109	94
49	116	93	93	94	72	102	115	111	96
50	119	95	95	96	73	104	118	114	98
51	121	97	97	97	73	107	120	116	100
52	124	100	99	99	74	109	123	119	103
53	127	102	101	101	75	112	126	121	105
54	130	105	103	102	76	115	129	124	107
55	132	107	106	104	77	117	132	126	110
56	135	110	108	106	78	120	136	129	112
57	139	114	110	108	79	123	140	132	116
58	142	117	113	110	80	126	144	136	118
59	145	120	115	112	81	130	148	140	121
60	149	123	117	114	82	133	152	145	123
61									
62									
63									
64									
65									
66									
67									
68									
69									
70									
71									
72									
73									
74									
MAX	149	123	117	114	82	133	152	145	123

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 12 (°F)	TC # 13 (°F)	TC # 14 (°F)	TC # 15 (°F)	TC # 16 (°F)	TC # 17 (°F)	TC # 18 (°F)	TC # 19 (°F)
0	63	64	63	63	63	63	63	63
1	63	64	63	63	63	63	63	63
2	63	64	63	63	63	63	63	63
3	63	64	63	63	63	63	63	63
4	63	64	63	63	63	63	63	63
5	63	64	63	63	63	63	63	63
6	63	64	63	63	63	63	63	63
7	63	64	63	63	63	63	63	63
8	63	64	63	63	63	63	63	64
9	63	64	63	64	64	63	63	64
10	63	64	63	64	64	63	63	65
11	63	64	63	65	65	63	63	66
12	63	64	63	66	66	63	63	66
13	63	64	63	68	66	63	63	68
14	63	65	63	69	67	64	63	69
15	64	65	63	71	69	64	63	70
16	64	65	63	72	70	64	64	72
17	64	65	63	74	71	65	64	73
18	64	66	63	76	73	65	64	75
19	65	66	63	78	75	66	64	77
20	65	67	64	80	76	67	65	79
21	65	67	64	82	78	68	65	81
22	66	68	64	85	80	68	66	82
23	66	69	65	87	83	69	66	84
24	67	69	65	90	85	71	67	86
25	68	70	66	92	87	72	68	88
26	69	71	67	95	90	73	68	90
27	69	72	67	97	92	75	69	92
28	70	73	68	100	95	76	70	94
29	71	74	69	103	97	78	71	96
30	72	75	70	106	100	80	72	99
31	74	76	71	109	103	82	73	101
32	75	77	72	112	106	84	75	103
33	76	79	73	115	108	86	76	105
34	78	80	74	118	111	88	77	107
35	79	81	76	120	113	90	79	109
36	81	83	77	123	116	93	80	111
37	82	84	79	126	119	95	82	114
38	84	85	80	128	121	98	84	116
39	86	87	82	131	124	100	86	118
40	87	88	84	134	127	103	88	121

OMEGA POINT LABORATORIES

Time (min)	TC # 12 (°F)	TC # 13 (°F)	TC # 14 (°F)	TC # 15 (°F)	TC # 16 (°F)	TC # 17 (°F)	TC # 18 (°F)	TC # 19 (°F)
41	89	90	86	136	130	106	90	123
42	91	92	88	139	133	108	92	125
43	93	93	91	142	136	111	94	127
44	95	95	93	145	139	114	96	129
45	97	96	96	147	142	117	98	131
46	99	98	99	150	145	120	100	133
47	101	100	102	153	149	123	102	135
48	103	102	105	156	152	125	104	137
49	105	103	109	159	155	128	107	139
50	107	105	114	162	159	131	109	141
51	109	107	119	166	163	134	111	143
52	111	109	123	169	166	137	114	146
53	114	112	128	172	170	140	116	149
54	116	114	131	176	174	143	119	151
55	119	117	136	179	178	146	121	154
56	123	120	140	182	183	148	123	157
57	126	127	143	186	187	150	126	160
58	129	131	146	190	191	153	128	163
59	131	133	149	193	196	155	130	166
60	134	135	151	197	200	158	132	169
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	134	135	151	197	200	158	132	169

OMEGA POINT LABORATORIES

Time (min)	TC # 20 (°F)	TC # 21 (°F)	TC # 22 (°F)	TC # 23 (°F)	TC # 24 (°F)	TC # 25 (°F)	TC # 26 (°F)	TC # 27 (°F)
0	64	63	63	63	63	63	64	63
1	64	63	63	63	63	63	64	63
2	64	63	63	63	63	63	64	63
3	64	63	63	63	63	63	64	63
4	64	63	63	63	63	63	64	63
5	64	63	63	63	63	63	64	63
6	64	63	63	63	63	63	65	63
7	64	63	63	63	63	64	65	63
8	64	63	63	64	63	64	67	63
9	64	64	64	64	63	64	68	63
10	64	64	65	65	63	65	69	63
11	64	65	66	66	63	66	71	63
12	64	65	67	67	63	66	73	63
13	64	66	68	63	64	67	75	63
14	64	67	70	69	64	69	77	63
15	34	68	71	71	64	70	80	63
16	64	70	73	72	64	71	82	63
17	64	71	75	74	64	73	84	63
18	64	72	78	76	65	75	87	64
19	64	74	80	77	65	76	90	64
20	64	76	82	79	66	78	92	64
21	64	78	85	81	66	80	95	65
22	65	80	87	83	67	83	98	65
23	65	82	90	85	68	85	101	66
24	65	85	93	87	68	87	103	66
25	65	87	96	89	69	90	106	67
26	66	89	99	92	70	93	109	68
27	66	92	102	94	71	96	112	68
28	66	95	106	97	73	99	115	69
29	67	97	109	99	74	102	117	70
30	67	100	112	102	75	105	120	71
31	68	103	115	104	76	108	122	72
32	68	106	119	107	78	111	125	74
33	69	110	122	110	80	114	127	75
34	70	115	125	113	81	117	130	76
35	70	119	128	116	83	120	132	78
36	71	123	131	118	85	123	134	80
37	72	126	134	121	87	126	137	82
38	73	129	138	123	89	130	139	83
39	73	132	141	126	91	133	142	85
40	74	135	144	128	93	136	144	87

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 20 (°F)	TC # 21 (°F)	TC # 22 (°F)	TC # 23 (°F)	TC # 24 (°F)	TC # 25 (°F)	TC # 26 (°F)	TC # 27 (°F)
41	75	138	148	131	96	139	147	89
42	76	141	152	134	98	142	150	92
43	77	144	155	137	100	145	153	94
44	78	147	159	140	103	148	156	97
45	80	150	163	143	105	151	160	100
46	81	153	167	146	108	154	163	103
47	82	156	171	149	110	157	166	106
48	83	159	175	152	113	160	170	109
49	84	162	180	155	115	163	173	113
50	86	165	184	159	118	166	176	116
51	87	168	189	162	121	169	180	122
52	89	172	193	166	123	172	184	126
53	90	175	198	170	126	175	187	130
54	92	178	203	174	128	178	191	135
55	93	182	208	177	131	180	195	138
56	95	186	213	182	133	183	200	143
57	96	189	218	186	136	186	204	146
58	99	193	223	190	138	189	208	149
59	101	197	228	194	141	192	213	151
60	103	201	233	199	144	194	217	154
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	103	201	233	199	144	194	217	154

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 28 (°F)	TC # 29 (°F)	TC # 30 (°F)	TC # 31 (°F)	TC # 32 (°F)	TC # 33 (°F)	TC # 34 (°F)	TC # 35 (°F)
0	63	63	63	63	63	64	63	63
1	63	63	63	63	63	64	63	63
2	63	63	63	63	63	64	63	63
3	63	63	63	63	63	64	63	63
4	63	63	63	63	63	64	63	63
5	63	63	63	63	63	64	63	63
6	63	63	63	63	63	64	63	63
7	64	63	63	63	63	64	63	63
8	64	63	63	63	63	64	63	64
9	65	63	63	63	63	64	64	64
10	67	63	63	63	63	64	64	65
11	68	64	63	63	64	64	65	66
12	70	64	63	64	64	64	66	67
13	73	64	63	64	64	64	67	68
14	75	65	64	64	64	64	68	69
15	78	66	64	65	65	64	69	70
16	81	66	64	65	65	64	70	72
17	84	67	64	66	66	64	71	73
18	88	68	65	67	66	64	73	75
19	91	69	66	68	67	64	74	77
20	95	71	66	69	68	64	76	79
21	98	72	67	70	68	64	78	81
22	102	73	68	71	69	65	80	84
23	105	75	69	73	70	65	82	86
24	109	77	70	74	71	65	84	89
25	113	78	71	76	72	65	86	91
26	117	80	72	77	72	66	89	94
27	120	82	74	79	73	66	91	97
28	124	84	75	81	74	67	93	100
29	128	87	77	83	76	68	96	103
30	133	89	78	85	77	68	99	106
31	137	91	80	87	78	69	101	110
32	141	94	82	89	79	69	104	113
33	145	96	84	92	80	70	107	116
34	148	99	87	94	82	71	112	120
35	151	101	89	97	83	72	117	123
36	154	104	91	99	85	73	121	126
37	157	106	94	102	86	73	125	129
38	160	109	96	105	88	75	128	133
39	163	111	99	108	89	75	132	136
40	166	114	102	110	91	77	135	139

OMEGA POINT LABORATORIES

Time (min)	TC # 28 (°F)	TC # 29 (°F)	TC # 30 (°F)	TC # 31 (°F)	TC # 32 (°F)	TC # 33 (°F)	TC # 34 (°F)	TC # 35 (°F)
41	169	117	104	113	93	77	138	143
42	172	120	107	116	94	78	141	146
43	175	122	110	119	96	78	144	150
44	178	125	113	122	98	78	147	153
45	181	128	116	125	100	79	150	157
46	184	131	119	128	101	80	153	161
47	187	134	121	131	103	80	156	165
48	190	136	124	134	105	81	159	169
49	193	140	127	137	107	82	161	173
50	196	142	130	140	109	83	165	178
51	200	146	133	143	111	84	168	182
52	203	149	136	146	112	85	171	187
53	207	152	139	148	114	86	174	191
54	210	155	142	151	116	88	177	196
55	214	159	145	153	118	89	181	201
56	217	162	148	155	120	91	184	205
57	221	166	150	157	122	93	188	210
58	225	170	152	158	124	94	191	215
59	228	173	155	160	126	97	195	220
60	232	177	157	161	129	99	198	225
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	232	177	157	161	129	99	198	225

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 36 (°F)	TC # 37 (°F)	TC # 38 (°F)	TC # 39 (°F)	TC # 40 (°F)	TC # 41 (°F)	TC # 42 (°F)	TC # 43 (°F)
0	63	63	63	64	63	63	63	63
1	63	63	63	64	63	63	63	63
2	63	63	63	64	63	63	63	63
3	63	63	63	64	63	63	63	63
4	63	63	63	64	63	63	63	63
5	63	63	63	64	63	63	63	63
6	63	63	63	64	63	63	63	63
7	63	63	63	64	63	63	63	63
8	63	63	64	65	63	63	63	63
9	64	63	64	65	63	63	63	63
10	64	63	64	65	63	63	63	63
11	65	63	64	66	63	63	63	63
12	66	63	64	66	63	63	63	63
13	66	64	65	67	63	63	63	64
14	67	64	65	68	63	64	63	64
15	68	64	66	69	63	64	64	64
16	69	64	67	70	64	64	64	65
17	71	65	68	71	64	64	64	65
18	72	65	68	72	64	65	65	66
19	73	66	69	73	65	65	65	67
20	75	66	71	74	65	66	66	67
21	76	67	72	76	66	67	67	68
22	78	68	73	77	67	68	67	69
23	80	69	75	79	68	68	68	71
24	82	70	77	80	69	69	69	72
25	84	71	78	82	70	71	70	73
26	86	72	80	84	72	72	72	75
27	88	73	82	86	74	73	73	76
28	90	75	84	88	75	74	75	78
29	92	76	87	89	77	76	76	79
30	94	77	89	91	79	78	78	81
31	97	79	91	93	81	79	80	83
32	99	81	94	95	84	80	83	85
33	102	83	96	97	86	83	85	87
34	104	85	99	99	89	84	88	89
35	107	87	102	101	93	87	91	91
36	109	89	104	103	97	89	94	94
37	112	91	107	106	102	91	99	96
38	114	93	110	108	110	94	106	99
39	117	96	113	110	116	97	115	101
40	120	98	115	112	122	99	122	104

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 36 (°F)	TC # 37 (°F)	TC # 38 (°F)	TC # 39 (°F)	TC # 40 (°F)	TC # 41 (°F)	TC # 42 (°F)	TC # 43 (°F)
41	122	101	118	114	126	103	129	118
42	125	103	121	117	131	106	133	122
43	128	106	123	119	137	109	137	126
44	130	109	126	121	141	113	141	130
45	133	112	129	124	143	117	146	133
46	136	114	131	126	145	120	149	136
47	139	117	134	128	148	124	149	140
48	142	120	137	131	150	127	151	143
49	145	123	139	133	152	132	153	147
50	148	126	142	136	156	136	155	151
51	151	129	145	139	156	141	157	154
52	154	132	147	142	158	145	159	157
53	158	134	150	144	160	148	162	160
54	161	137	153	147	162	152	164	163
55	165	140	155	151	164	155	165	166
56	169	143	158	154	166	157	167	169
57	172	146	161	157	167	159	168	171
58	176	148	163	161	169	161	170	173
59	180	151	166	164	170	162	170	175
60	184	154	169	168	171	165	172	177
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	184	154	169	168	171	165	172	177

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 44 (°F)	TC # 45 (°F)	TC # 46 (°F)	TC # 47 (°F)	TC # 48 (°F)	TC # 49 (°F)	TC # 50 (°F)	TC # 51 (°F)
0	63	63	63	63	63	63	64	64
1	63	63	63	63	63	63	64	64
2	63	63	63	63	63	63	64	64
3	63	63	63	63	63	63	64	64
4	63	63	63	63	63	63	64	64
5	63	63	63	63	63	63	64	64
6	63	63	63	63	63	63	64	64
7	63	63	63	63	63	63	64	64
8	63	63	63	63	64	63	64	64
9	63	63	63	63	64	63	64	64
10	63	63	63	63	64	63	64	64
11	63	63	64	63	64	63	64	64
12	63	63	64	63	65	64	64	64
13	64	64	64	63	65	64	64	64
14	64	64	65	64	66	64	65	64
15	64	64	65	64	67	64	65	65
16	65	65	66	64	68	65	66	65
17	66	65	67	64	69	65	66	65
18	66	66	68	65	70	66	67	66
19	67	67	69	65	72	66	68	67
20	69	67	69	66	73	67	68	67
21	70	68	71	66	75	68	69	68
22	71	69	72	67	76	69	70	69
23	73	70	73	68	78	70	72	70
24	74	72	75	69	80	71	73	71
25	76	73	76	70	81	72	74	72
26	78	74	78	71	83	73	75	73
27	80	76	80	72	85	75	77	75
28	82	77	82	73	87	76	79	76
29	84	79	84	74	89	77	81	78
30	86	81	86	76	91	79	82	79
31	88	83	89	77	94	80	85	81
32	90	85	92	79	96	82	87	83
33	92	87	95	80	98	84	89	84
34	94	89	99	82	101	85	91	86
35	97	92	104	84	103	87	93	88
36	99	95	109	86	105	90	96	91
37	102	97	114	88	108	94	99	93
38	105	101	118	90	110	97	102	95
39	108	104	121	92	113	101	105	97
40	110	107	125	95	116	104	109	99

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 44 (°F)	TC # 45 (°F)	TC # 46 (°F)	TC # 47 (°F)	TC # 48 (°F)	TC # 49 (°F)	TC # 50 (°F)	TC # 51 (°F)
41	113	111	128	97	119	108	113	102
42	116	114	130	100	122	111	117	104
43	118	118	133	103	125	115	121	107
44	121	122	136	106	129	119	125	110
45	124	126	139	109	132	124	132	113
46	128	130	143	112	135	131	138	117
47	131	134	146	115	139	138	145	121
48	134	138	149	118	142	146	153	125
49	138	141	152	122	146	152	161	129
50	141	145	155	127	149	157	167	133
51	144	148	159	132	153	164	174	137
52	147	151	162	136	157	167	181	144
53	151	154	166	140	160	170	187	148
54	154	157	169	143	164	171	191	152
55	157	160	169	147	168	172	195	155
56	159	162	169	151	172	172	197	158
57	162	164	171	154	175	172	197	161
58	165	166	172	156	179	173	198	162
59	167	168	173	158	182	174	198	164
60	170	170	175	160	186	175	197	165
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	170	170	175	160	186	175	198	165

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 52 (°F)	TC # 53 (°F)	TC # 54 (°F)	TC # 55 (°F)	TC # 56 (°F)	TC # 57 (°F)	TC # 58 (°F)	TC # 59 (°F)
0	63	64	64	65	65	64	64	64
1	63	64	64	65	65	64	64	64
2	63	64	64	65	65	64	64	64
3	63	64	64	65	65	64	64	64
4	63	64	64	65	65	64	64	64
5	63	64	64	65	65	64	64	64
6	63	64	64	65	65	64	64	64
7	63	64	64	65	65	64	64	64
8	63	64	64	65	65	64	64	64
9	63	64	64	65	65	64	64	64
10	63	64	64	65	65	64	64	64
11	64	64	64	65	65	64	64	64
12	64	64	64	65	65	64	64	64
13	65	64	64	65	65	64	64	64
14	65	64	64	65	65	64	65	64
15	65	64	64	65	65	64	65	65
16	66	64	65	65	65	65	65	65
17	67	65	65	65	65	65	66	65
18	68	65	65	65	65	65	66	66
19	69	65	65	65	65	66	67	66
20	70	66	65	65	65	66	68	67
21	74	66	65	65	66	67	68	67
22	77	67	65	65	66	67	69	68
23	78	68	66	66	66	68	70	69
24	79	68	66	66	67	69	71	69
25	81	69	66	66	67	70	72	70
26	84	70	67	66	67	71	73	71
27	85	71	67	67	68	72	74	72
28	87	72	68	67	68	73	76	73
29	89	73	68	67	69	75	77	74
30	91	75	69	68	69	76	78	75
31	93	76	70	68	70	77	80	77
32	95	77	70	69	71	79	81	78
33	98	79	71	69	71	80	83	79
34	100	80	72	70	72	82	84	80
35	103	82	73	70	73	83	86	82
36	105	83	73	71	74	85	88	83
37	107	85	74	72	75	87	90	85
38	110	86	75	72	76	89	91	86
39	113	88	76	73	77	90	93	88
40	115	90	77	74	78	92	95	89

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 52 (°F)	TC # 53 (°F)	TC # 54 (°F)	TC # 55 (°F)	TC # 56 (°F)	TC # 57 (°F)	TC # 58 (°F)	TC # 59 (°F)
41	117	92	78	75	79	94	97	91
42	120	94	80	76	80	96	99	93
43	122	96	81	77	81	99	101	95
44	125	98	82	78	83	101	103	96
45	127	99	83	79	84	104	105	98
46	130	102	85	80	86	108	108	100
47	133	104	86	81	87	111	110	102
48	137	106	88	82	89	113	112	104
49	140	108	89	83	90	116	114	106
50	144	110	91	85	92	119	117	108
51	150	112	93	87	93	122	119	110
52	155	115	94	90	95	125	122	113
53	160	117	96	92	98	128	124	115
54	165	119	98	93	100	132	127	118
55	179	122	99	94	103	134	130	120
56	187	126	101	95	105	138	133	123
57	194	131	103	98	108	143	137	125
58	195	133	106	101	111	148	141	128
59	195	135	108	104	114	151	144	131
60	192	138	111	107	117	153	147	134
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	195	138	111	107	117	153	147	134

OMEGA POINT LABORATORIES

Time (min)	TC # 60 (°F)	TC # 61 (°F)	TC # 62 (°F)	TC # 63 (°F)	TC # 64 (°F)	TC # 65 (°F)	TC # 66 (°F)	TC # 67 (°F)
0	63	63	62	63	63	63	64	62
1	63	63	62	63	63	63	64	62
2	63	63	62	63	63	63	64	62
3	63	63	62	63	63	63	64	62
4	63	63	62	63	63	63	64	62
5	63	63	62	63	63	63	64	62
6	63	63	62	63	63	63	64	62
7	63	63	62	62	63	63	64	62
8	63	63	62	62	63	63	64	62
9	63	63	63	63	63	63	64	62
10	63	63	62	62	63	63	64	62
11	63	63	63	63	63	63	64	63
12	63	63	63	63	63	63	64	63
13	63	63	63	63	63	63	64	63
14	63	63	63	62	63	63	64	63
15	63	64	64	63	63	64	64	63
16	63	64	64	63	64	64	64	63
17	63	65	65	63	64	64	64	63
18	64	65	65	63	64	64	64	64
19	64	66	66	63	65	65	64	64
20	64	66	66	63	65	65	64	64
21	64	67	67	63	66	66	64	65
22	64	68	68	64	66	66	64	66
23	64	69	69	64	67	67	64	66
24	64	69	70	64	67	67	64	67
25	65	70	71	64	68	68	64	68
26	65	71	72	65	69	69	64	69
27	65	72	73	65	70	69	64	70
28	66	73	74	66	71	70	64	71
29	66	75	76	66	72	71	64	72
30	67	76	77	67	73	72	64	73
31	67	77	78	68	74	73	65	74
32	68	78	80	68	76	74	65	75
33	69	80	82	69	77	75	65	77
34	69	81	83	70	78	76	65	78
35	70	83	85	71	80	77	66	80
36	71	84	87	72	81	78	66	81
37	72	85	88	73	83	79	66	83
38	73	87	90	75	85	80	66	85
39	75	89	92	76	86	82	67	87
40	76	90	94	77	88	83	67	89

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 60 (°F)	TC # 61 (°F)	TC # 62 (°F)	TC # 63 (°F)	TC # 64 (°F)	TC # 65 (°F)	TC # 66 (°F)	TC # 67 (°F)
41	78	92	96	79	90	84	67	90
42	79	94	98	80	92	85	68	92
43	81	95	100	82	94	87	68	94
44	82	97	102	84	96	88	69	96
45	85	99	104	85	98	90	69	98
46	87	101	106	87	101	91	70	100
47	89	103	108	89	103	93	71	103
48	92	105	110	91	105	94	71	105
49	95	107	112	93	107	96	72	107
50	98	109	114	95	110	97	72	109
51	101	111	117	97	112	99	73	111
52	105	114	119	99	114	100	74	113
53	109	116	121	101	117	102	75	116
54	113	118	124	103	119	104	75	118
55	118	121	126	105	122	106	76	121
56	124	124	129	107	124	107	77	124
57	127	126	131	110	126	109	78	127
58	131	129	134	112	129	111	79	130
59	134	132	137	114	131	113	81	133
60	138	135	139	117	133	114	82	136
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	138	135	139	117	133	114	82	136

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 68 (°F)	TC # 69 (°F)	TC # 70 (°F)	TC # 71 (°F)	TC # 72 (°F)	TC # 73 (°F)	TC # 74 (°F)	TC # 75 (°F)
0	62	62	62	63	63	62	63	63
1	62	62	62	63	63	63	63	63
2	62	62	63	63	63	62	62	63
3	62	62	63	63	63	62	63	63
4	62	62	62	63	63	62	62	63
5	62	62	62	63	63	63	63	63
6	62	62	63	63	63	63	63	63
7	62	62	62	63	64	62	62	63
8	62	62	62	63	64	63	63	63
9	62	63	63	63	64	62	62	63
10	62	62	62	63	65	62	63	63
11	63	63	63	63	65	62	63	63
12	63	63	63	63	66	62	63	63
13	63	63	63	63	67	63	63	63
14	63	64	63	64	68	62	63	63
15	63	64	63	64	70	62	63	63
16	64	65	63	64	71	63	63	64
17	64	66	63	65	73	63	64	64
18	65	67	64	65	75	63	64	65
19	66	68	64	66	77	63	64	65
20	66	69	64	66	80	63	65	66
21	68	70	65	67	82	63	66	66
22	69	72	65	68	84	63	66	67
23	70	73	66	69	87	63	67	68
24	71	74	66	70	89	63	67	68
25	73	76	67	71	92	64	68	69
26	74	78	68	72	94	64	69	70
27	76	79	69	74	97	64	70	71
28	77	81	70	75	100	65	71	73
29	79	83	71	77	102	65	72	74
30	81	85	72	79	105	66	73	75
31	83	87	73	80	108	66	74	76
32	85	89	74	82	110	67	75	78
33	87	91	76	84	113	67	77	79
34	89	93	77	86	116	68	78	81
35	91	95	79	88	118	69	79	83
36	93	97	81	90	121	69	81	84
37	95	99	82	93	123	70	82	86
38	97	102	84	95	126	71	84	88
39	100	104	86	97	128	72	85	90
40	102	106	88	100	131	73	87	92

OMEGA POINT LABORATORIES

Time (min)	TC # 68 (°F)	TC # 69 (°F)	TC # 70 (°F)	TC # 71 (°F)	TC # 72 (°F)	TC # 73 (°F)	TC # 74 (°F)	TC # 75 (°F)
41	104	108	91	102	134	75	88	94
42	106	111	93	104	136	76	90	96
43	109	113	95	107	139	77	92	98
44	111	115	97	109	142	78	93	100
45	113	118	100	112	144	80	95	102
46	115	120	102	114	147	81	97	104
47	118	123	105	117	150	83	99	106
48	120	125	108	119	153	85	101	108
49	123	128	110	122	157	87	103	110
50	125	131	113	124	160	89	105	113
51	128	134	116	127	163	91	107	115
52	131	137	118	129	166	93	109	117
53	134	140	121	132	170	96	112	119
54	138	143	124	135	173	98	114	122
55	141	147	127	137	178	102	116	124
56	144	150	130	140	183	104	119	127
57	148	154	133	144	187	107	121	129
58	151	157	136	147	190	110	124	132
59	155	161	139	150	194	113	126	134
60	158	165	142	153	197	116	129	137
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	158	165	142	153	197	116	129	137

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 76 (°F)	TC # 77 (°F)	TC # 78 (°F)	TC # 79 (°F)	TC # 80 (°F)	TC # 81 (°F)	TC # 82 (°F)	TC # 83 (°F)
0	63	63	63	64	63	63	63	63
1	63	63	63	64	63	63	63	63
2	63	63	63	64	63	63	63	63
3	63	63	63	64	63	63	63	63
4	63	63	63	64	62	63	63	63
5	63	63	63	64	63	63	63	63
6	63	63	63	64	63	63	63	63
7	63	63	63	64	63	63	63	63
8	63	63	63	64	63	63	63	63
9	63	63	63	64	63	63	63	63
10	63	63	63	64	63	63	63	63
11	63	63	63	64	63	64	63	63
12	63	63	63	64	63	64	63	63
13	63	63	63	64	63	65	63	63
14	63	63	63	64	63	65	64	63
15	63	63	63	64	63	66	64	63
16	63	63	63	64	63	67	65	63
17	63	63	64	64	63	68	65	63
18	63	63	64	64	63	69	66	63
19	63	63	64	64	63	71	67	64
20	63	63	64	64	64	73	68	64
21	64	64	64	64	64	74	69	64
22	64	64	64	64	65	76	70	65
23	64	64	65	64	65	78	71	65
24	64	64	65	64	66	80	72	65
25	65	65	65	64	66	82	74	66
26	65	65	66	64	67	85	75	66
27	66	65	66	64	68	87	77	67
28	66	66	67	64	68	89	79	68
29	67	66	67	64	69	92	80	68
30	68	67	68	64	70	94	82	69
31	68	68	68	65	71	96	84	70
32	69	68	69	65	72	99	86	71
33	70	69	69	65	74	101	88	72
34	71	70	70	65	75	104	90	73
35	72	71	71	65	76	106	92	75
36	73	71	71	65	77	109	94	76
37	75	72	72	66	79	111	96	78
38	76	73	73	66	81	114	99	79
39	77	74	74	66	82	116	101	81
40	79	76	75	66	84	119	103	82

OMEGA POINT LABORATORIES

Time (min)	TC # 76 (°F)	TC # 77 (°F)	TC # 78 (°F)	TC # 79 (°F)	TC # 80 (°F)	TC # 81 (°F)	TC # 82 (°F)	TC # 83 (°F)
41	80	77	75	67	86	121	105	84
42	82	78	76	67	87	124	108	86
43	83	79	77	67	89	126	110	88
44	85	81	78	68	91	128	112	90
45	87	82	80	68	93	131	115	92
46	89	84	81	69	95	133	117	94
47	91	85	82	69	96	136	119	96
48	93	87	83	70	99	138	122	98
49	95	89	85	70	101	141	124	101
50	97	90	86	71	103	144	127	103
51	99	92	87	71	105	146	129	105
52	101	94	89	72	107	149	132	108
53	104	96	90	72	109	152	135	110
54	106	98	92	73	111	155	138	113
55	108	99	93	74	113	158	141	115
56	110	101	95	74	116	161	143	118
57	113	103	96	75	119	164	146	120
58	115	105	98	76	121	168	150	123
59	117	107	99	77	124	171	153	125
60	119	109	101	78	127	174	156	128
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	119	109	101	78	127	174	156	128

OMEGA POINT LABORATORIES

Time (min)	TC # 84 (°F)	TC # 85 (°F)	TC # 86 (°F)	TC # 87 (°F)	TC # 88 (°F)	TC # 89 (°F)	TC # 90 (°F)	TC # 91 (°F)
0	64	64	63	63	63	63	63	63
1	63	64	63	63	63	63	63	63
2	63	64	63	63	63	63	63	63
3	63	64	63	63	63	63	63	63
4	63	64	63	63	63	63	63	63
5	63	64	63	63	63	63	63	63
6	63	64	63	63	63	63	63	63
7	63	64	63	63	63	63	63	63
8	63	64	63	63	63	63	63	63
9	63	64	63	63	63	63	63	64
10	63	64	63	64	64	63	63	64
11	63	64	63	64	64	63	63	64
12	64	64	63	65	64	63	63	64
13	64	65	63	65	65	64	64	65
14	64	65	63	66	65	64	64	65
15	64	65	63	67	66	64	64	65
16	64	65	63	68	67	64	64	66
17	64	66	63	69	68	65	65	67
18	64	66	63	70	69	65	65	67
19	64	67	64	72	70	65	65	68
20	64	68	64	73	71	66	66	69
21	65	68	64	75	73	66	66	70
22	65	69	64	76	74	67	67	71
23	66	70	64	78	76	67	68	72
24	66	71	65	79	77	68	69	73
25	67	72	65	81	79	69	69	75
26	67	74	65	83	81	70	70	76
27	68	75	66	85	83	71	71	77
28	69	76	66	87	84	72	72	79
29	70	78	67	89	86	73	73	80
30	71	79	67	91	88	74	75	82
31	72	81	68	93	91	76	76	83
32	73	83	69	95	93	77	77	85
33	74	84	70	97	95	79	79	86
34	75	86	70	99	97	80	80	88
35	77	88	71	101	100	82	82	89
36	78	90	72	104	102	84	83	91
37	80	92	73	106	104	86	85	93
38	82	94	74	108	106	88	87	95
39	83	96	75	110	109	90	89	96
40	85	98	77	113	111	92	91	98

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 84 (°F)	TC # 85 (°F)	TC # 86 (°F)	TC # 87 (°F)	TC # 88 (°F)	TC # 89 (°F)	TC # 90 (°F)	TC # 91 (°F)
41	87	100	78	115	113	94	93	100
42	89	102	79	117	116	97	95	102
43	91	104	81	120	118	99	97	104
44	93	106	82	122	121	102	99	106
45	95	108	84	125	123	104	102	108
46	97	110	86	127	126	107	104	110
47	99	112	88	130	128	109	106	112
48	101	114	90	133	131	112	109	114
49	103	116	92	135	133	115	111	117
50	105	118	95	138	136	117	114	119
51	108	120	98	141	139	120	116	121
52	110	123	101	144	142	123	118	123
53	112	125	104	147	144	125	121	125
54	114	127	108	150	147	128	123	127
55	117	130	112	153	150	131	126	129
56	119	132	116	157	153	133	128	131
57	121	135	119	160	156	136	130	133
58	124	137	122	163	159	138	133	135
59	126	140	125	167	162	141	135	137
60	129	143	129	170	166	143	137	139
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	129	143	129	170	166	143	137	139

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 92 (°F)	TC # 93 (°F)	TC # 94 (°F)	TC # 95 (°F)	TC # 96 (°F)	TC # 97 (°F)	TC # 98 (°F)	TC # 99 (°F)
0	64	63	63	63	63	63	64	63
1	64	63	63	63	63	63	64	63
2	64	63	63	63	63	63	64	63
3	64	63	63	63	63	63	64	63
4	64	63	63	63	63	63	64	63
5	64	63	63	63	63	63	64	63
6	64	63	63	63	63	63	64	63
7	64	63	63	63	63	63	64	63
8	64	63	63	63	63	64	64	64
9	64	63	63	64	63	64	65	65
10	64	63	63	64	63	64	65	66
11	64	63	64	65	64	64	66	68
12	64	63	64	66	64	64	67	70
13	64	64	65	67	64	65	68	72
14	64	64	66	69	65	65	69	75
15	64	64	67	70	65	65	70	78
16	64	65	69	72	66	66	72	81
17	64	65	70	74	66	67	74	84
18	6[illegible]	66	72	76	67	68	76	104
19	[illegible]	66	74	78	68	69	78	121
20	64	67	76	80	69	70	80	134
21	64	68	78	82	70	71	82	152
22	65	69	80	85	71	72	85	157
23	65	69	82	87	72	73	87	192
24	65	71	85	90	74	75	90	209
25	65	72	87	93	75	77	93	219
26	65	73	90	95	77	79	95	237
27	65	74	93	98	78	80	98	261
28	66	75	95	101	80	82	100	284
29	66	77	98	103	82	85	103	308
30	66	78	101	106	84	87	106	355
31	67	80	104	109	86	89	108	320
32	67	81	106	112	89	92	111	434
33	68	83	109	115	91	94	114	674
34	68	85	112	117	94	96	116	741
35	69	87	114	120	96	99	119	754
36	69	89	117	123	99	102	121	773
37	70	91	120	126	102	104	124	785
38	70	94	123	128	105	107	126	775
39	71	96	125	131	108	110	129	770
40	72	98	128	134	111	112	131	751

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 92 (°F)	TC # 93 (°F)	TC # 94 (°F)	TC # 95 (°F)	TC # 96 (°F)	TC # 97 (°F)	TC # 98 (°F)	TC # 99 (°F)
41	73	101	131	137	114	115	133	736
42	73	103	134	140	118	118	136	705
43	74	105	136	143	121	120	138	671
44	75	108	139	145	124	123	141	631
45	76	110	142	148	127	125	143	591
46	77	112	145	151	131	128	146	560
47	78	114	148	154	134	130	149	520
48	79	117	151	157	137	133	152	505
49	80	119	154	161	140	135	155	523
50	81	121	157	164	143	138	158	522
51	82	124	161	167	146	140	161	519
52	83	126	164	170	149	143	164	526
53	85	128	168	174	152	146	167	549
54	86	131	171	178	155	148	170	600
55	87	134	175	181	158	151	173	590
56	89	136	178	185	160	153	176	560
57	91	139	182	189	163	155	179	503
58	93	142	186	193	166	158	183	465
59	96	145	190	198	169	163	187	449
60	99	148	194	201	171	165	190	424
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
MAX	99	148	194	201	171	165	190	785

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 100 (°F)	TC # 101 (°F)	TC # 102 (°F)	TC # 103 (°F)	TC # 104 (°F)	TC # 105 (°F)	TC # 106 (°F)
0	63	63	63	63	63	63	63
1	63	63	63	63	63	63	63
2	63	63	63	63	63	63	63
3	63	63	63	63	63	63	63
4	65	63	64	63	63	64	64
5	68	63	65	64	63	66	66
6	71	64	66	66	63	68	68
7	76	64	66	68	63	71	72
8	81	65	67	71	63	76	76
9	86	66	69	75	64	80	80
10	91	67	70	79	64	85	85
11	97	69	72	83	65	91	91
12	103	70	73	88	66	96	97
13	110	74	75	93	67	102	103
14	116	82	78	99	68	109	110
15	123	92	81	101	69	118	118
16	133	103	83	105	71	131	126
17	145	112	87	109	73	148	142
18	157	119	92	114	75	159	154
19	168	127	95	119	77	173	171
20	179	139	103	123	79	175	190
21	192	152	107	128	82	193	206
22	207	163	111	133	85	207	225
23	218	173	115	137	88	226	243
24	229	185	120	141	91	240	267
25	242	198	126	145	94	266	295
26	256	214	133	150	98	290	328
27	269	233	139	154	101	312	358
28	292	245	145	158	104	332	394
29	315	259	153	161	107	349	425
30	339	266	159	165	110	402	458
31	366	272	167	169	113	457	515
32	389	270	173	172	118	516	550
33	401	265	178	176	125	564	582
34	418	268	185	179	131	600	606
35	430	268	195	183	143	628	641
36	461	274	206	186	158	673	696
37	480	278	214	190	176	708	737
38	497	277	222	193	187	692	764
39	502	276	233	196	194	686	759
40	501	274	241	199	197	670	760

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 100 (°F)	TC # 101 (°F)	TC # 102 (°F)	TC # 103 (°F)	TC # 104 (°F)	TC # 105 (°F)	TC # 106 (°F)
41	510	272	248	202	198	694	803
42	505	266	255	205	199	709	807
43	497	258	257	208	199	690	787
44	488	251	261	210	200	668	765
45	472	249	261	212	161	635	760
46	451	244	260	214	141	615	746
47	433	236	257	219	159	595	751
48	424	232	253	221	162	575	759
49	418	231	255	226	192	580	792
50	414	235	257	233	196	591	819
51	414	250	268	245	197	596	839
52	418	266	278	255	198	606	841
53	434	283	287	265	137	634	836
54	471	303	308	272	190	674	825
55	483	308	318	274	187	666	829
56	490	313	317	279	172	653	80[illegible]
57	491	311	308	282	373	628	76[illegible]
58	495	308	301	286	171	620	736
59	503	308	293	295	190	606	701
60	502	304	286	29[illegible]	195	595	680
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	510	313	318	298	373	709	841

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 107 (°F)	TC # 108 (°F)	TC # 109 (°F)	TC # 110 (°F)	TC # 111 (°F)	TC # 112 (°F)	TC # 113 (°F)
0	63	62	65	66	63	63	63
1	63	63	65	66	63	63	63
2	63	63	65	66	63	63	63
3	63	63	65	66	63	63	63
4	64	64	65	66	63	65	63
5	64	65	65	68	63	68	63
6	64	67	65	70	63	72	64
7	64	6[illegible]	66	73	64	77	64
8	64	70	66	77	64	82	65
9	64	72	67	81	65	88	66
10	65	74	68	86	66	92	67
11	65	76	70	91	68	98	69
12	66	79	73	96	71	103	71
13	67	82	83	102	75	109	72
14	68	84	97	108	77	115	74
15	70	88	105	112	79	122	77
16	75	90	116	119	82	129	79
17	83	96	133	124	85	136	82
18	127	98	149	131	89	144	85
19	162	98	163	139	93	152	88
20	196	101	201	150	97	159	90
21	207	104	218	157	104	167	93
22	230	111	240	166	110	180	99
23	257	116	262	174	117	189	104
24	276	123	291	187	124	194	108
25	313	121	318	202	133	199	114
26	340	124	367	224	141	206	119
27	385	130	430	255	148	213	124
28	436	140	492	286	161	221	132
29	490	151	547	319	173	228	138
30	565	294	629	385	181	234	143
31	641	663	670	442	193	240	149
32	706	812	734	495	203	252	156
33	773	896	810	554	212	263	163
34	761	882	836	618	220	270	170
35	750	915	830	661	229	281	180
36	755	952	825	680	248	298	189
37	758	924	814	675	272	322	201
38	757	948	781	666	285	351	211
39	753	923	750	651	284	371	218
40	761	884	733	645	288	384	227

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 107 (°F)	TC # 108 (°F)	TC # 109 (°F)	TC # 110 (°F)	TC # 111 (°F)	TC # 112 (°F)	TC # 113 (°F)
41	768	875	721	648	294	401	234
42	775	848	721	663	297	411	241
43	760	811	757	693	301	413	247
44	732	777	780	712	328	424	251
45	698	741	781	729	320	428	251
46	666	697	795	746	331	446	261
47	679	622	792	763	333	450	265
48	679	591	819	779	336	458	273
49	665	557	911	795	350	462	281
50	651	554	982	806	363	468	293
51	630	541	1028	840	363	460	297
52	619	570	1086	870	355	441	294
53	635	543	1141	908	341	438	296
54	680	555	1132	902	334	433	297
55	651	582	1066	870	335	431	308
56	610	585	976	832	336	430	314
57	547	563	899	789	338	434	315
58	527	564	850	798	332	442	305
59	491	565	824	794	324	451	297
60	470	556	806	808	315	463	292
61							
62							
63							
64							
65							
66							
67							
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69							
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71							
72							
73							
74							
MAX	775	952	1141	908	363	468	315

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 114 (°F)	TC # 115 (°F)	TC # 116 (°F)	TC # 117 (°F)	TC # 118 (°F)	TC # 119 (°F)	TC # 120 (°F)
0	63	63	63	63	63	63	64
1	63	63	63	63	63	63	64
2	63	63	63	63	63	63	64
3	63	63	63	64	64	64	64
4	63	64	63	65	65	64	65
5	64	66	64	66	67	64	65
6	64	69	64	69	70	64	66
7	65	72	64	73	75	64	67
8	66	76	64	77	80	64	68
9	67	79	64	83	87	64	69
10	68	84	65	89	94	65	70
11	69	89	66	95	102	65	72
12	71	94	67	103	111	66	75
13	72	100	70	110	118	71	79
14	74	105	74	118	126	74	84
15	76	111	79	126	133	75	94
16	78	116	83	136	142	78	105
17	80	109	88	144	150	82	109
18	83	105	94	152	158	87	112
19	85	109	100	159	166	93	120
20	88	114	106	165	176	99	130
21	91	117	113	171	187	108	144
22	93	120	123	179	205	112	172
23	92	124	139	190	223	121	192
24	97	128	146	202	230	129	217
25	101	132	155	217	244	136	234
26	104	135	164	234	258	145	257
27	108	139	173	253	271	156	273
28	112	142	176	279	286	166	286
29	11[illegible]	146	179	305	304	180	299
30	124	149	182	335	321	199	309
31	133	158	199	367	338	224	317
32	139	161	213	385	367	265	323
33	147	165	226	405	38[illegible]	314	329
34	153	169	233	411	404	349	352
35	159	173	248	418	445	380	392
36	166	177	267	472	461	387	467
37	177	180	313	499	488	394	477
38	191	184	344	547	557	434	540
39	197	188	343	557	569	436	556
40	168	191	350	569	585	453	565

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 114 (°F)	TC # 115 (°F)	TC # 116 (°F)	TC # 117 (°F)	TC # 118 (°F)	TC # 119 (°F)	TC # 120 (°F)
41	154	194	358	581	601	465	583
42	159	197	379	587	602	483	606
43	236	199	389	592	616	511	622
44	160	201	407	604	616	532	645
45	249	203	404	609	622	534	642
46	172	205	416	632	668	571	663
47	177	206	426	645	672	586	672
48	183	208	441	654	681	594	718
49	186	209	451	650	696	618	712
50	190	210	453	649	713	644	722
51	193	211	448	620	691	640	698
52	195	211	419	584	654	608	672
53	197	212	397	551	624	574	654
54	199	213	386	530	603	556	639
55	203	214	368	519	610	573	654
56	205	217	378	511	617	571	640
57	207	225	376	516	638	568	626
58	210	239	371	526	619	553	587
59	211	253	366	504	606	534	549
60	213	262	364	488	594	511	521
61							
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63							
64							
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67							
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69							
70							
71							
72							
73							
74							
MAX	249	262	453	654	713	644	722

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 121 (°F)	TC # 123 (°F)	TC # 124 (°F)	TC # 125 (°F)	TC # 126 (°F)	TC # 127 (°F)	TC # 128 (°F)
0	63	63	63	63	63	63	64
1	64	63	63	63	63	63	64
2	64	63	63	63	63	63	64
3	64	63	63	63	63	63	64
4	64	63	63	63	63	63	64
5	64	63	63	63	63	63	64
6	65	63	63	63	63	63	64
7	65	63	63	63	63	63	64
8	66	63	63	63	63	64	64
9	67	63	64	63	63	64	64
10	69	63	64	63	63	64	64
11	71	63	64	63	63	65	64
12	73	63	65	63	63	66	64
13	76	63	66	64	63	66	64
14	79	64	66	64	64	67	64
15	83	64	67	64	64	68	64
16	89	64	68	65	64	69	64
17	95	64	69	65	64	70	64
18	100	65	70	66	65	71	64
19	106	65	71	67	65	72	64
20	112	66	73	68	65	73	64
21	121	66	74	68	66	75	65
22	130	67	76	69	66	76	65
23	139	67	78	70	67	78	65
24	149	68	79	71	68	79	65
25	162	69	81	73	68	81	66
26	179	69	83	74	69	82	66
27	199	70	84	75	70	84	67
28	219	71	86	77	71	85	67
29	229	72	87	78	72	87	67
30	238	73	89	80	73	89	68
31	211	74	91	81	75	91	69
32	137	75	92	83	76	93	69
33	142	76	93	85	78	94	70
34	149	78	94	87	79	96	70
35	224	79	96	89	81	98	71
36	366	80	98	91	82	100	72
37	387	82	100	94	84	103	73
38	538	84	102	96	86	105	74
39	613	85	104	99	88	107	74
40	604	87	106	101	90	109	75

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 121 (°F)	TC # 123 (°F)	TC # 124 (°F)	TC # 125 (°F)	TC # 126 (°F)	TC # 127 (°F)	TC # 128 (°F)
41	647	89	108	103	92	112	76
42	669	90	110	106	94	114	77
43	649	92	112	108	96	116	78
44	667	94	115	111	99	119	79
45	628	96	117	113	101	121	80
46	668	98	120	115	103	123	81
47	650	100	122	117	106	125	82
48	669	102	125	119	108	128	84
49	690	104	128	121	111	130	85
50	700	106	131	123	113	133	86
51	661	108	134	125	116	135	88
52	603	110	137	128	118	137	89
53	572	113	140	130	120	139	91
54	554	115	144	132	123	141	92
55	573	117	147	135	125	144	94
56	581	120	151	137	128	146	96
57	595	123	155	140	130	148	98
58	582	125	159	142	132	151	101
59	578	128	163	144	135	153	103
60	576	131	167	147	137	156	106
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	700	131	167	147	137	156	106

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 129 (°F)	TC # 130 (°F)	TC # 131 (°F)	TC # 132 (°F)	TC # 133 (°F)	TC # 134 (°F)	TC # 135 (°F)
0	63	63	63	63	63	64	63
1	63	63	63	63	63	64	63
2	63	63	63	63	63	64	63
3	63	63	63	63	63	64	63
4	63	63	63	63	63	64	63
5	63	63	63	63	63	64	63
6	63	63	63	63	63	64	63
7	63	63	63	63	63	64	63
8	63	64	64	63	63	64	63
9	63	64	64	63	63	64	63
10	63	65	65	63	63	64	63
11	63	66	66	64	63	64	63
12	63	67	68	64	64	65	63
13	63	68	70	64	64	65	63
14	63	70	71	65	64	66	63
15	63	71	73	66	65	67	63
16	63	73	76	66	65	68	64
17	63	75	78	67	65	69	64
18	63	77	80	68	66	70	64
19	64	79	82	69	67	72	64
20	64	81	84	70	67	73	65
21	64	83	87	71	68	75	65
22	65	85	89	72	69	77	65
23	65	87	91	73	70	78	66
24	66	89	94	74	71	80	66
25	66	91	96	76	73	83	67
26	67	93	98	77	74	85	67
27	67	95	101	79	75	87	68
28	68	98	103	80	77	90	69
29	69	100	106	82	78	92	69
30	70	102	108	84	80	95	70
31	71	104	110	85	82	97	71
32	72	107	112	87	84	100	72
33	73	109	115	89	86	103	73
34	74	112	117	91	88	105	74
35	75	114	119	93	90	108	75
36	76	117	122	96	92	111	76
37	78	119	124	98	95	114	77
38	80	122	127	100	97	117	78
39	81	124	130	102	100	119	80
40	83	127	132	105	102	122	81

OMEGA POINT LABORATORIES

Time (min)	TC # 129 (°F)	TC # 130 (°F)	TC # 131 (°F)	TC # 132 (°F)	TC # 133 (°F)	TC # 134 (°F)	TC # 135 (°F)
41	85	129	135	107	105	125	83
42	88	132	138	110	107	127	84
43	90	134	141	112	110	130	85
44	92	137	144	115	113	132	87
45	95	140	147	118	115	135	88
46	98	142	150	121	118	137	90
47	100	145	153	123	121	140	92
48	103	148	157	126	124	143	93
49	106	151	160	129	127	145	95
50	109	155	164	132	129	148	97
51	113	158	168	135	132	151	99
52	117	161	172	138	135	154	101
53	120	165	176	141	138	157	103
54	125	168	180	145	141	160	105
55	130	173	184	148	144	164	107
56	134	177	188	151	147	167	109
57	136	180	193	155	150	171	111
58	140	185	198	158	153	176	114
59	143	189	202	162	156	181	116
60	146	193	206	165	160	186	119
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	146	193	206	165	160	186	119

OMEGA POINT LABORATORIES

Time (min)	TC # 136 (°F)	TC # 137 (°F)	TC # 138 (°F)	TC # 139 (°F)	TC # 140 (°F)	TC # 141 (°F)	TC # 142 (°F)
0	63	63	63	63	64	63	63
1	63	63	63	63	64	63	63
2	63	63	63	63	64	63	63
3	63	63	63	63	64	63	63
4	63	63	63	63	64	63	63
5	63	63	63	63	64	63	63
6	63	63	63	63	64	63	63
7	63	63	63	63	64	63	63
8	63	63	63	63	64	63	63
9	63	63	63	63	64	63	63
10	63	63	63	63	64	63	63
11	63	63	63	63	64	63	63
12	63	63	63	63	64	63	63
13	63	63	63	63	64	63	63
14	63	63	63	63	64	63	63
15	63	63	63	63	64	63	64
16	64	63	63	64	64	63	64
17	64	63	63	64	64	63	64
18	64	64	63	64	64	63	65
19	64	64	63	64	64	63	66
20	65	64	63	64	64	63	66
21	65	64	64	64	64	63	67
22	66	65	64	65	64	64	68
23	67	65	64	65	65	64	69
24	67	66	64	65	65	64	70
25	68	67	64	66	65	64	71
26	69	67	65	66	65	65	72
27	70	68	65	67	65	65	74
28	71	69	65	67	66	65	75
29	72	70	66	68	66	66	77
30	73	71	66	68	66	66	78
31	74	72	67	69	67	67	80
32	75	73	68	70	67	68	81
33	76	75	68	70	67	68	83
34	78	76	69	71	68	69	85
35	79	78	70	72	68	70	87
36	80	79	71	73	69	71	89
37	82	81	72	74	69	72	91
38	83	83	73	75	70	73	93
39	85	84	74	76	70	74	95
40	87	86	75	77	71	75	97

OMEGA POINT LABORATORIES

Time (min)	TC # 136 (°F)	TC # 137 (°F)	TC # 138 (°F)	TC # 139 (°F)	TC # 140 (°F)	TC # 141 (°F)	TC # 142 (°F)
41	88	88	76	78	72	77	99
42	90	90	78	79	72	78	101
43	92	92	79	80	73	80	103
44	93	94	80	82	74	82	106
45	95	96	82	83	74	83	108
46	97	98	84	84	75	85	110
47	99	100	85	86	76	87	112
48	101	102	87	87	77	89	114
49	103	104	89	88	78	91	117
50	105	106	91	90	79	94	119
51	107	108	92	92	80	96	121
52	109	110	94	93	81	99	124
53	111	112	96	95	82	102	126
54	114	114	98	96	83	105	129
55	116	116	100	98	85	108	132
56	118	118	103	100	86	111	134
57	121	120	105	101	87	115	137
58	123	122	107	103	89	118	140
59	126	124	109	105	90	122	143
60	129	127	111	107	92	125	147
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	129	127	111	107	92	125	147

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 143 (°F)	TC # 144 (°F)	TC # 145 (°F)	TC # 146 (°F)	TC # 147 (°F)	TC # 148 (°F)	TC # 149 (°F)
0	63	63	63	63	63	63	63
1	63	63	63	63	63	63	63
2	63	63	63	63	63	63	63
3	63	63	63	63	63	63	63
4	63	63	63	63	63	63	63
5	63	63	63	63	63	63	63
6	63	63	63	63	63	63	63
7	63	63	63	63	63	63	63
8	63	63	63	63	63	64	63
9	63	63	63	63	63	65	63
10	63	63	63	63	64	66	63
11	63	63	63	64	64	68	63
12	63	63	63	64	65	69	64
13	64	63	63	64	66	71	64
14	64	63	63	64	67	73	64
15	65	64	63	64	68	75	65
16	66	64	63	64	69	78	65
17	67	64	64	64	70	80	66
18	68	65	64	65	71	83	66
19	69	66	64	65	73	86	67
20	70	66	64	66	74	89	68
21	71	67	65	66	76	92	69
22	73	68	65	67	78	94	70
23	75	69	65	68	79	97	71
24	76	70	66	68	81	100	72
25	78	71	66	69	83	103	73
26	80	72	67	70	85	107	75
27	82	73	68	71	87	110	76
28	84	75	68	72	89	113	78
29	86	76	69	74	91	116	80
30	88	77	70	75	93	119	81
31	90	79	71	76	95	122	83
32	93	81	72	78	97	125	85
33	95	82	73	80	99	128	88
34	97	84	74	81	101	130	90
35	100	86	76	83	104	133	92
36	102	88	77	85	107	135	95
37	104	90	79	87	109	138	97
38	107	92	80	89	112	141	100
39	109	94	82	91	114	144	103
40	112	96	84	93	117	148	105

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 143 (°F)	TC # 144 (°F)	TC # 145 (°F)	TC # 146 (°F)	TC # 147 (°F)	TC # 148 (°F)	TC # 149 (°F)
41	114	98	86	95	119	151	108
42	117	100	88	97	122	154	110
43	119	102	89	99	125	158	113
44	121	104	91	101	127	161	115
45	124	107	94	103	130	165	117
46	127	109	96	105	133	169	120
47	129	111	98	107	136	173	122
48	132	114	100	109	139	177	124
49	134	116	102	111	142	181	127
50	137	119	105	114	145	185	129
51	140	121	107	116	148	189	131
52	143	124	109	118	150	193	134
53	146	126	111	120	153	198	136
54	149	129	114	123	156	202	138
55	152	132	116	125	158	207	141
56	155	135	119	128	161	211	143
57	158	138	121	130	163	216	145
58	162	140	123	133	166	221	148
59	165	143	126	135	168	226	150
60	169	146	129	138	171	232	152
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	169	146	129	138	171	232	152

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 150 (°F)	TC # 151 (°F)	TC # 152 (°F)	TC # 154 (°F)	TC # 155 (°F)	TC # 156 (°F)	TC # 157 (°F)
0	63	63	64	63	63	63	63
1	63	63	64	63	63	63	63
2	63	63	64	63	63	63	63
3	63	63	64	63	63	63	63
4	63	63	64	63	63	63	63
5	63	63	64	63	63	63	63
6	63	63	64	63	63	63	63
7	63	63	64	63	63	63	63
8	63	63	64	64	64	63	63
9	63	63	64	64	65	63	63
10	63	64	64	65	66	63	63
11	63	64	64	65	67	63	63
12	63	64	64	66	69	64	64
13	64	64	64	67	70	64	64
14	64	65	64	69	72	65	64
15	64	65	64	70	74	66	64
16	64	66	64	71	77	66	64
17	65	66	64	73	79	67	65
18	65	67	64	75	81	68	65
19	66	68	65	76	84	69	66
20	66	69	65	78	86	71	66
21	67	70	65	80	89	72	67
22	68	71	66	82	92	73	68
23	69	72	66	84	95	75	69
24	70	73	66	86	97	76	70
25	70	74	67	88	100	78	71
26	72	75	68	91	103	80	72
27	73	77	68	93	106	82	74
28	74	78	69	95	109	84	75
29	75	80	69	97	112	86	76
30	77	81	70	100	115	88	78
31	78	82	71	102	117	90	80
32	80	84	71	105	120	92	82
33	82	86	72	107	123	94	83
34	84	87	73	110	126	97	85
35	86	89	74	113	129	99	87
36	88	91	75	115	132	101	90
37	90	93	76	118	134	104	92
38	92	95	77	121	137	106	94
39	94	97	78	124	140	109	97
40	97	99	79	126	143	111	99

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 150 (°F)	TC # 151 (°F)	TC # 152 (°F)	TC # 154 (°F)	TC # 155 (°F)	TC # 156 (°F)	TC # 157 (°F)
41	99	101	80	129	147	114	102
42	102	103	81	132	150	117	104
43	104	105	83	134	153	120	107
44	107	107	84	137	156	122	109
45	110	109	85	140	160	125	112
46	113	111	86	143	163	128	115
47	115	113	88	146	167	131	117
48	118	116	89	149	170	134	120
49	121	118	91	152	174	137	122
50	124	120	92	155	178	140	125
51	127	122	94	158	181	143	128
52	130	124	96	161	185	146	130
53	133	126	98	165	189	149	133
54	135	129	100	168	193	153	135
55	138	131	102	172	198	156	138
56	141	133	104	175	202	160	141
57	143	135	106	179	207	164	143
58	146	137	108	183	211	169	146
59	148	139	111	187	215	172	149
60	151	141	113	191	219	173	151
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	151	141	113	191	219	173	151

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 158 (°F)	TC # 159 (°F)	TC # 160 (°F)	TC # 161 (°F)	TC # 162 (°F)	TC # 163 (°F)	TC # 164 (°F)
0	64	63	63	63	63	63	64
1	64	63	63	63	63	63	64
2	64	63	63	63	63	63	64
3	64	63	63	63	63	63	64
4	63	63	63	63	63	63	64
5	64	63	63	63	63	63	64
6	64	63	63	63	63	63	64
7	64	63	63	63	63	63	64
8	64	63	63	63	63	63	64
9	64	63	63	63	63	63	64
10	64	63	63	63	63	63	64
11	64	63	64	63	63	63	64
12	64	63	64	63	63	63	64
13	65	64	64	63	63	63	64
14	65	64	64	63	63	63	64
15	66	64	64	63	63	63	64
16	66	65	65	63	64	64	64
17	67	65	65	64	64	64	64
18	68	66	66	64	64	64	64
19	69	66	66	64	64	64	64
20	70	67	67	64	65	65	64
21	71	68	68	65	65	65	64
22	72	68	69	65	66	65	64
23	74	69	70	66	66	66	65
24	75	70	71	66	67	66	65
25	77	71	72	67	67	67	65
26	79	72	73	68	68	67	65
27	81	73	74	68	69	68	66
28	83	75	76	69	70	69	66
29	85	76	77	70	70	69	66
30	87	77	79	71	71	70	67
31	89	79	80	72	72	71	67
32	92	80	82	73	74	72	68
33	94	82	84	75	75	73	68
34	97	83	85	76	76	74	69
35	99	85	87	77	77	75	69
36	102	87	89	79	79	76	70
37	104	89	91	80	81	77	71
38	107	91	93	82	82	78	72
39	109	93	95	83	84	80	72
40	112	95	97	85	86	81	73

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 158 (°F)	TC # 159 (°F)	TC # 160 (°F)	TC # 161 (°F)	TC # 162 (°F)	TC # 163 (°F)	TC # 164 (°F)
41	114	97	99	87	88	83	74
42	117	99	101	89	90	84	75
43	119	101	103	91	92	85	76
44	122	103	106	92	94	87	77
45	124	104	108	94	96	89	78
46	126	106	110	96	98	90	79
47	129	108	112	98	101	92	80
48	131	111	115	100	103	93	81
49	133	113	117	103	105	95	83
50	136	116	120	105	108	97	84
51	139	119	123	107	110	98	85
52	141	122	125	110	112	100	86
53	144	125	129	113	115	102	87
54	146	129	132	115	117	104	88
55	149	134	135	119	120	106	89
56	152	138	139	122	122	108	90
57	155	142	142	125	125	110	92
58	158	146	145	129	127	112	93
59	161	149	148	132	130	114	94
60	165	153	152	135	132	116	96
61							
62							
63							
64							
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67							
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69							
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71							
72							
73							
74							
MAX	165	153	152	135	132	116	96

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 165 (°F)	TC # 166 (°F)	TC # 167 (°F)	TC # 168 (°F)	TC # 169 (°F)	TC # 170 (°F)	TC # 171 (°F)
0	63	63	63	63	63	64	63
1	63	63	63	63	63	64	63
2	63	63	63	63	63	64	63
3	63	63	63	63	63	64	63
4	63	63	63	63	63	64	63
5	63	63	63	63	63	64	63
6	63	63	63	63	63	64	63
7	63	63	63	63	63	64	63
8	63	63	63	63	64	64	63
9	63	63	63	63	64	64	63
10	63	63	63	63	64	64	63
11	63	63	63	63	65	64	63
12	63	63	63	63	65	64	64
13	63	64	63	63	66	64	64
14	63	64	64	63	67	64	64
15	63	64	64	63	68	64	65
16	63	65	64	63	68	64	65
17	63	65	65	64	70	64	66
18	63	66	65	64	71	65	67
19	63	67	66	64	72	65	67
20	63	67	66	64	74	65	68
21	64	68	67	65	75	66	69
22	64	69	68	65	77	66	70
23	64	70	69	66	78	67	71
24	64	71	70	66	80	67	72
25	65	72	71	67	82	68	73
26	65	74	72	67	84	69	75
27	65	75	74	68	86	69	76
28	66	76	75	69	88	70	77
29	66	78	76	69	91	71	79
30	67	80	78	70	93	72	80
31	67	81	80	71	95	73	82
32	68	83	81	72	98	74	84
33	69	85	83	73	100	75	86
34	70	87	85	74	103	77	88
35	71	89	87	76	106	78	90
36	72	91	89	77	108	79	92
37	73	93	91	78	111	81	94
38	74	95	93	80	114	82	96
39	76	98	95	81	117	84	99
40	77	100	97	83	120	85	101

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 165 (°F)	TC # 166 (°F)	TC # 167 (°F)	TC # 168 (°F)	TC # 169 (°F)	TC # 170 (°F)	TC # 171 (°F)
41	79	102	99	84	123	87	103
42	81	105	101	86	126	89	105
43	83	107	103	88	128	90	108
44	85	110	106	90	131	92	110
45	87	113	108	92	134	94	112
46	89	115	110	94	137	96	114
47	92	118	113	96	140	97	117
48	94	120	115	98	143	99	119
49	98	123	118	100	146	101	122
50	101	126	121	102	148	103	124
51	105	129	123	104	151	105	127
52	109	132	127	106	154	107	130
53	113	135	130	109	157	111	133
54	116	139	134	111	160	114	136
55	120	142	141	114	163	118	139
56	124	146	145	118	168	123	143
57	128	150	148	122	171	127	146
58	132	155	152	124	172	130	150
59	136	160	155	124	173	132	153
60	139	164	158	125	174	135	156
61							
62							
63							
64							
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66							
67							
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69							
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71							
72							
73							
74							
MAX	139	164	158	125	174	135	156

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 172 (°F)	TC # 173 (°F)	TC # 174 (°F)	TC # 175 (°F)	TC # 176 (°F)	TC # 177 (°F)	TC # 178 (°F)
0	63	63	63	63	64	63	63
1	63	63	63	63	64	63	63
2	63	63	63	63	64	63	63
3	63	63	63	63	64	63	63
4	63	63	63	63	64	63	63
5	63	63	63	63	64	63	63
6	63	63	63	63	64	63	63
7	63	63	63	63	64	63	63
8	63	63	63	63	64	63	63
9	64	63	64	63	64	63	63
10	64	63	64	64	64	63	63
11	64	63	64	64	64	64	63
12	65	63	64	64	64	64	63
13	66	64	65	64	64	64	63
14	67	64	65	64	64	65	63
15	68	64	66	64	64	65	63
16	69	65	67	64	64	66	64
17	71	65	67	65	64	67	64
18	72	66	68	65	65	68	64
19	74	66	69	66	65	69	65
20	76	67	70	66	65	70	65
21	78	68	71	67	65	71	65
22	80	69	72	67	66	72	66
23	82	70	74	68	66	74	67
24	84	71	75	69	66	75	67
25	86	72	76	69	67	77	68
26	89	73	78	70	67	79	69
27	91	75	80	71	68	81	70
28	94	76	82	72	68	83	71
29	96	78	84	73	69	85	72
30	99	80	86	74	69	87	73
31	101	81	88	75	70	89	74
32	104	83	91	76	71	92	76
33	107	85	94	77	72	94	77
34	109	87	97	79	72	96	79
35	112	90	99	80	73	99	80
36	114	92	102	82	74	101	82
37	117	94	104	83	75	104	84
38	120	96	107	85	76	107	87
39	122	99	110	86	77	110	89
40	125	101	113	88	78	112	92

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 172 (°F)	TC # 173 (°F)	TC # 174 (°F)	TC # 175 (°F)	TC # 176 (°F)	TC # 177 (°F)	TC # 178 (°F)
41	128	104	116	90	79	115	94
42	131	106	119	92	81	118	97
43	134	108	122	93	82	121	100
44	137	111	125	95	83	124	102
45	140	113	128	97	85	127	105
46	143	116	131	99	86	130	108
47	146	118	135	101	88	133	110
48	149	121	138	103	89	136	113
49	152	123	141	105	90	139	116
50	156	126	144	107	92	142	119
51	159	129	147	109	93	145	122
52	163	132	149	111	95	149	126
53	166	135	152	113	96	152	129
54	170	138	154	115	97	156	132
55	173	141	155	117	99	160	136
56	177	144	156	120	100	164	139
57	181	148	159	122	102	168	143
58	185	151	161	124	104	172	146
59	189	154	163	126	105	176	149
60	193	158	166	129	107	180	152
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	193	158	166	129	107	180	152

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 179 (°F)	TC # 180 (°F)	TC # 181 (°F)	TC # 182 (°F)	TC # 183 (°F)	TC # 184 (°F)	TC # 185 (°F)
0	63	63	63	64	63	63	63
1	63	63	64	64	63	63	63
2	63	63	63	64	63	63	63
3	63	63	63	64	63	63	63
4	63	63	63	64	63	63	63
5	63	63	63	64	63	63	63
6	63	63	63	64	63	63	63
7	63	63	63	64	63	63	63
8	63	63	63	64	63	63	63
9	63	63	63	64	63	63	63
10	64	63	64	64	63	64	63
11	64	64	64	64	64	64	63
12	64	64	64	64	64	65	63
13	65	64	64	65	64	65	64
14	65	64	64	65	65	66	64
15	66	64	64	66	66	67	64
16	67	64	64	66	66	68	65
17	68	65	65	67	67	69	65
18	69	65	65	67	69	70	66
19	70	66	65	68	70	72	67
20	71	66	66	69	71	74	68
21	73	67	66	70	72	75	69
22	74	68	67	71	74	77	70
23	76	68	68	72	75	79	71
24	78	69	68	73	77	81	72
25	80	70	69	74	79	84	74
26	82	71	70	76	80	86	75
27	84	72	71	77	82	88	77
28	86	73	72	79	84	91	79
29	88	74	73	80	86	93	81
30	90	75	75	82	88	96	83
31	93	77	76	84	90	99	85
32	95	78	77	85	93	101	87
33	98	80	79	87	95	104	89
34	100	81	80	89	98	107	92
35	103	83	82	91	100	109	94
36	105	85	84	93	103	112	97
37	108	87	86	95	106	115	99
38	110	89	88	97	108	118	102
39	113	91	90	99	111	120	105
40	115	93	92	101	113	123	107

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 179 (°F)	TC # 180 (°F)	TC # 181 (°F)	TC # 182 (°F)	TC # 183 (°F)	TC # 184 (°F)	TC # 185 (°F)
41	118	95	94	103	116	126	110
42	121	97	96	105	118	129	113
43	123	99	98	107	120	132	115
44	126	102	100	109	122	135	118
45	129	104	102	111	125	138	120
46	132	106	105	113	127	141	123
47	135	109	107	116	129	144	126
48	138	111	109	118	132	147	128
49	141	113	111	120	134	150	131
50	144	116	114	122	137	153	134
51	148	118	116	125	139	157	136
52	151	121	119	127	142	160	139
53	155	124	121	130	145	164	142
54	158	127	124	132	148	167	145
55	162	130	126	135	151	171	148
56	166	133	129	138	155	174	151
57	171	136	132	141	158	178	154
58	175	139	136	144	161	182	157
59	180	142	139	148	163	186	160
60	185	146	142	151	166	190	163
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	185	146	142	151	166	190	163

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 186 (°F)	TC # 187 (°F)	TC # 188 (°F)	TC # 189 (°F)	TC # 190 (°F)	TC # 191 (°F)	TC # 192 (°F)
0	63	63	64	63	63	63	63
1	63	63	64	63	63	63	63
2	63	63	64	63	63	63	63
3	63	63	64	63	63	63	63
4	63	63	64	63	63	63	63
5	63	63	64	63	63	63	63
6	63	63	64	63	63	63	63
7	63	63	64	63	63	63	63
8	63	63	64	63	64	63	63
9	63	63	64	63	64	63	63
10	63	64	64	63	65	64	63
11	63	64	64	63	65	64	63
12	63	64	64	63	66	64	64
13	63	64	64	63	67	65	64
14	63	64	64	63	68	65	64
15	63	64	64	63	69	66	64
16	64	65	64	64	70	67	64
17	64	65	64	64	72	68	65
18	64	66	64	64	74	69	65
19	64	66	65	65	75	70	66
20	64	66	65	65	77	71	66
21	65	67	65	65	79	72	67
22	65	68	65	66	81	74	68
23	65	68	66	67	84	76	69
24	66	69	66	67	86	77	70
25	66	70	67	68	89	79	71
26	67	71	67	69	91	81	72
27	68	72	68	70	94	83	73
28	68	73	68	71	97	85	74
29	69	74	69	72	100	88	75
30	70	75	70	73	102	90	77
31	71	76	70	75	105	92	78
32	72	78	71	76	108	95	79
33	74	79	72	78	112	97	81
34	75	81	73	79	115	100	83
35	76	82	74	81	118	102	85
36	78	84	75	83	122	105	87
37	79	85	76	85	125	108	89
38	81	87	77	87	128	110	91
39	83	89	78	90	132	113	93
40	85	90	79	92	135	115	95

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 186 (°F)	TC # 187 (°F)	TC # 188 (°F)	TC # 189 (°F)	TC # 190 (°F)	TC # 191 (°F)	TC # 192 (°F)
41	87	92	80	95	139	118	98
42	89	94	82	98	142	121	100
43	91	96	83	101	146	123	102
44	94	98	84	104	149	126	105
45	96	100	86	107	153	129	108
46	98	102	87	109	156	132	110
47	100	104	89	112	160	135	113
48	103	106	90	115	164	138	115
49	105	108	92	119	168	141	118
50	108	111	93	123	172	144	120
51	110	113	93	127	176	148	123
52	113	115	94	131	180	151	125
53	115	117	95	134	185	155	127
54	118	119	96	138	189	158	130
55	121	121	97	140	194	162	133
56	124	124	98	144	198	166	135
57	127	126	100	147	203	170	138
58	129	128	101	150	208	174	141
59	132	130	103	153	212	178	144
60	135	133	105	155	217	182	147
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
MAX	135	133	105	155	217	182	147

OMEGA POINT LABORATORIES

Time (min)	TC # 193 (°F)	TC # 194 (°F)	Ambient (°F)	Furnace #1 (°F)	Furnace #2 (°F)	Furnace #3 (°F)
0	64	64	65	62	61	61
1	64	64	64	160	124	165
2	64	64	64	642	396	596
3	64	64	65	871	604	846
4	64	64	64	867	629	813
5	64	64	64	811	612	765
6	64	64	65	850	660	869
7	64	64	64	1179	905	1190
8	64	64	64	1328	1102	1310
9	64	64	64	1274	1062	1237
10	64	64	64	1197	1025	1183
11	65	64	64	1325	1151	1362
12	65	65	64	1409	1236	1410
13	65	65	64	1379	1206	1349
14	66	65	65	1365	1215	1341
15	66	66	64	1473	1315	1481
16	67	66	65	1565	1393	1540
17	68	67	64	1498	1353	1461
18	69	67	64	1430	1292	1393
19	70	68	65	1419	1300	1384
20	71	69	64	1513	1374	1505
21	72	70	65	1567	1433	1540
22	73	71	64	1530	1403	1484
23	74	72	65	1479	1356	1428
24	76	74	65	1487	1372	1451
25	77	75	64	1615	1483	1622
26	79	76	65	1569	1437	1534
27	81	78	65	1513	1398	1476
28	82	80	65	1548	1438	1528
29	84	81	65	1614	1506	1604
30	86	83	64	1609	1508	1578
31	88	85	64	1574	1482	1535
32	90	87	64	1560	1477	1523
33	93	89	65	1574	1494	1545
34	95	91	64	1589	1512	1563
35	97	93	64	1604	1525	1576
36	100	95	65	1615	1536	1586
37	102	98	65	1620	1540	1586
38	105	100	65	1624	1541	1587
39	108	102	65	1626	1547	1592
40	110	104	65	1630	1552	1596

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	TC # 193 (°F)	TC # 194 (°F)	Ambient (°F)	Furnace #1 (°F)	Furnace #2 (°F)	Furnace #3 (°F)
41	113	107	64	1632	1555	1600
42	116	109	64	1637	1562	1607
43	119	111	64	1644	1571	1616
44	122	114	65	1653	1578	1624
45	125	116	64	1658	1585	1629
46	127	118	65	1663	1590	1635
47	130	121	65	1666	1595	1639
48	133	123	65	1670	1598	1644
49	136	125	65	1677	1605	1651
50	139	128	65	1684	1613	1659
51	.42	130	65	1690	1620	1666
52	145	133	65	1697	1626	1673
53	148	135	65	1699	1627	1672
54	151	138	65	1699	1629	1672
55	154	141	65	1702	1636	1679
56	157	144	62	1712	1646	1690
57	161	147	62	1714	1649	1693
58	165	151	61	1709	1643	1685
59	168	154	61	1707	1644	1686
60	173	158	61	1712	1649	1692
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						
71						
72						
73						
74						
MAX	173	158				

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Furnace #4 (°F)	Furnace #5 (°F)	Furnace #6 (°F)	Furnace #7 (°F)	Furnace #8 (°F)	Furnace #9 (°F)
0	61	62	61	61	61	60
1	121	138	152	140	112	272
2	441	593	592	508	346	880
3	686	865	792	751	579	912
4	748	861	793	746	650	836
5	739	813	747	708	653	771
6	810	840	831	756	695	918
7	1118	1131	1164	1067	925	1279
8	1272	1308	1293	1244	1132	1289
9	1232	1287	1222	1181	1133	1169
10	1172	1218	1158	1121	1093	1122
11	1311	1327	1316	1275	1199	1346
12	1401	1407	1377	1340	1289	1349
13	1366	1403	1329	1295	1271	1275
14	1351	1401	1320	1314	1271	1296
15	1464	1497	1435	1405	1354	1445
16	1558	1580	1522	1488	1446	1501
17	1495	1514	1452	1424	1417	1399
18	1417	1463	1382	1365	1358	1318
19	1402	1462	1373	1376	1354	1346
20	1503	1549	1473	1468	1430	1497
21	1567	1608	1523	1523	1489	1506
22	1526	1554	1475	1482	1462	1430
23	1472	1497	1419	1434	1414	1369
24	1481	1521	1439	1461	1421	1423
25	1614	1643	1597	1574	1523	1584
26	1571	1585	1520	1513	1493	1469
27	1512	1533	1472	1473	1452	1419
28	1548	1583	1509	1519	1485	1512
29	1618	1659	1576	1587	1550	1596
30	1612	1649	1567	1579	1556	1535
31	1575	1615	1532	1545	1528	1486
32	1557	1605	1522	1542	1519	1487
33	1571	1625	1539	156[illegible]	1537	1519
34	1588	1643	1556	1579	1556	1540
35	1604	1654	1570	1594	1570	1558
36	1612	1666	1580	1604	1581	1566
37	1614	1662	1583	1604	1584	1558
38	1616	1658	1585	1604	1584	1557
39	1622	1664	1589	1609	1589	1563
40	1622	1666	1594	1613	1593	1567

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Furnace #4 (°F)	Furnace #5 (°F)	Furnace #6 (°F)	Furnace #7 (°F)	Furnace #8 (°F)	Furnace #9 (°F)
41	1625	1672	1597	1615	1596	1571
42	1628	1676	1603	1622	1601	1580
43	1636	1683	1611	1632	1610	1593
44	1643	1687	1619	1637	1617	1600
45	1648	1694	1626	1644	1622	1607
46	1654	1696	1630	1645	1627	1612
47	1659	1703	1633	1650	1632	1619
48	1662	1709	1638	1653	1636	1625
49	1667	1713	1647	1659	1641	1630
50	1676	1721	1654	1667	1649	1642
51	1684	1728	1661	1674	1656	1647
52	1688	1732	1668	1679	1661	1652
53	1689	1730	1668	1679	1663	1649
54	1687	1730	1668	1680	1663	1646
55	1691	1737	1673	1686	1669	1659
56	1700	1745	1685	1695	1678	1670
57	1707	1749	1689	1698	1683	1677
58	1698	1744	1682	1689	1678	1665
59	1698	1744	1683	1691	1678	1672
60	1704	1748	1687	1696	1682	1674
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						
71						
72						
73						
74						
MAX						

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Furnace #10 (°F)
0	61
1	159
2	596
3	741
4	707
[illegible]	667
6	733
[illegible]	1091
8	1196
9	1088
10	1049
11	1233
12	1274
13	1212
14	1235
15	1358
16	1437
17	1352
18	1280
19	1314
20	1427
21	1469
22	1409
23	1353
24	1392
25	1522
26	1439
27	1400
28	1466
29	1544
30	1521
31	1483
32	1482
33	1510
34	1530
35	1545
36	1555
37	1554
38	1556
39	1564
40	1569

OMEGA POINT LABORATORIES

Texas Utilities Electric Scheme #10-1 November 5, 1992

Time (min)	Furnace #10 (°F)
41	1571
42	1581
43	1591
44	1598
45	1603
46	1610
47	1612
48	1617
49	1626
50	1633
51	1640
52	1644
53	1644
54	1646
55	1656
56	1667
57	1670
58	1659
59	1662
60	1667
61	
62	
63	
64	
65	
66	
67	
68	
69	
70	
71	
72	
73	
74	
MAX	

OMEGA POINT LABORATORIES

Appendix H

QUALITY ASSURANCE

OMEGA POINT LABORATORIES

Quality Assurance Statement

Omega Point Laboratories, Inc. is an independent, wholly owned company incorporated in the state of Texas, devoted to engineering, inspection, quality assurance and testing of building materials, products and assemblies. The company has developed and implemented a Quality Assurance Program designed to provide its clients with a planned procedure of order and document processing for inspection and testing services it provides to assure conformity to requirements, codes, standards and specifications. The Program is designed to meet the intent of ANSI 45.2 Quality Assurance Program Requirements for Nuclear Power Plants, and complies with the requirements of the ASME Code, SPPE, Military Standards and other less stringent programs. It is the Laboratory's intention to adhere strictly to this Program, to assure that the services offered to its clients remains of the highest quality and accuracy possible.

The overall responsibility of the supervision, operation and coordination of this Quality Assurance Program is that of the Quality Assurance Manager, a person not involved with the performance of the inspection or testing services, and who is under the full time employ of the Laboratory. This individual is responsible for implementing and enforcing all procedures presented in the Quality Assurance Manual and the Procedures Manual. All personnel involved with activities which fall under the scope of this Program are required to cooperate with the letter and intent of this Program.

All QA Surveillance documents remain on file at the Laboratory, and are available for inspection by authorized personnel in the performance of an on-site QA Audit. All materials, services and supplies utilized herein were obtained with appropriate QA Certifications of Compliance, which may be found in the following pages.

OMEGA POINT LABORATORIES

Acceptability Documentation

OMEGA POINT LABORATORIES

ACCEPTABILITY DOCUMENTATION

SCHEME # 10-1: PROJECT NO. 94367 C

The following signatures attest to the review and acceptance of each attribute listed regarding the above-noted test article:

I. CABLE TRAY / CONDUIT ASSEMBLY

Omega Point Laboratories, Inc. — 9/17/92 Date

TU Electric (CPSES) — 9/17/92 Date

II. ELECTRICAL CABLE INSTALLATION

Omega Point Laboratories, Inc. — 9/24/92 Date

TU Electric (CPSES) — 9-24-92 Date

III. THERMOCOUPLE INSTALLATION

Omega Point Laboratories, Inc. — 9/18/92 Date

TU Electric (CPSES) — 9-18-92 Date

OMEGA POINT LABORATORIES

IV. FIRE PROTECTION BARRIER

Omega Point Laboratories, Inc. — Date: 9/28/92

TU Electric (CPSES) — Date: 9-28-92

V. FINAL PRE-BURN INSPECTION

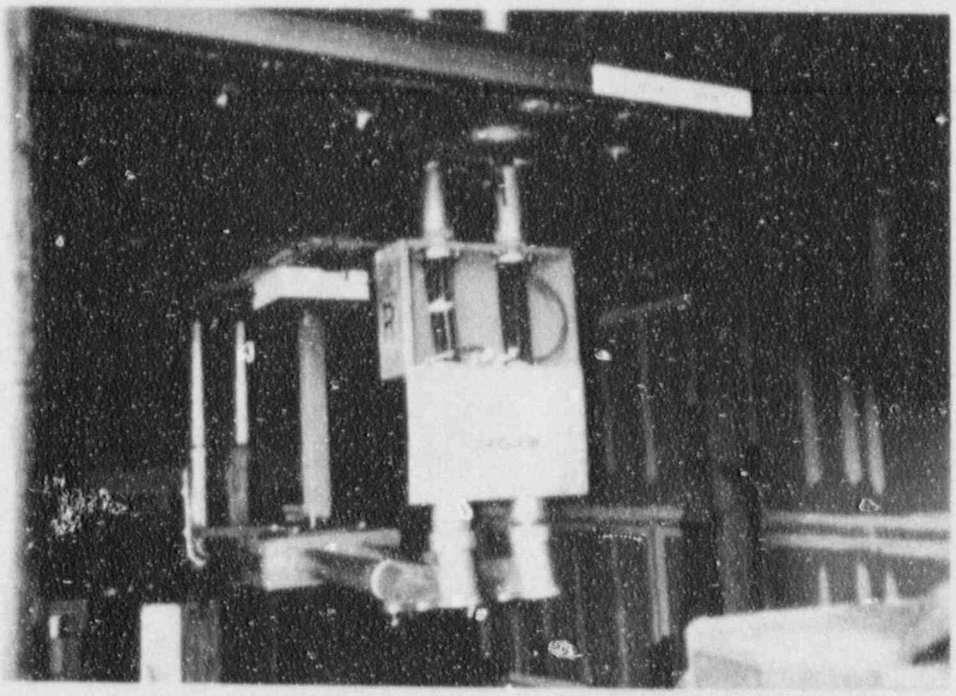
Omega Point Laboratories, Inc. — Date: 11/5/92

TU Electric (CPSES) — Date: 11-5-92

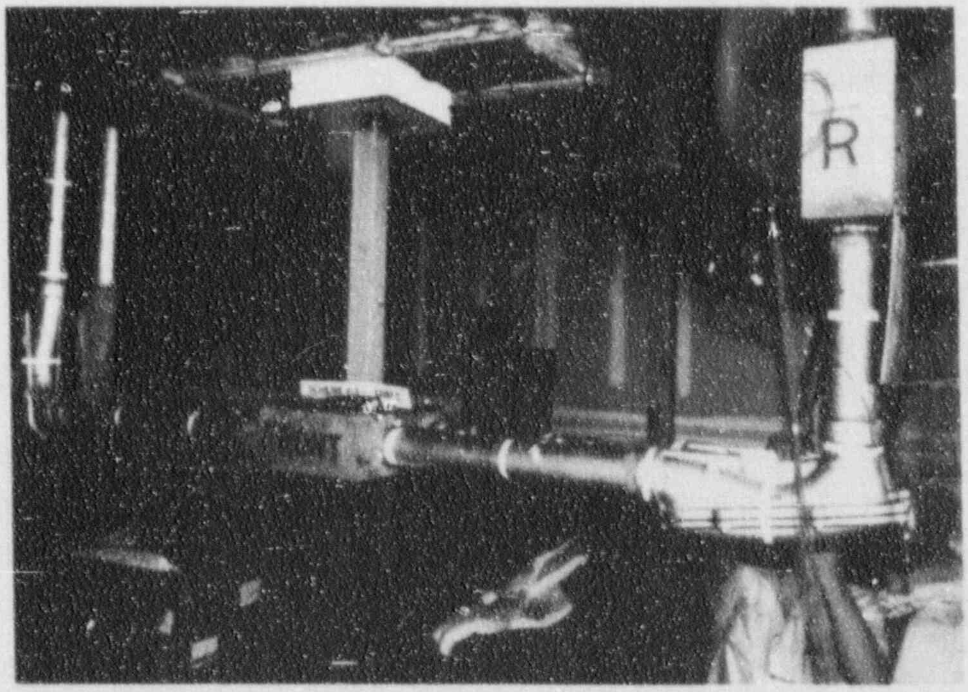
OMEGA POINT LABORATORIES

Appendix I

PHOTOGRAPHS

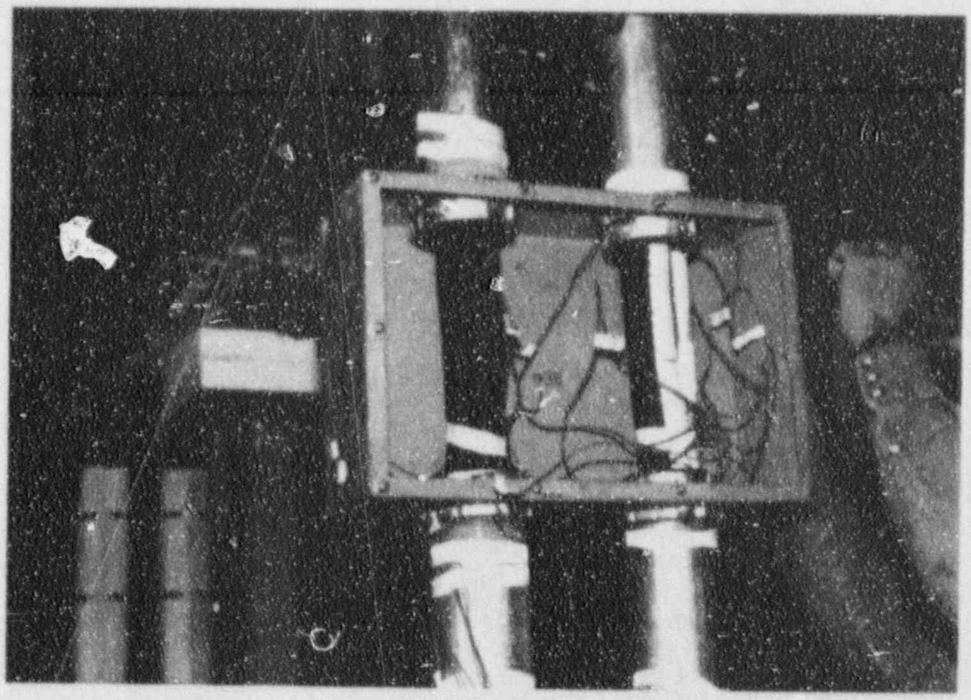


Conduit systems installed in test deck with cables in place.

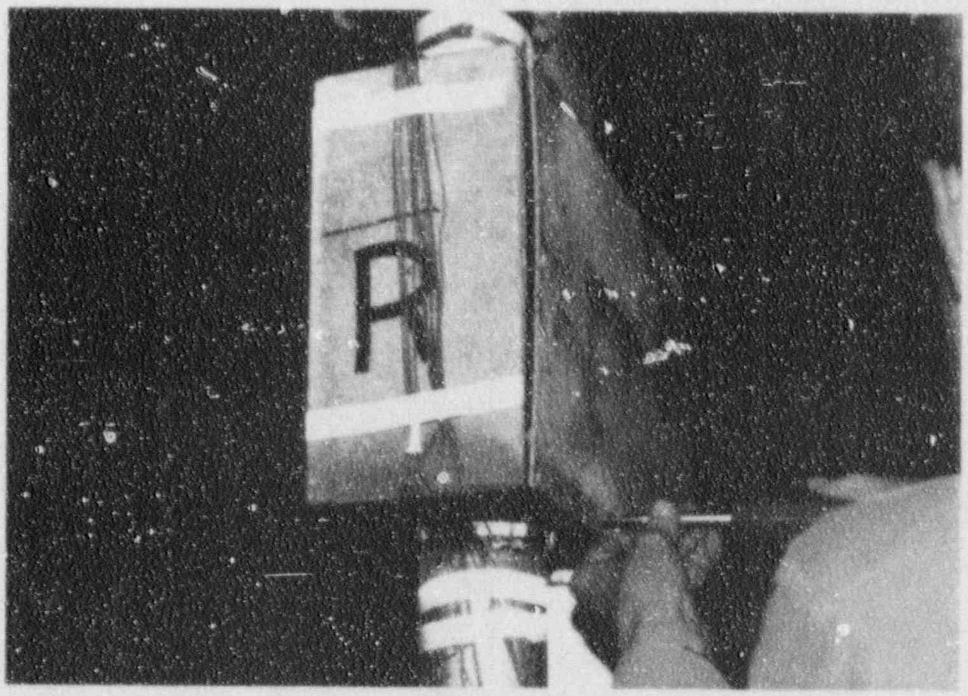


Condulet covers being secured.

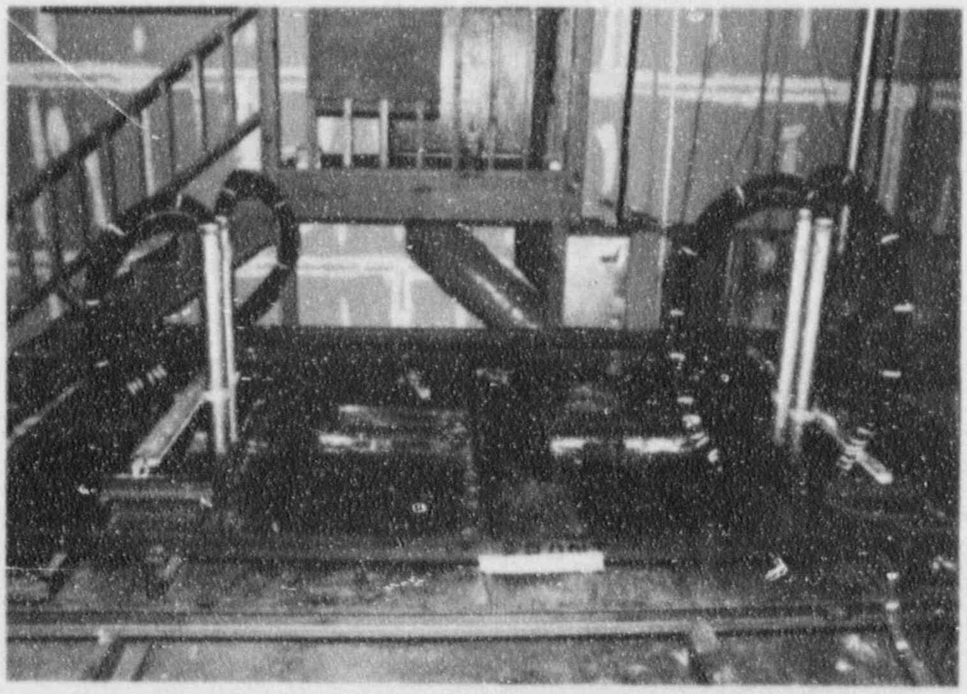
OMEGA POINT LABORATORIES



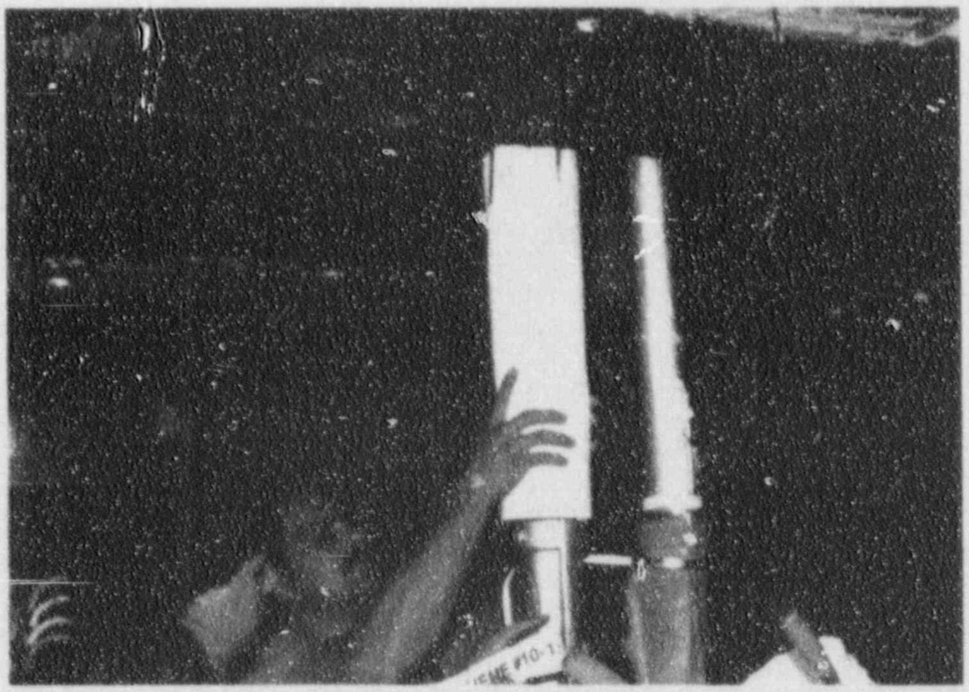
Thermocouples on inside surfaces of junction box.



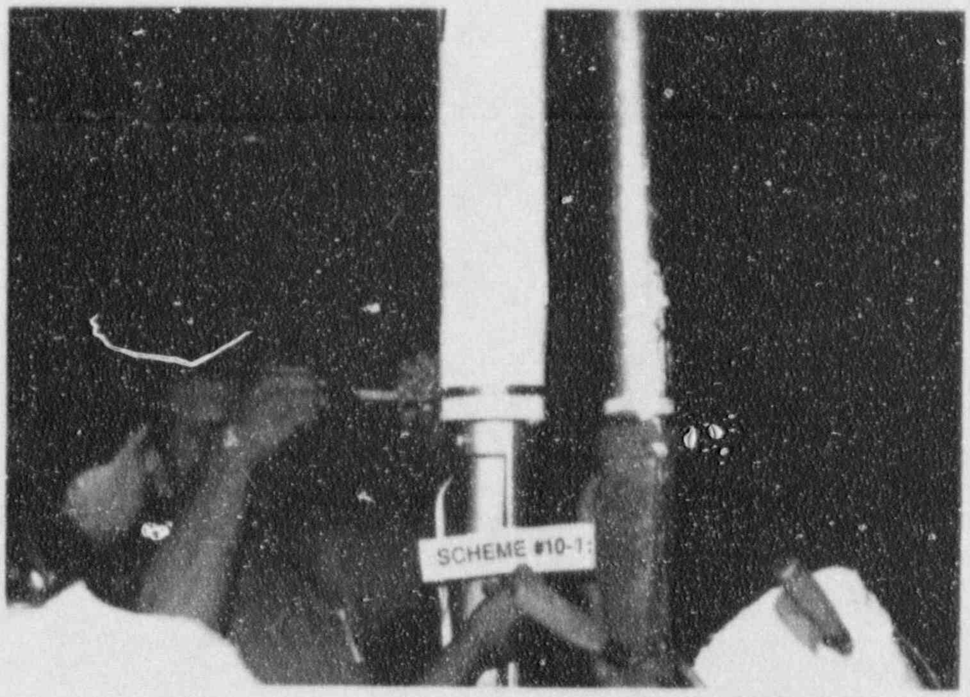
Junction box covers being secured.



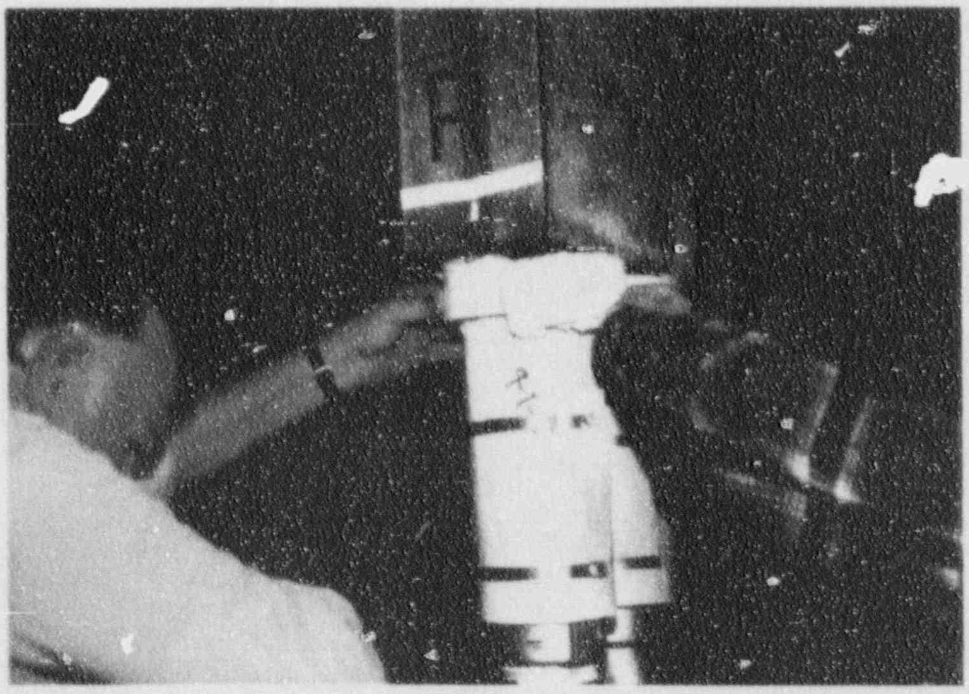
Top view of test deck prior to cladding.



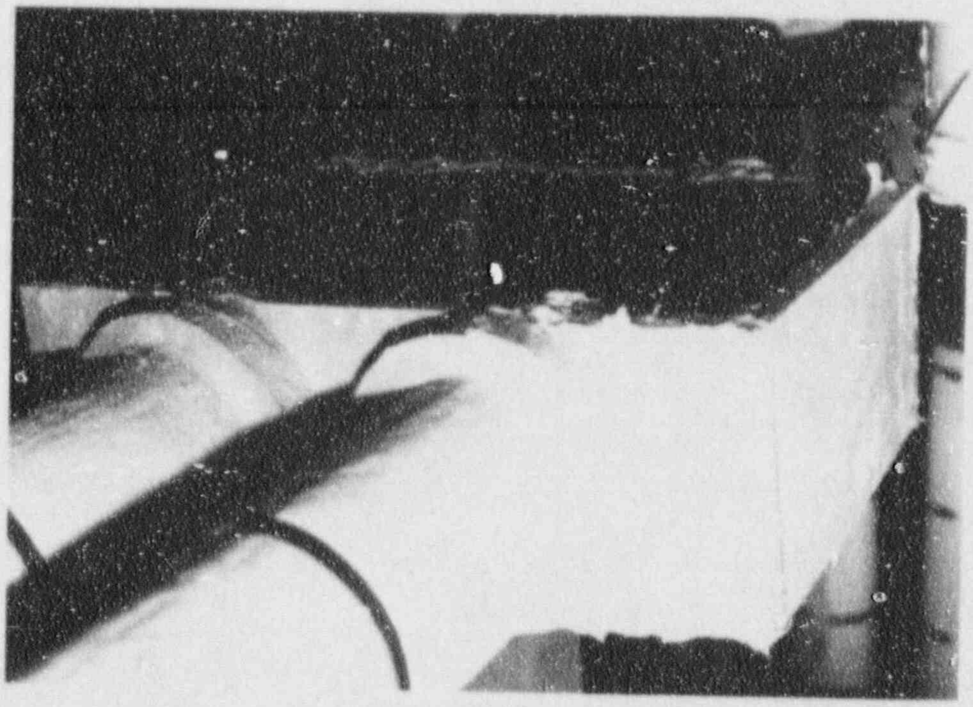
Pre-shaped conduit sections being installed on the conduit runs.



Pre-shaped conduit sections being secured with stainless steel banding



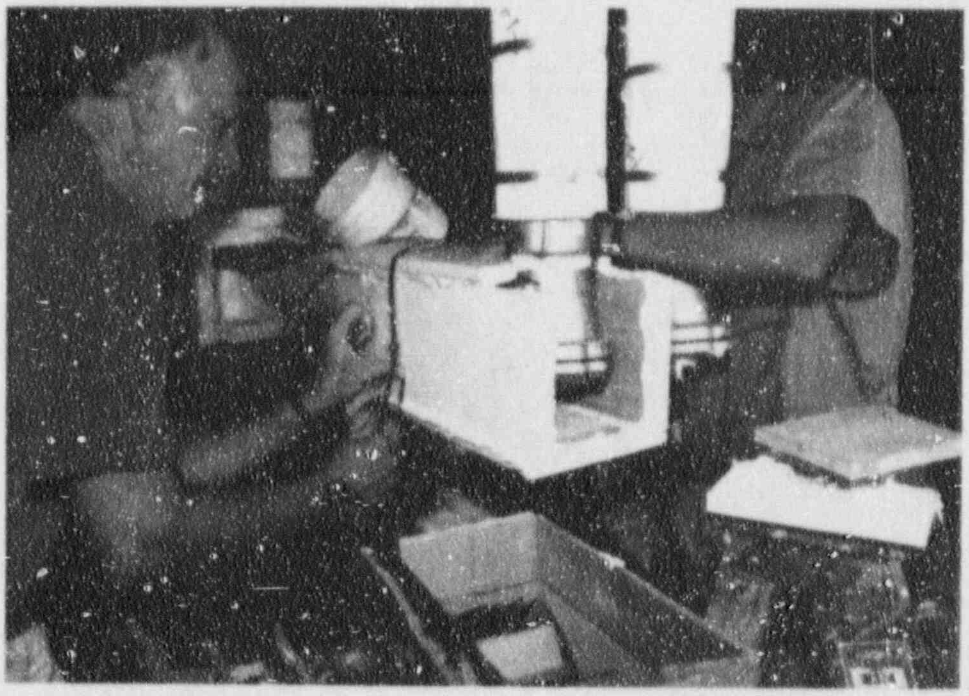
Thermo-Lag® collars added to conduit runs at entry and exit points on junction boxes.



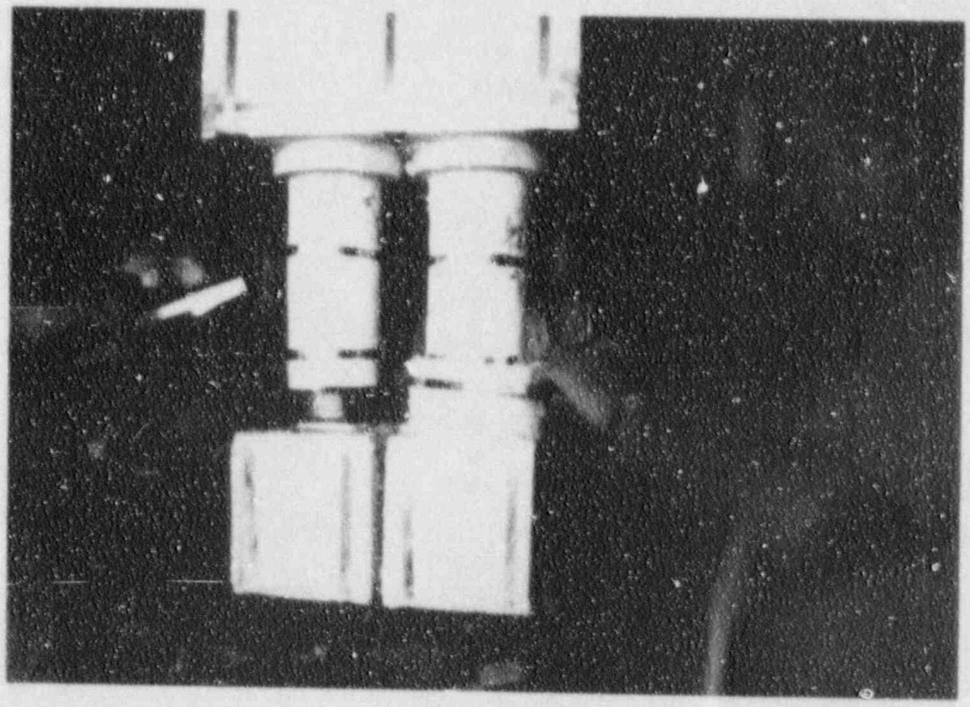
Thermo-Lag® panels installed on sides of horizontal junction box.

Thermo-Lag® panels installed on the top of horizontal junction box.

OMEGA POINT LABORATORIES

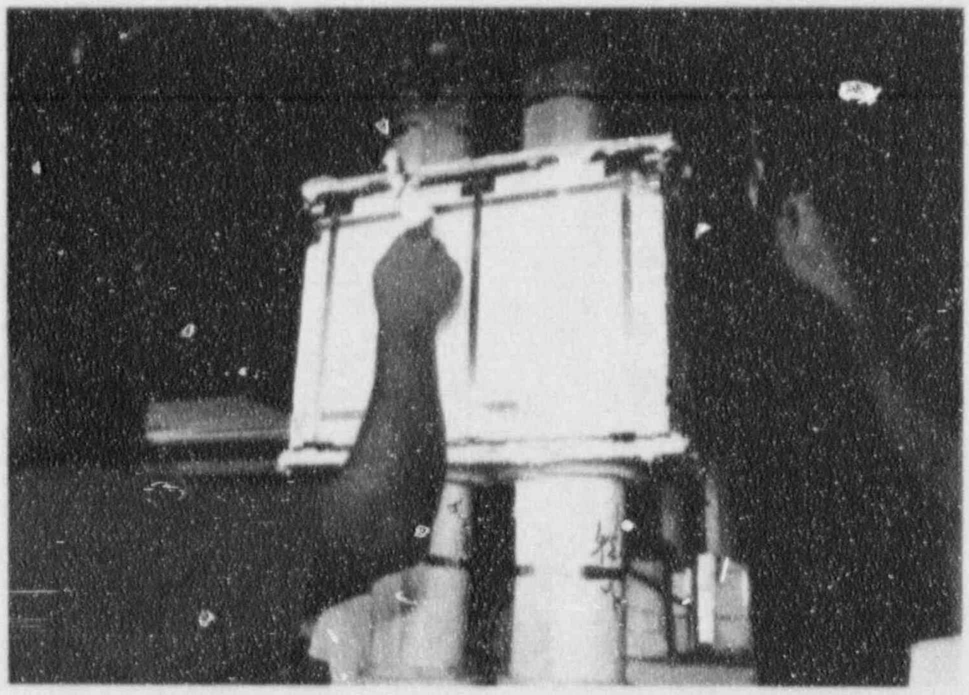


Securing Thermo-Lag® panels over condulets with stainless steel banding.

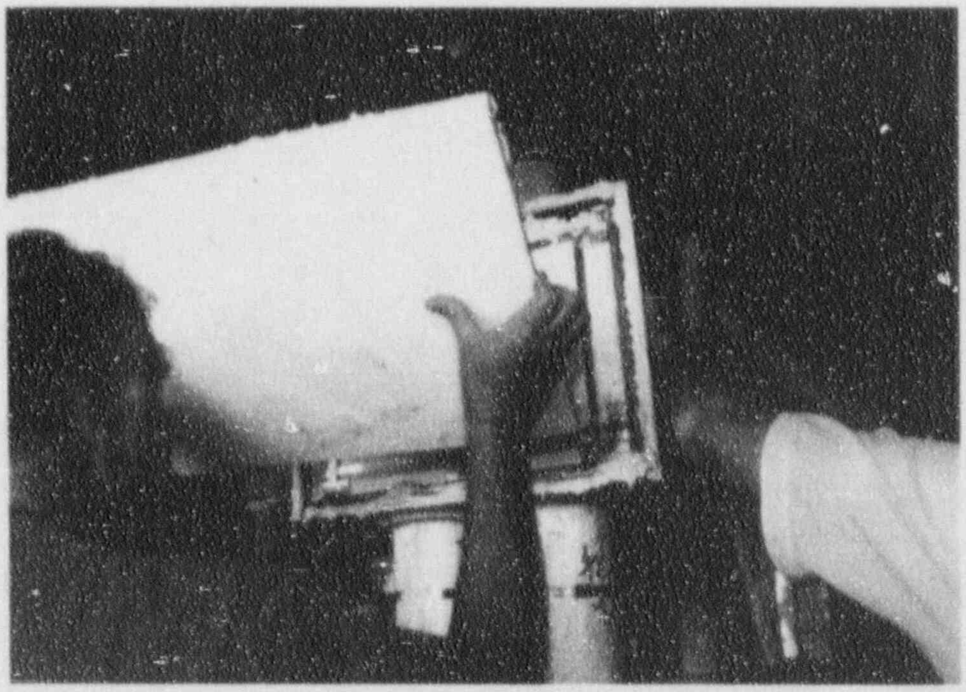


Collars installed at condulet entry and exit points

OMEGA POINT LABORATORIES

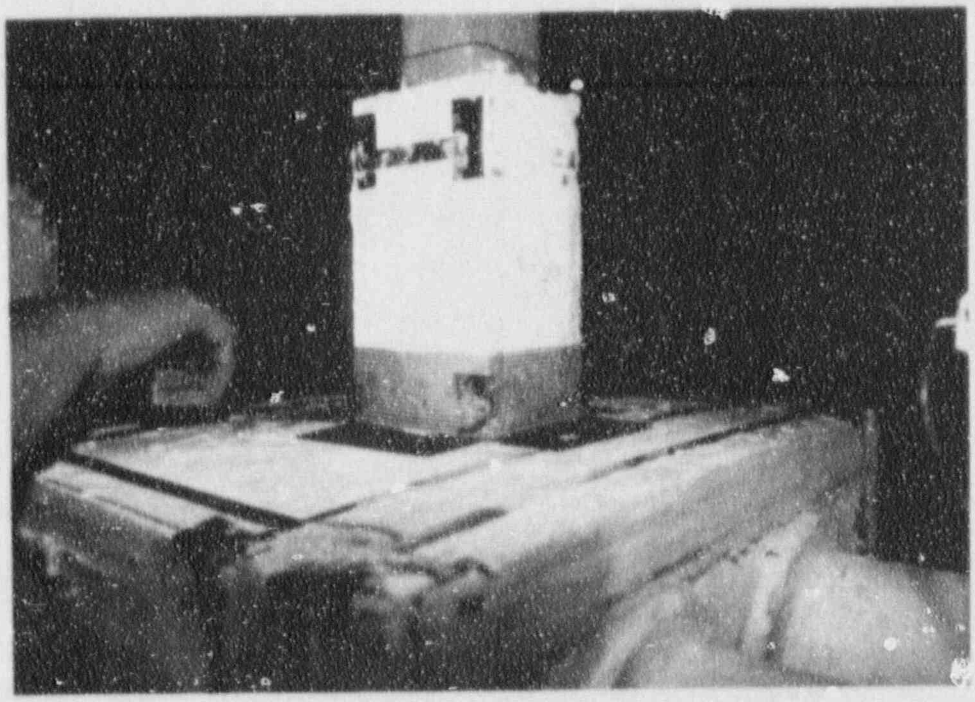


Second layer of panels installed over junction boxes as an "upgrade."

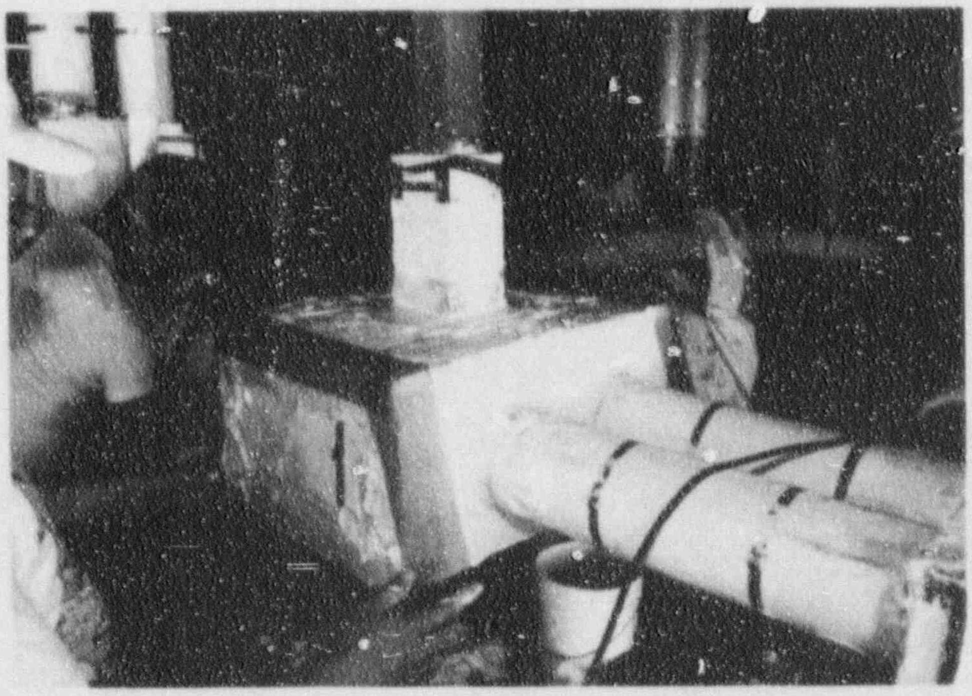


Second layer "upgrade" box being completed.

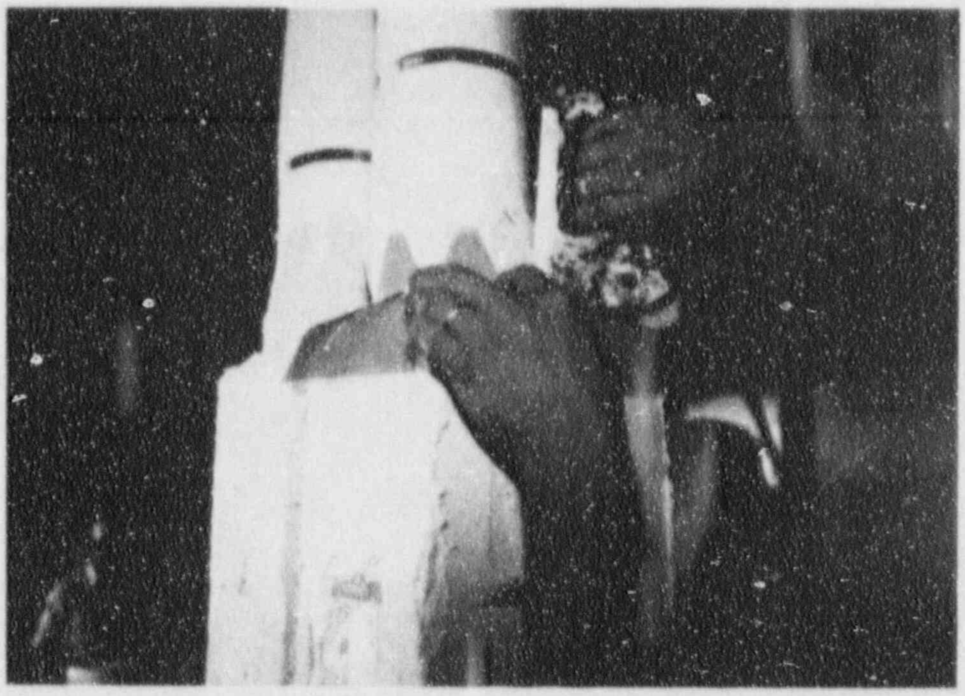
OMEGA POINT LABORATORIES



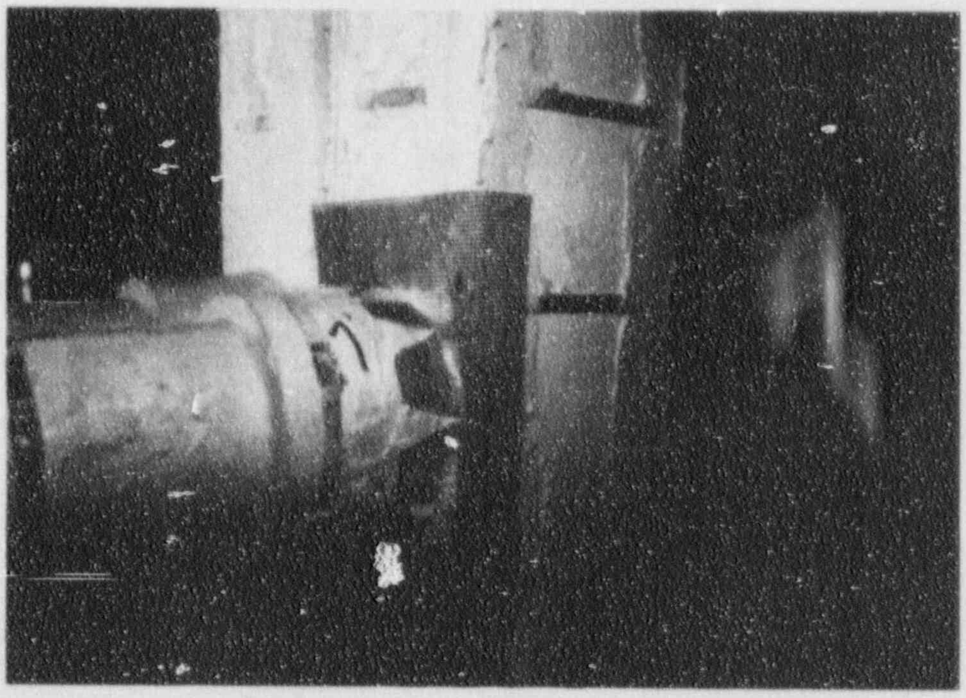
Transition piece from top of horizontal junction box to support member.



Stress skin edge treatment "upgrade" installed on junction boxes.

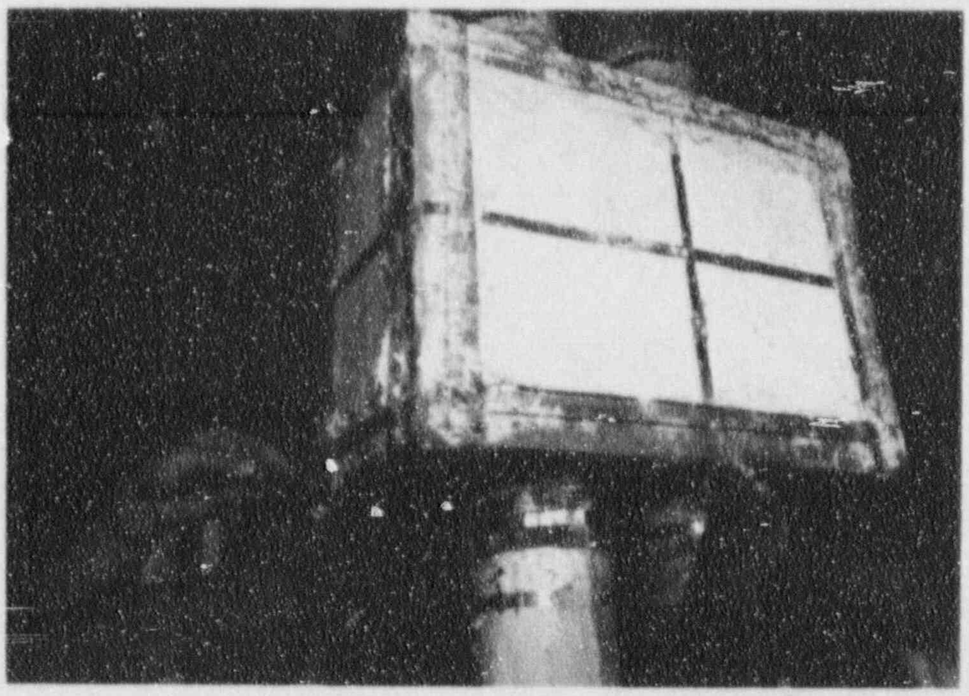


Stress skin transition piece from junction box exit to conduit run cover with additional circumferential wrap.

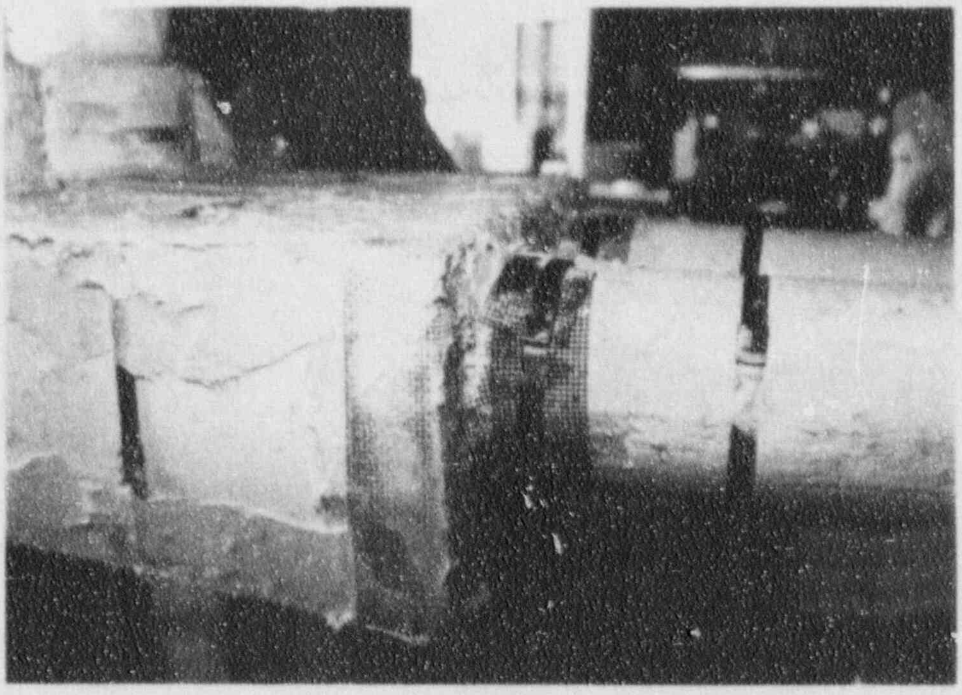


Stress skin transition piece from condulet exit to conduit run.

OMEGA POINT LABORATORIES

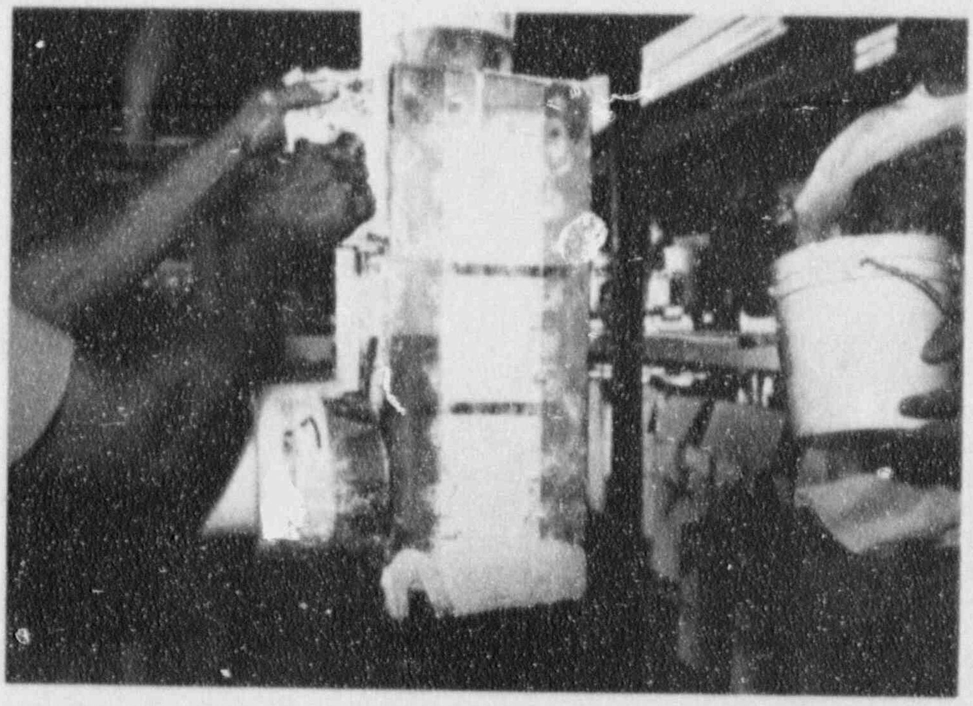


Stress skin transition piece from condulet exit to conduit run.

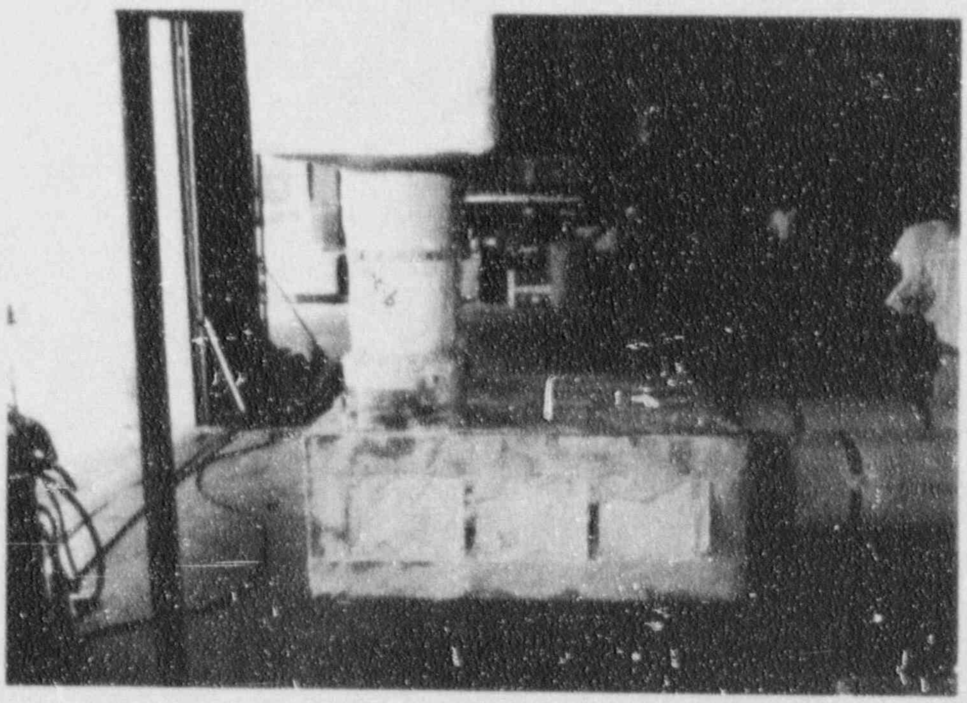


Stress skin circumferential wrap over transition piece into conduit run.

OMEGA POINT LABORATORIES

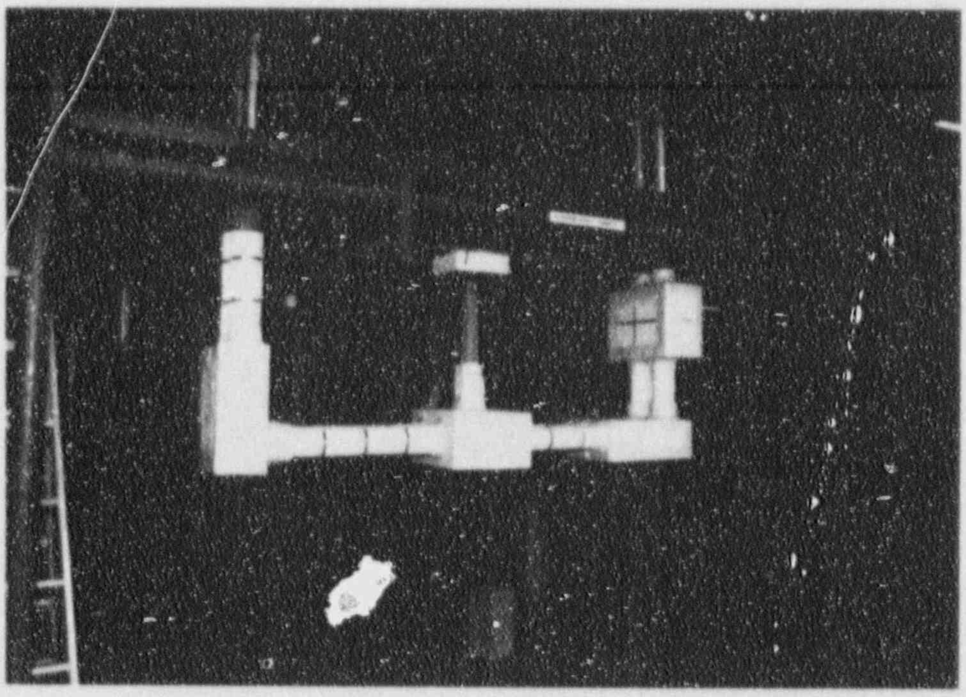


Stress skin edge treatment "upgrade" on LBD box edges.



Completed "upgrades" on LBD boxes.

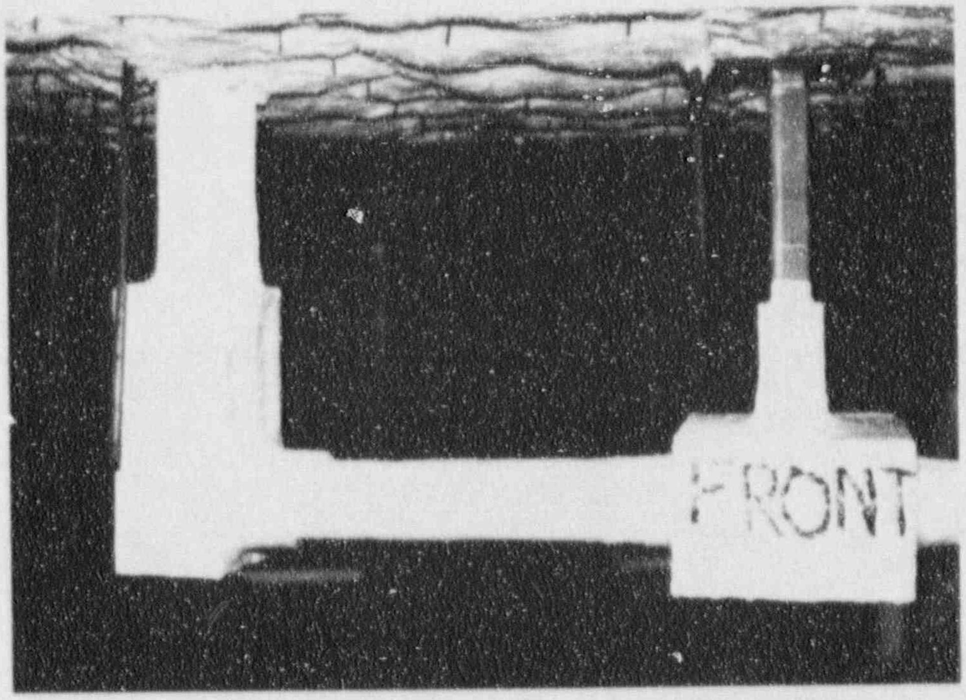
OMEGA POINT LABORATORIES



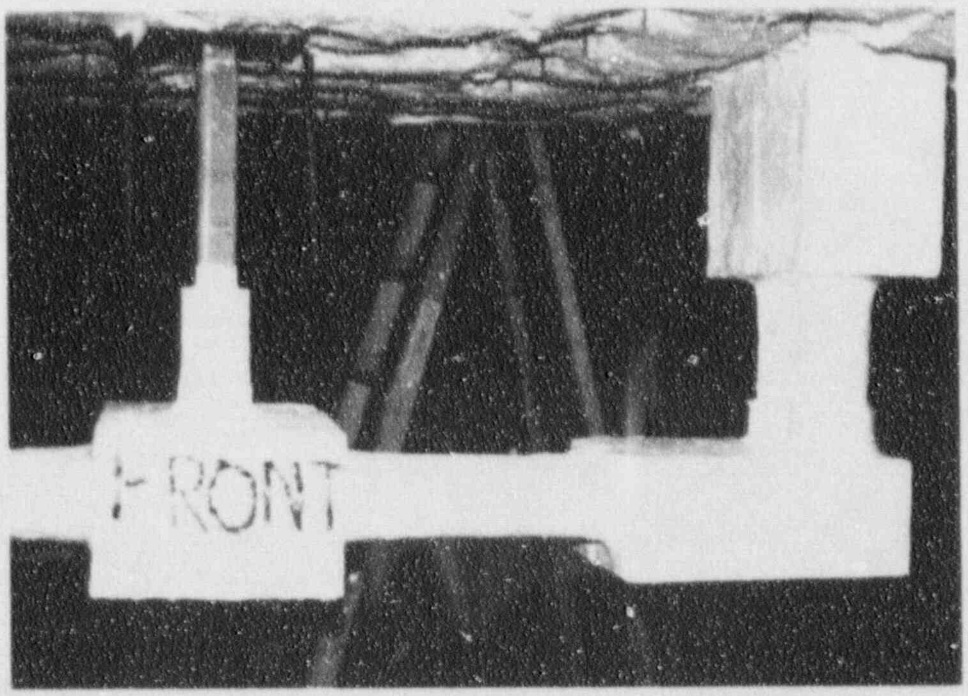
Conduit system completely clad.

Foam/silicon seals installed at top of conduit runs.

OMEGA POINT LABORATORIES

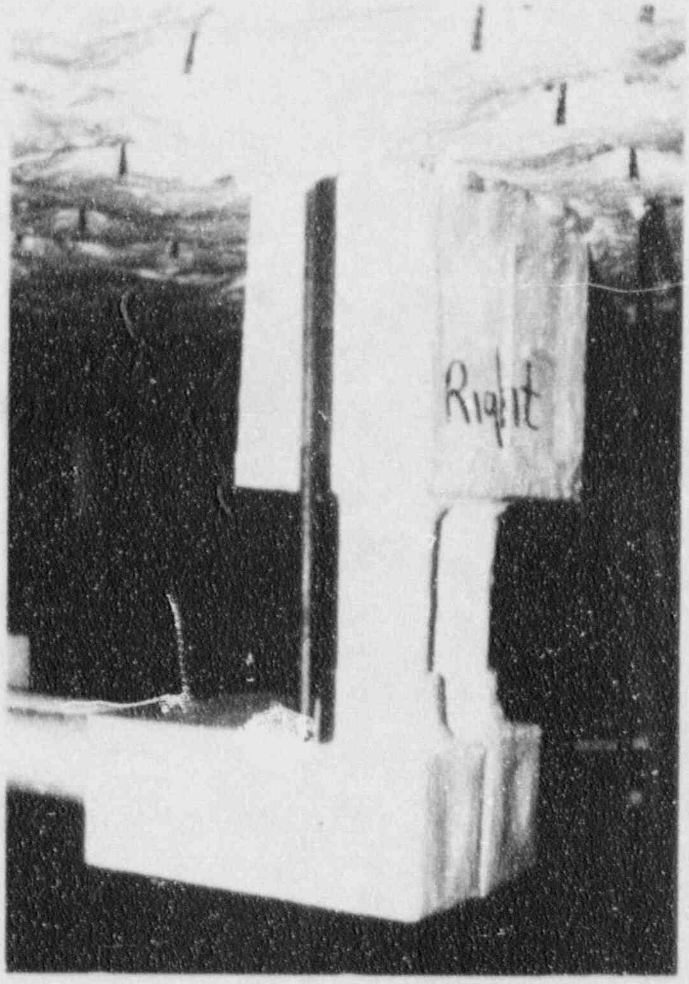


Front / left view of completed assembly prior to testing.



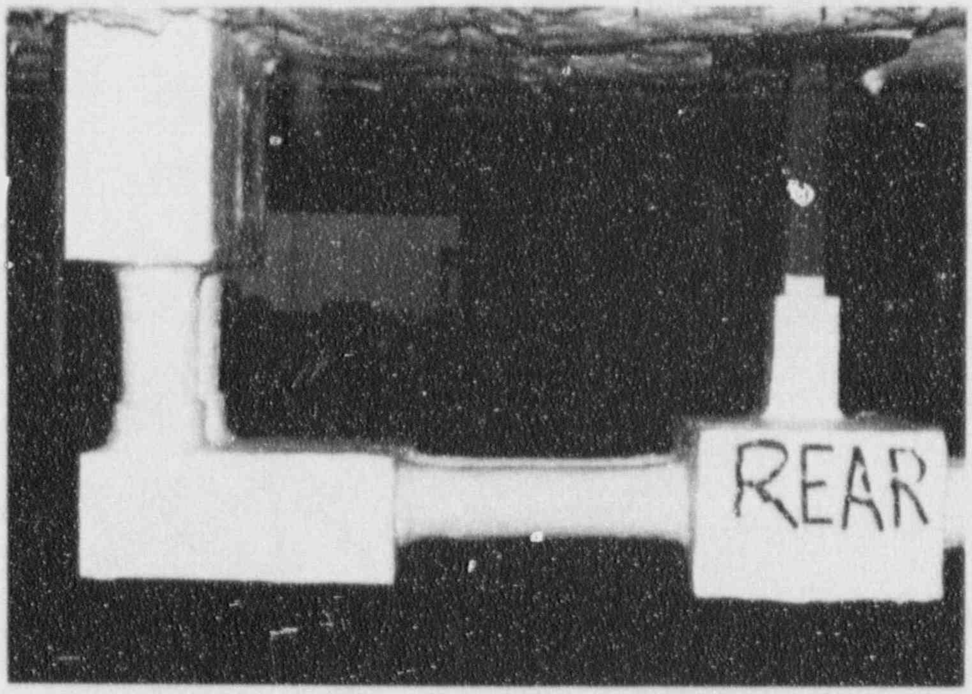
Front / right view of completed assembly prior to testing.

OMEGA POINT LABORATORIES

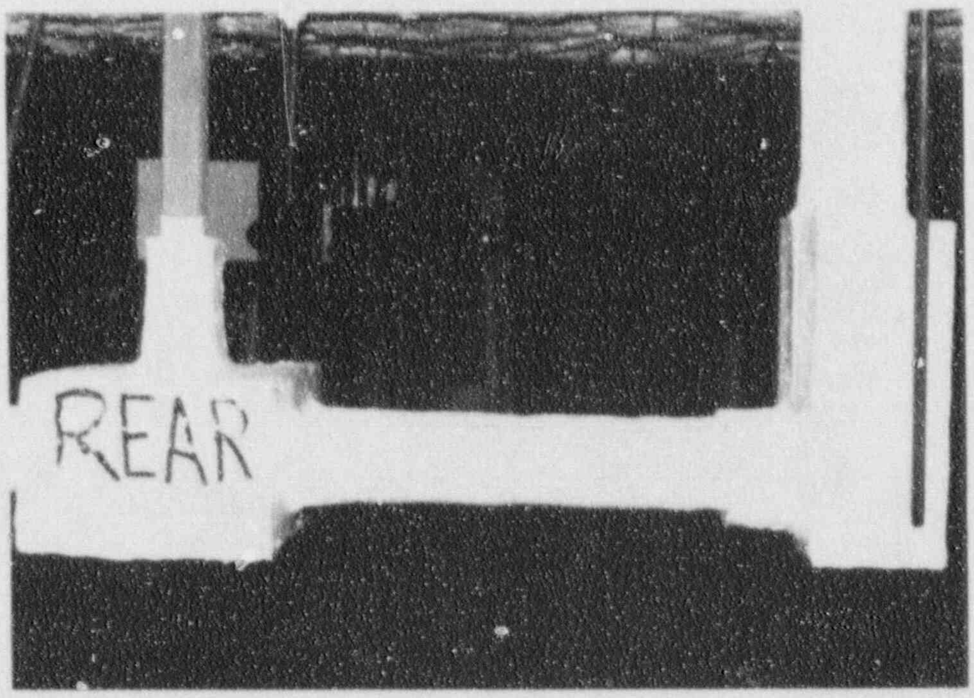


Right end view of completed assembly prior to testing.

OMEGA POINT LABORATORIES

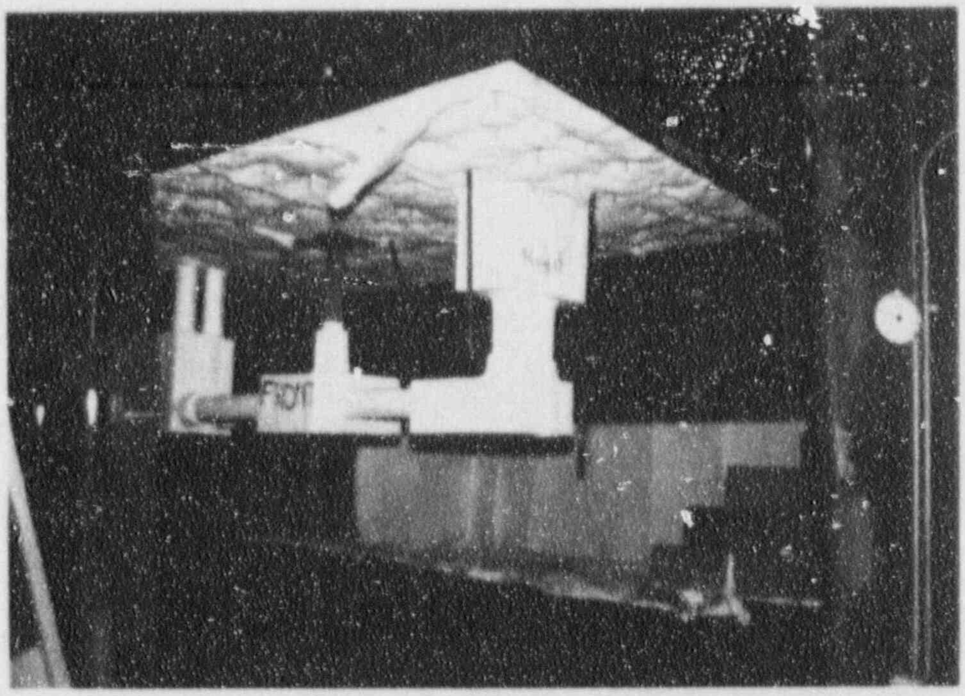


Rear / right view of completed assembly prior to testing.

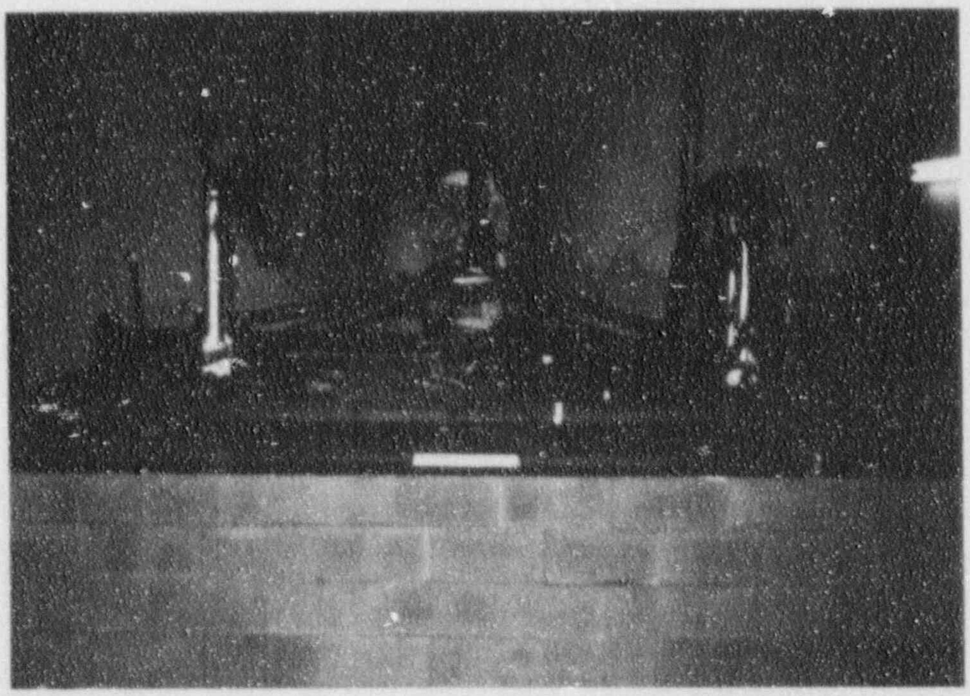


Rear / left view of completed assembly prior to testing.

Left end view of completed assembly prior to testing.

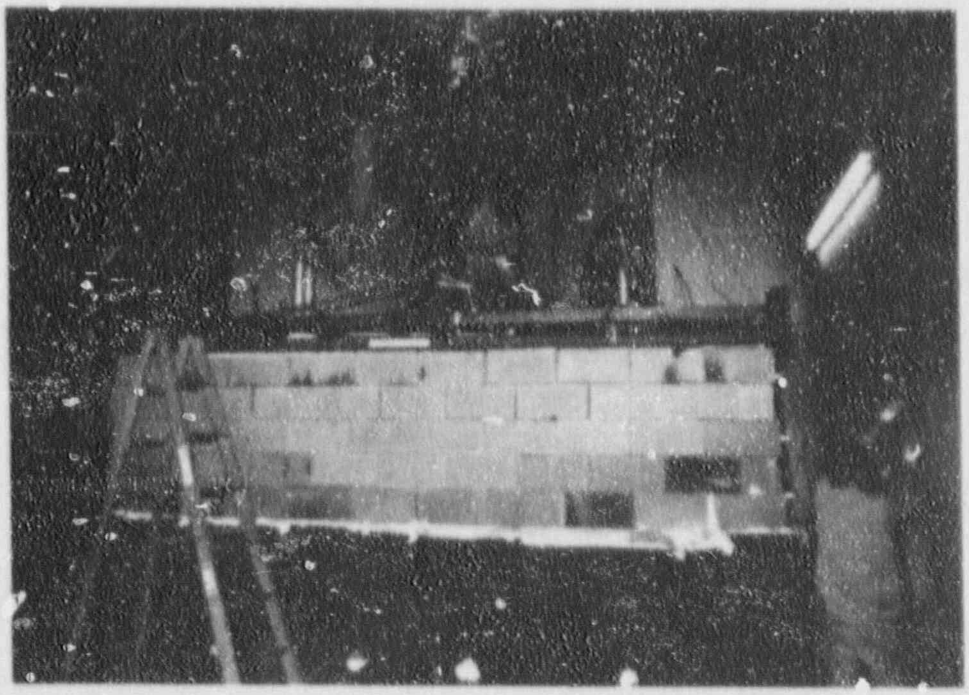


Test assembly being placed on the test furnace.

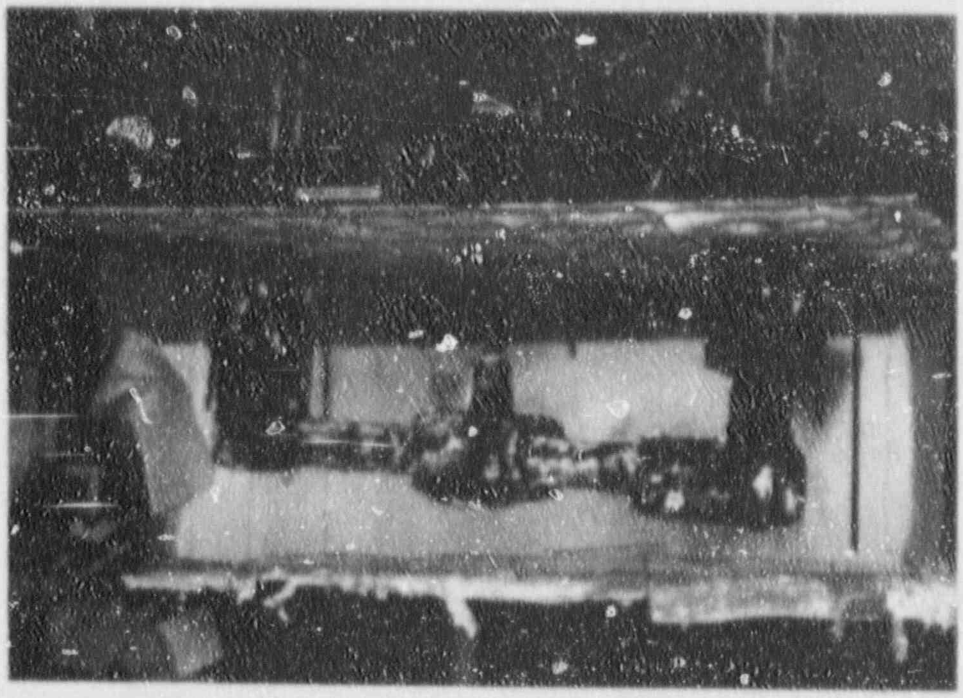


Test assembly installed on test deck, ready to test.

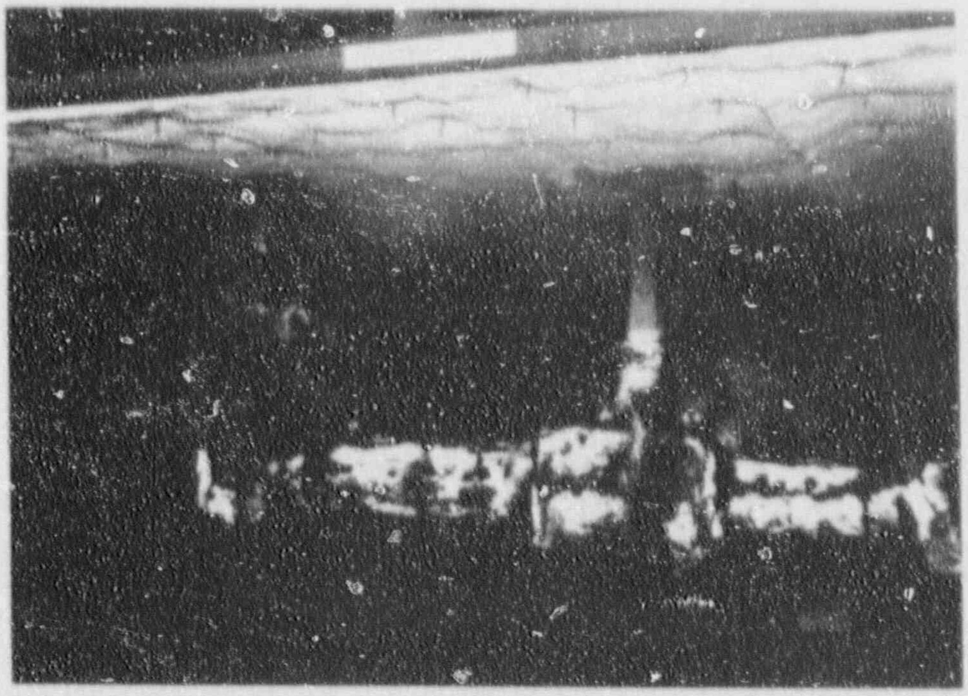
View of interior of test furnace.



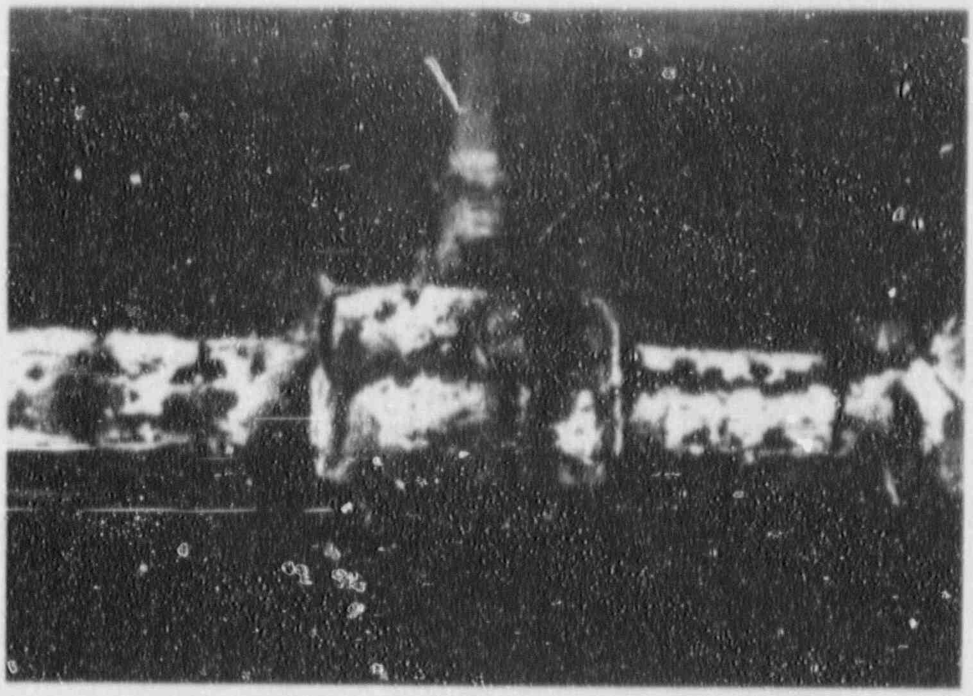
Test assembly being prepared for removal from furnace for hose stream.



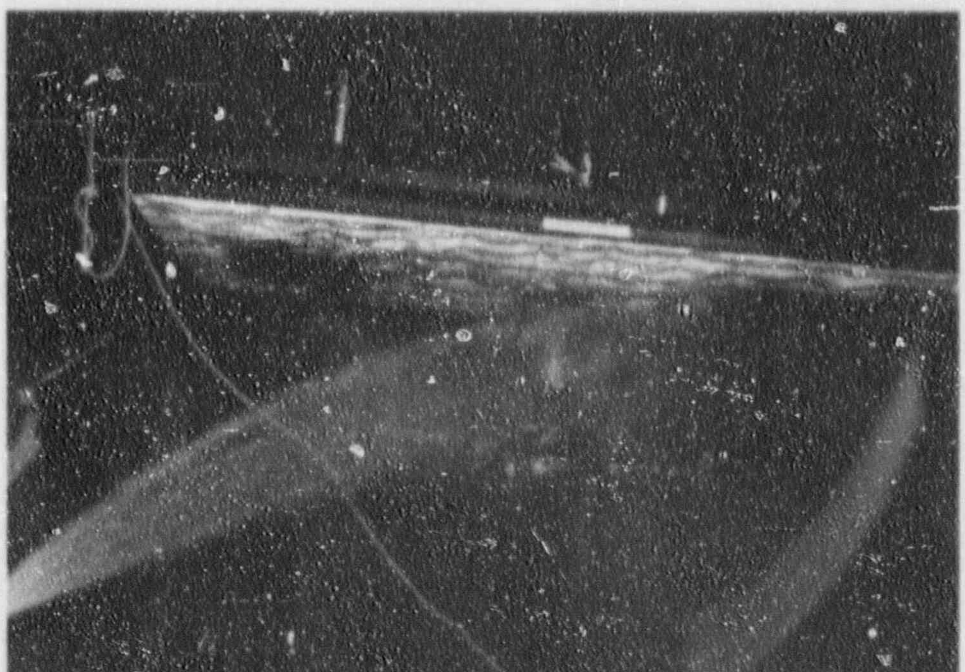
Specimen being lifted from test furnace.



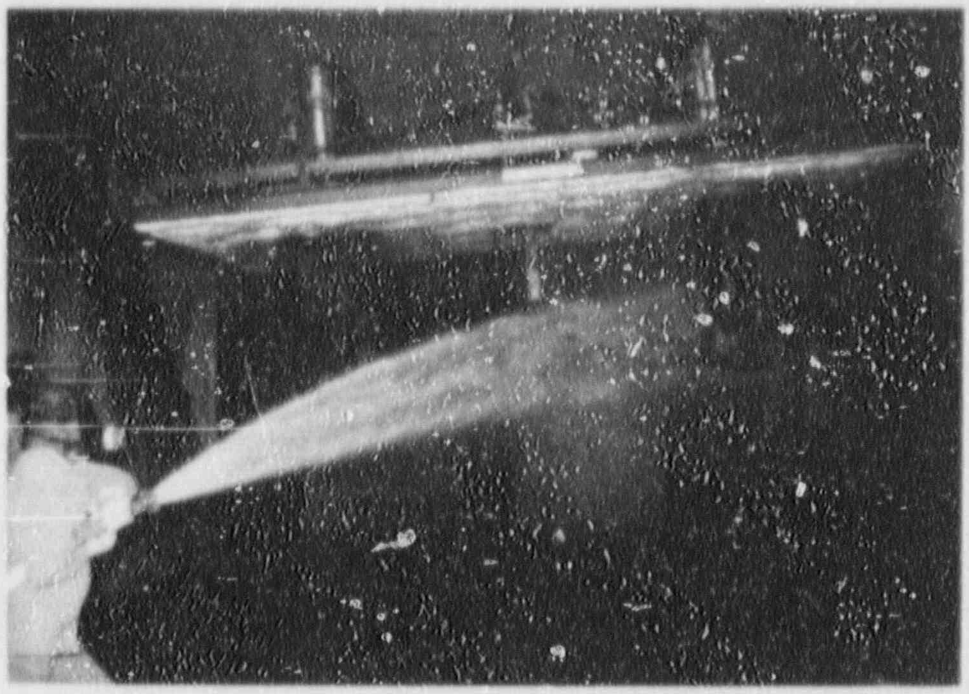
Specimen being positioned for hose stream test.



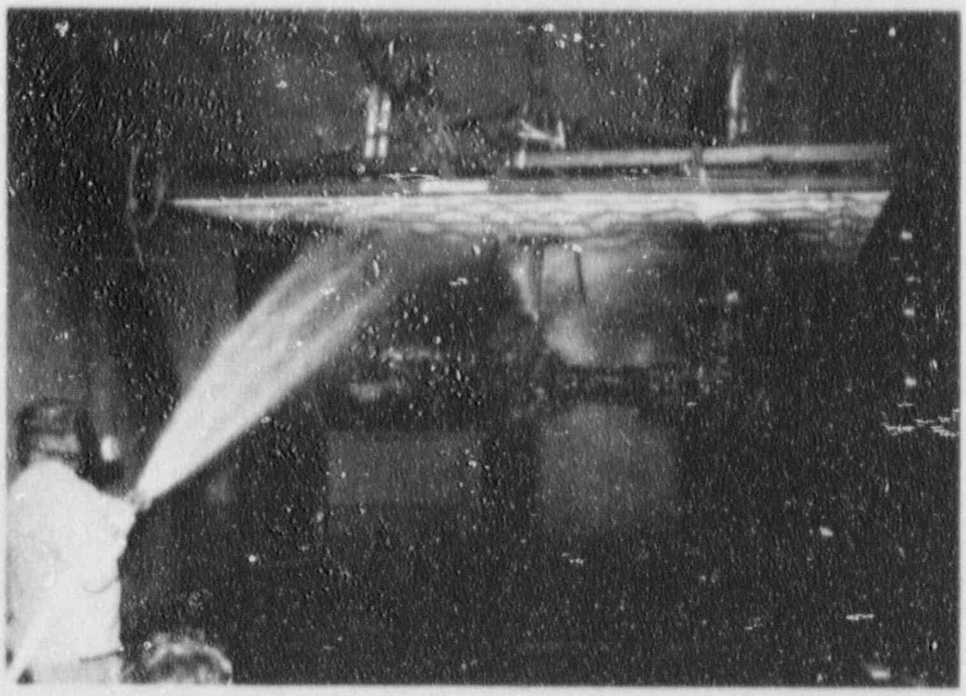
Close-up of horizontal junction box prior to hose stream test.



Hose stream test.

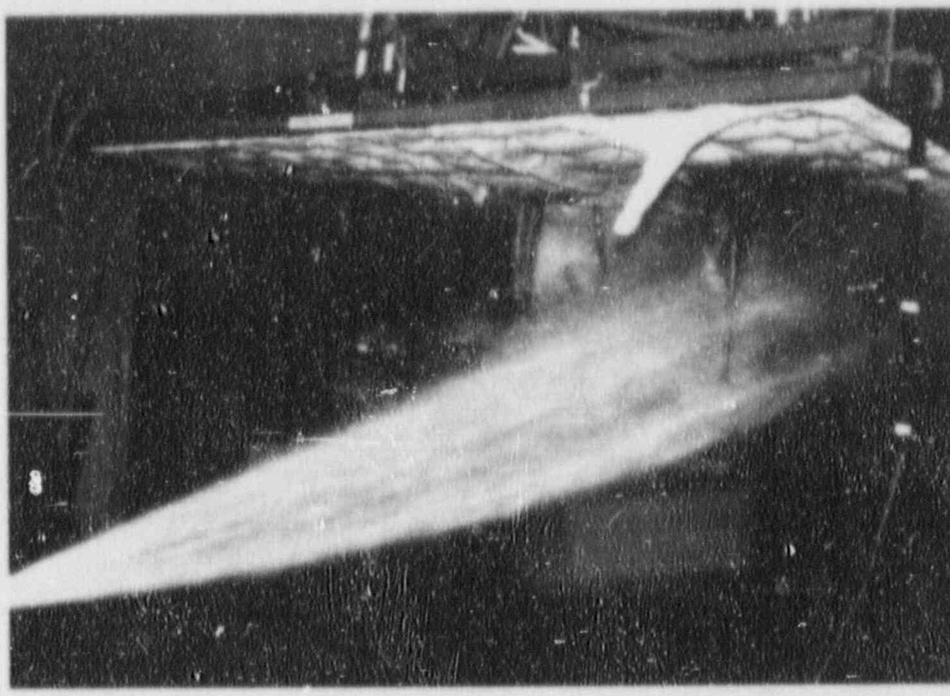


Hose stream test.

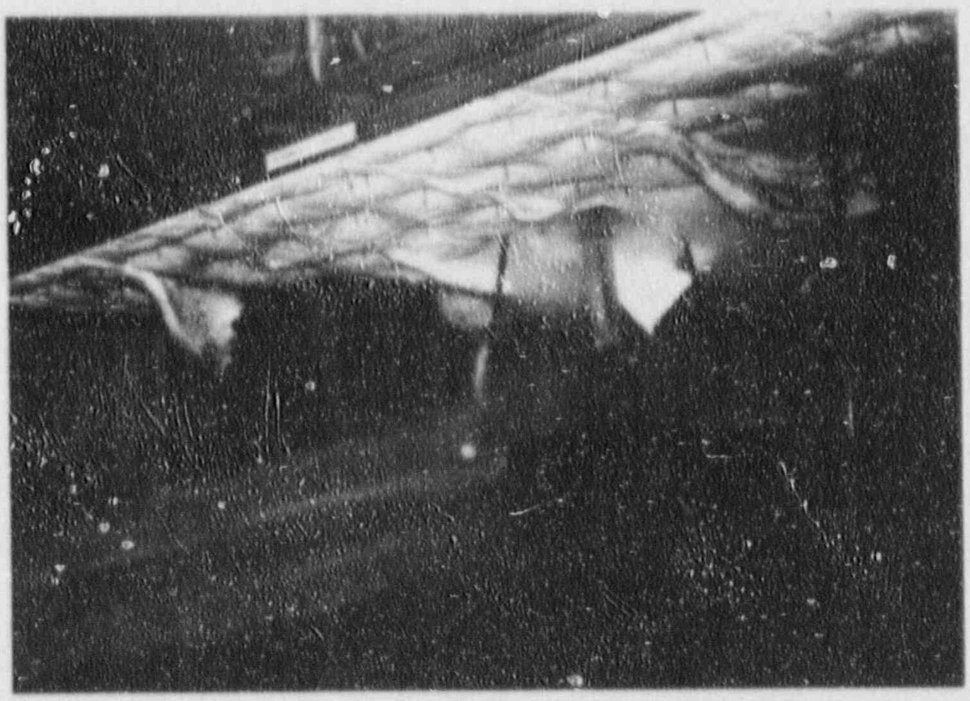


Hose stream test.

OMEGA POINT LABORATORIES



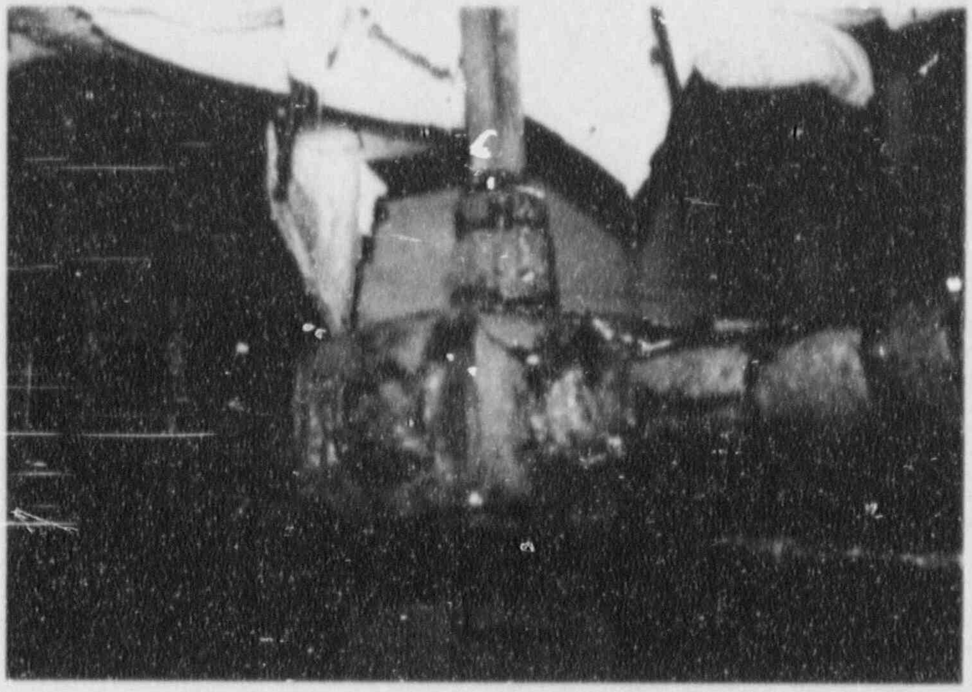
Hose stream test.



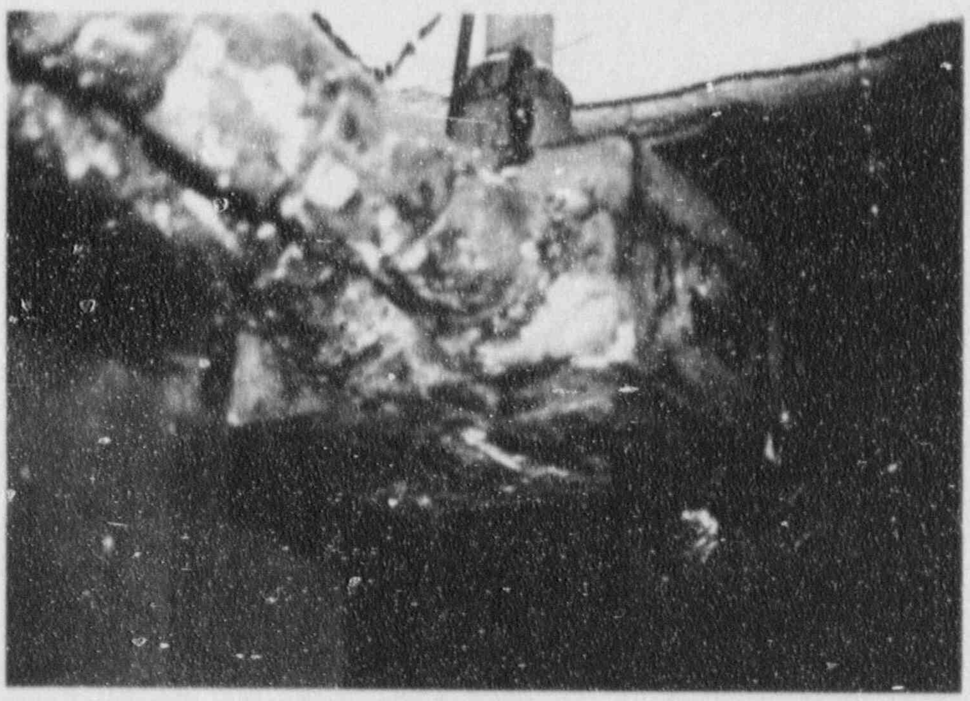
Hose stream test.

Hose stream test.

Front left view after hose stream test.

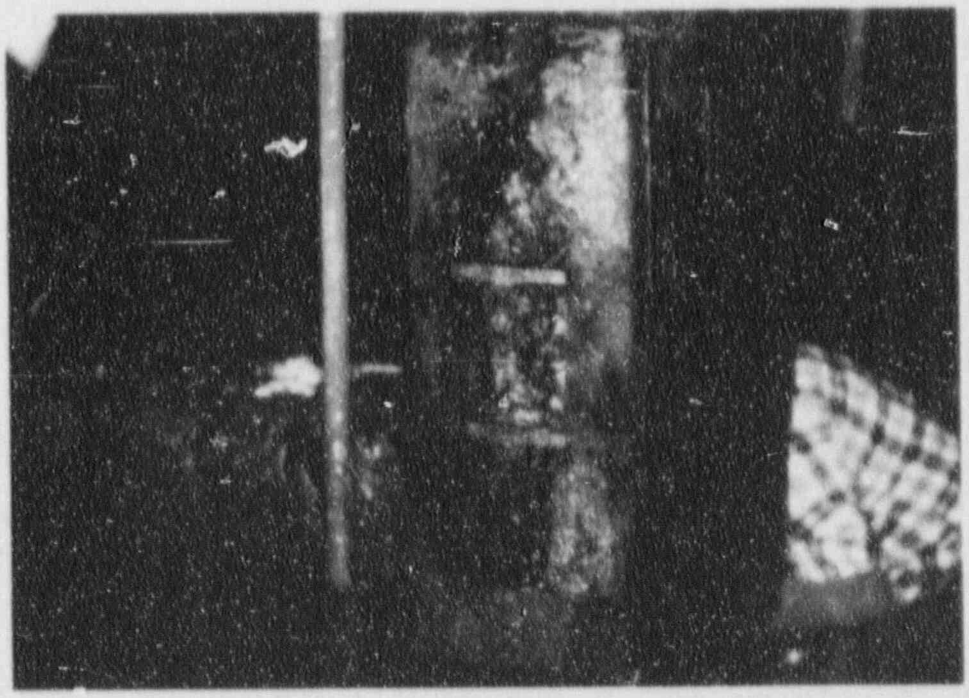


Front right interior view after hose stream test.



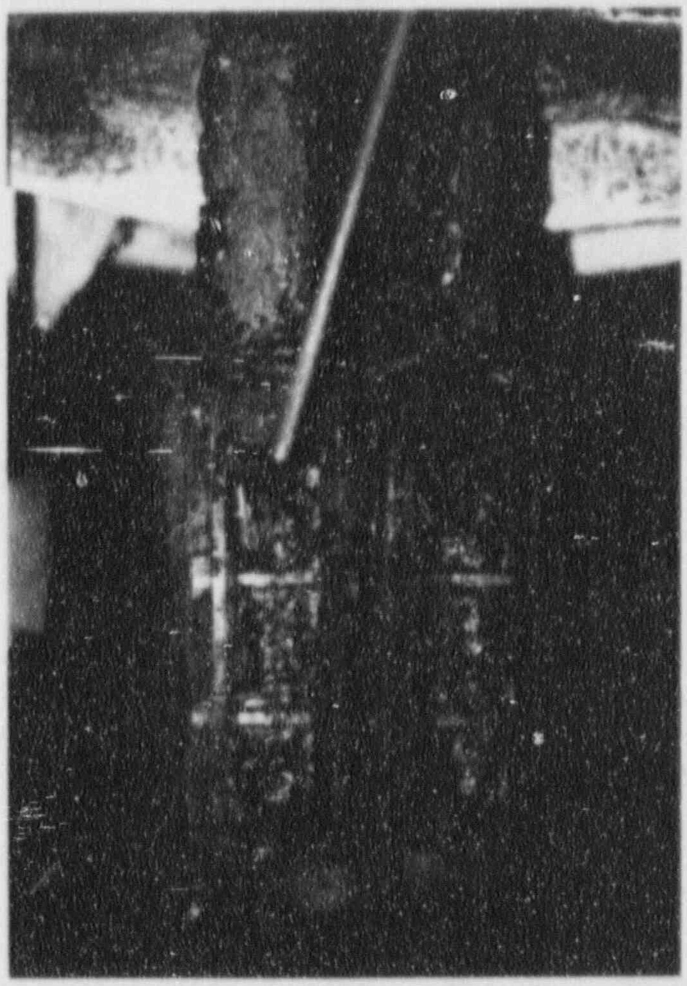
Bottom view of horizontal junction box after hose stream test.

Close rear view of right LBDs after hose stream test.



Close rear view of left LBDs after hose stream test.

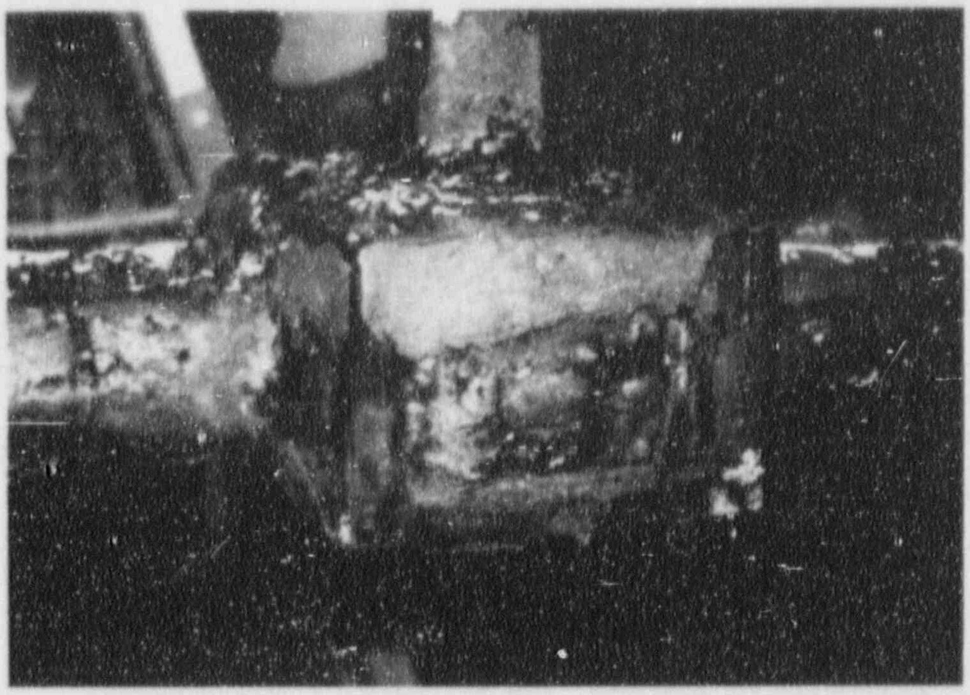
OMEGA POINT LABORATORIES



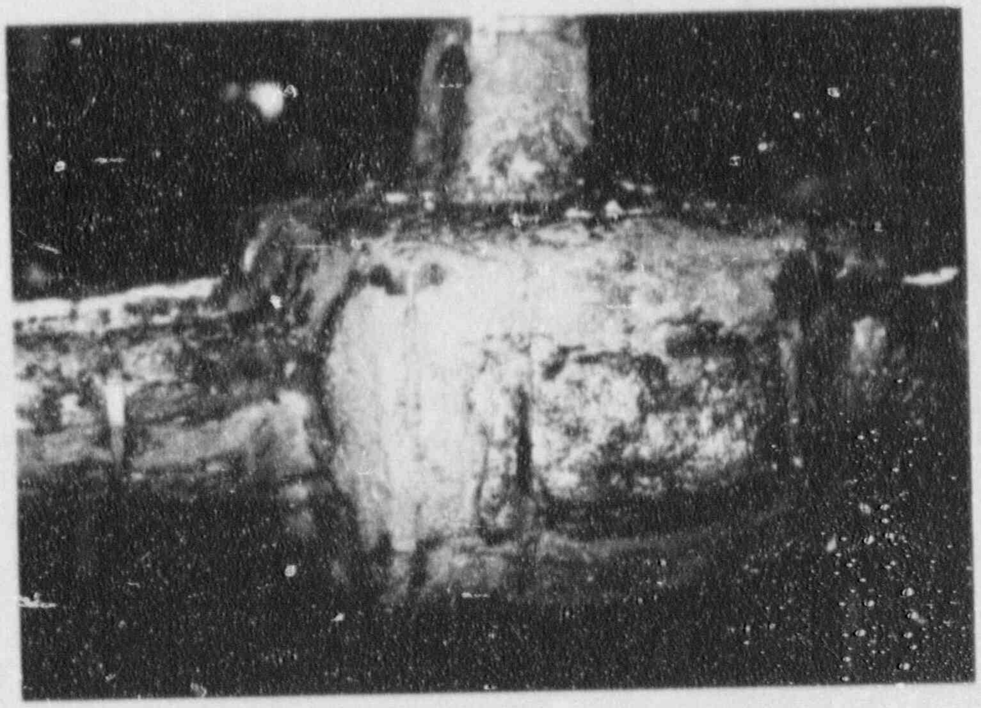
Left end view after hose stream test.

Close right end view of right LBDs after hose stream test.

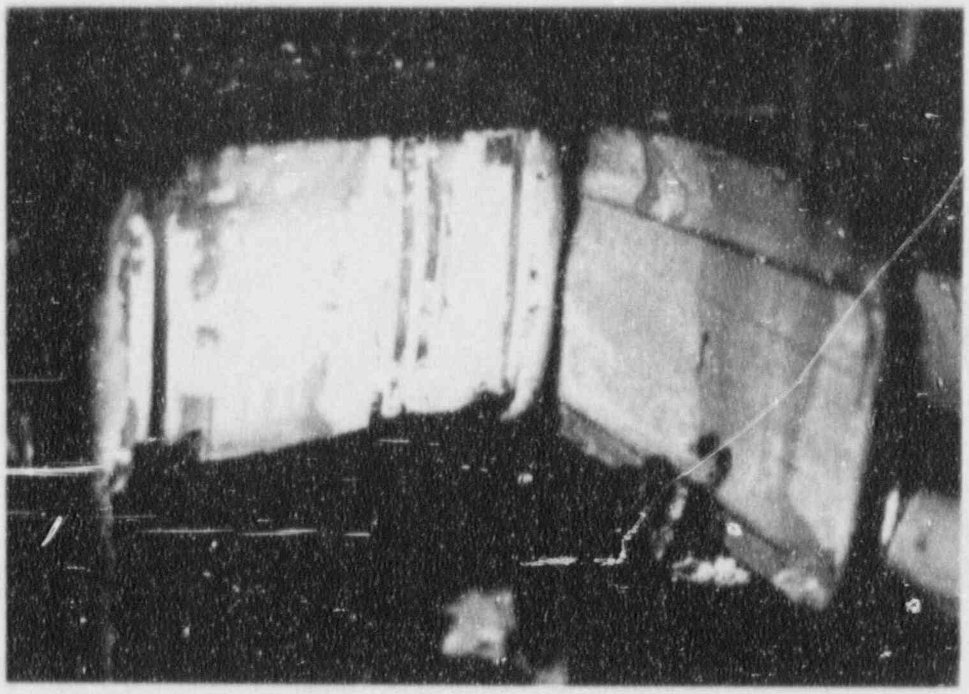
Front right interior view after hose stream test.



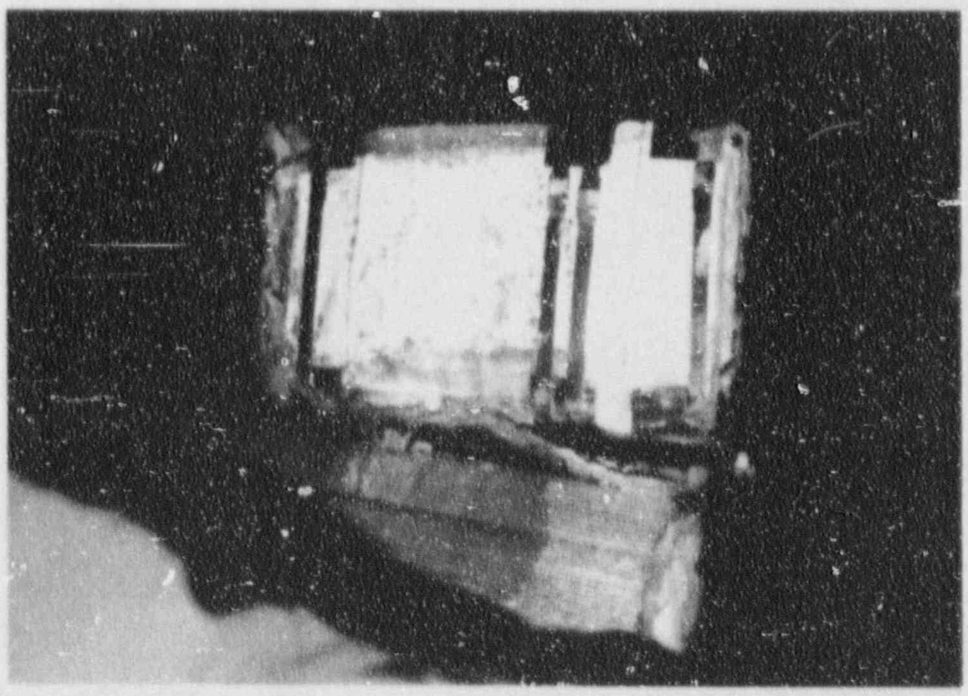
Close front view of horizontal junction box after hose stream test.



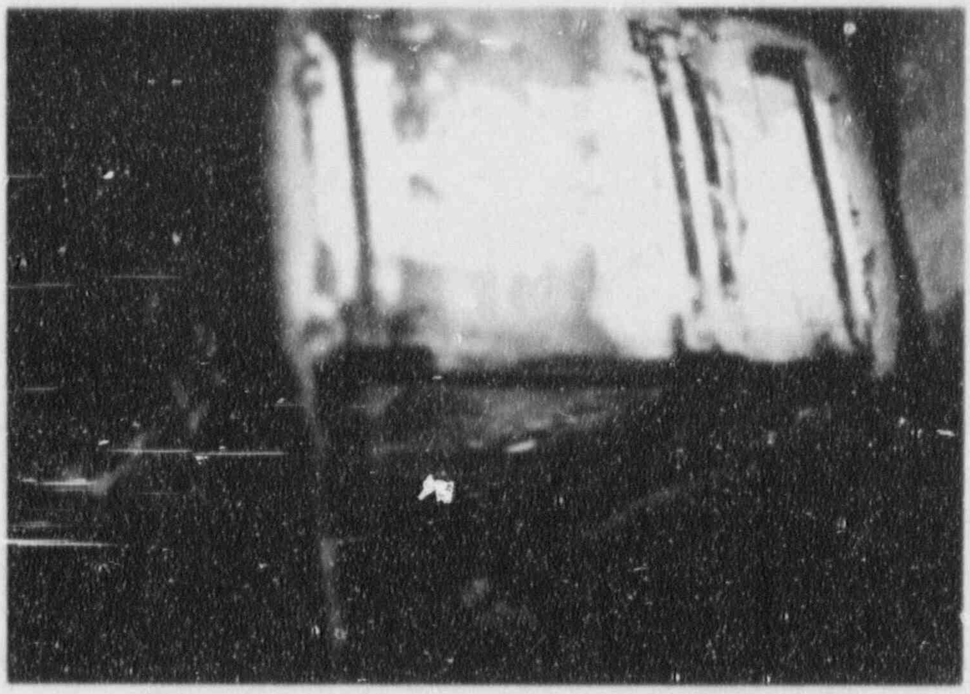
Close rear view of horizontal junction box after hose stream test.



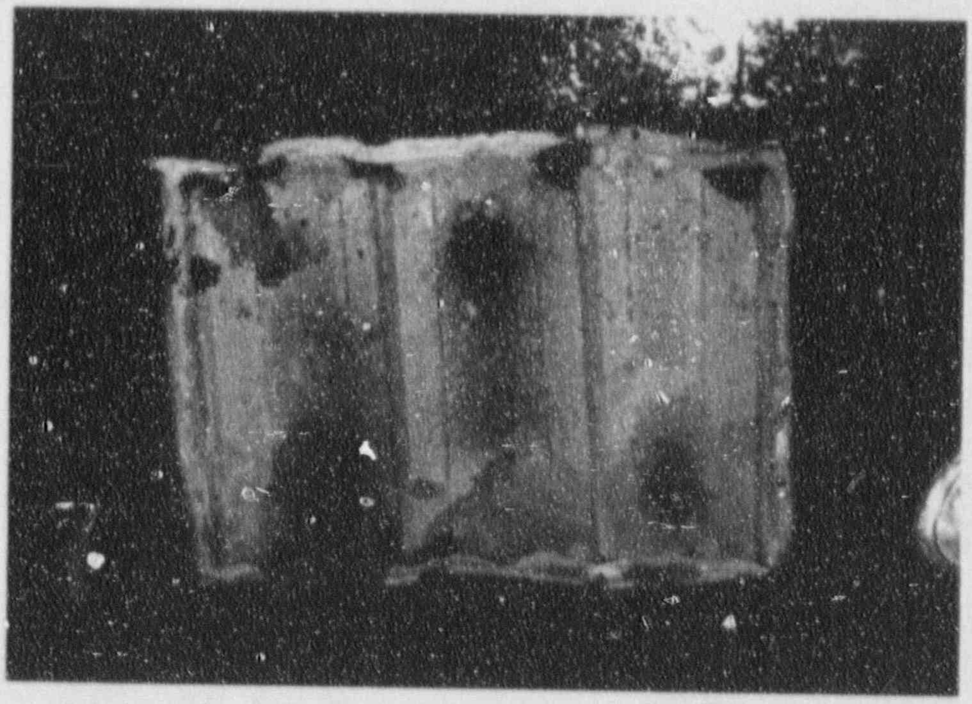
Outer layer removed from the rear surface of the horizontal junction box.



Outer layer removed from the front surface of the horizontal junction box.

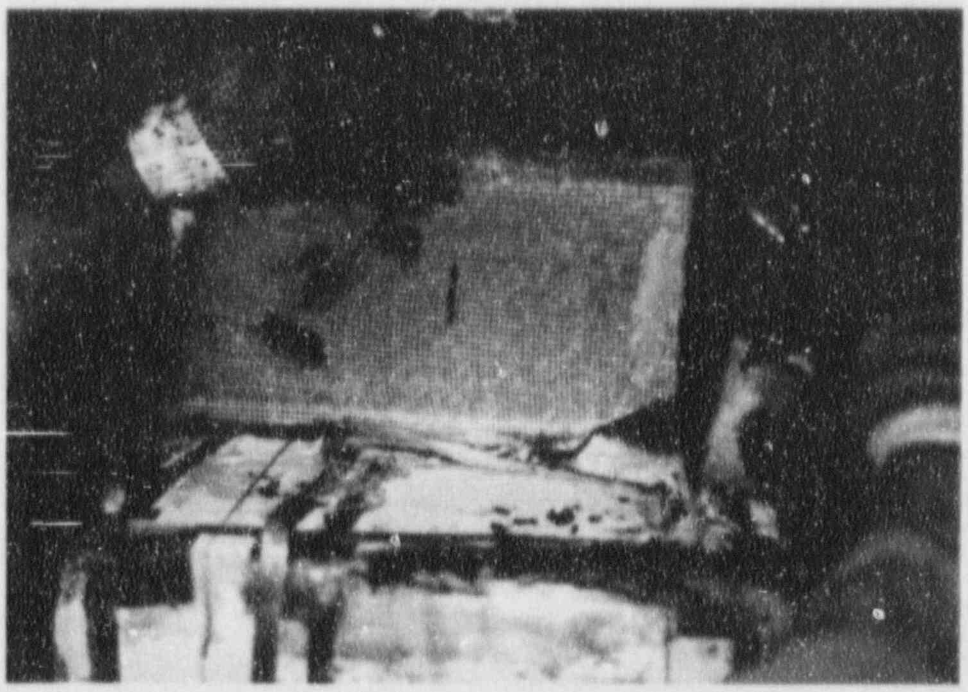


Outer layer removed from the bottom surface of the horizontal junction box.

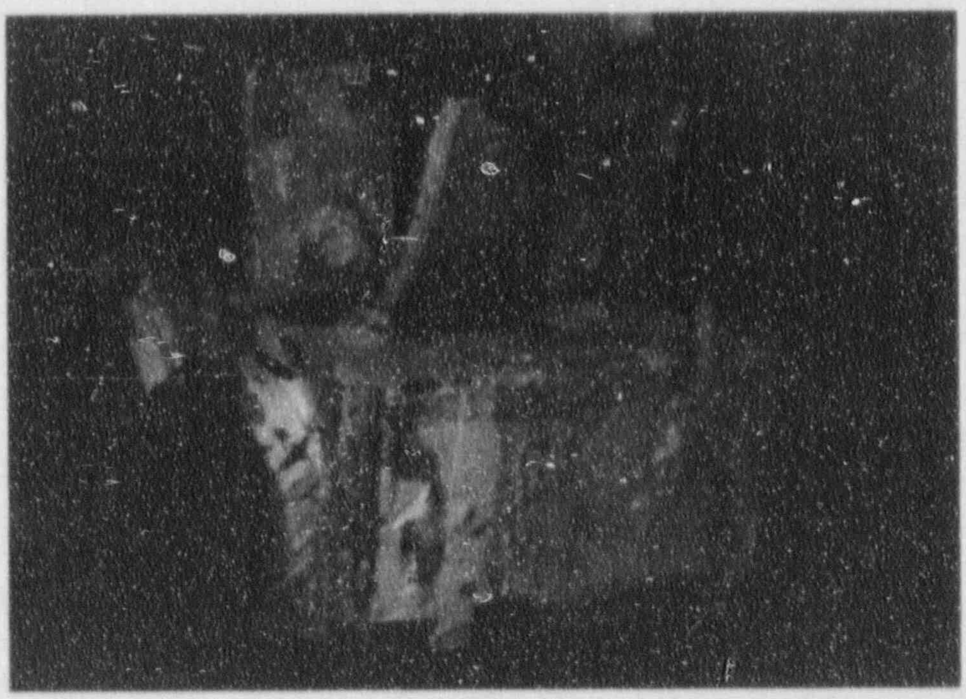


View of the inside of the outer layer piece removed from the bottom of the horizontal junction box.

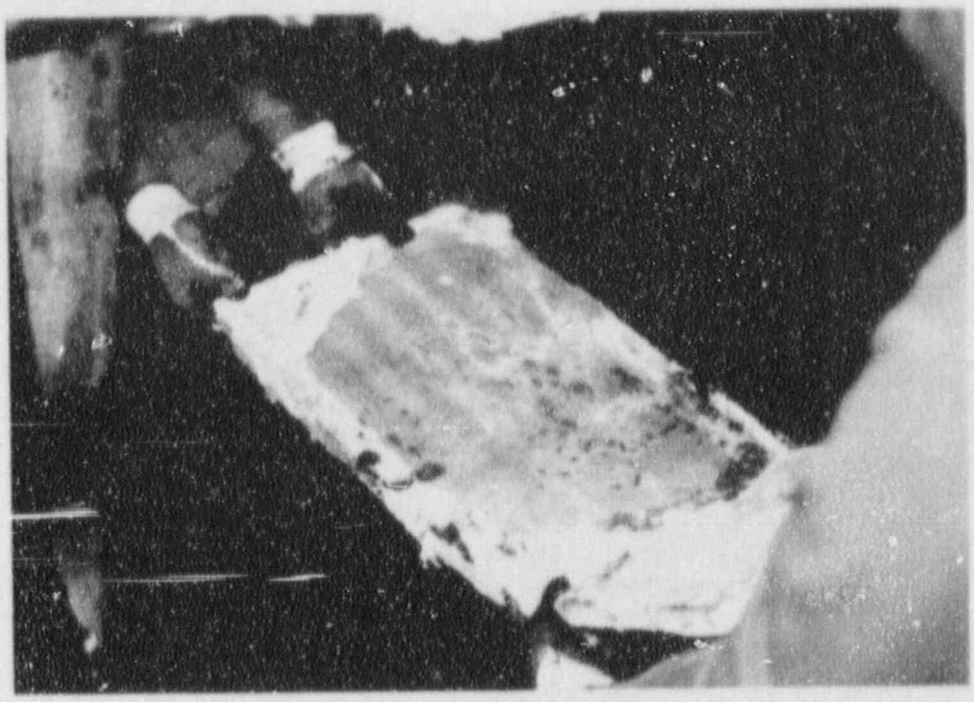
OMEGA POINT LABORATORIES



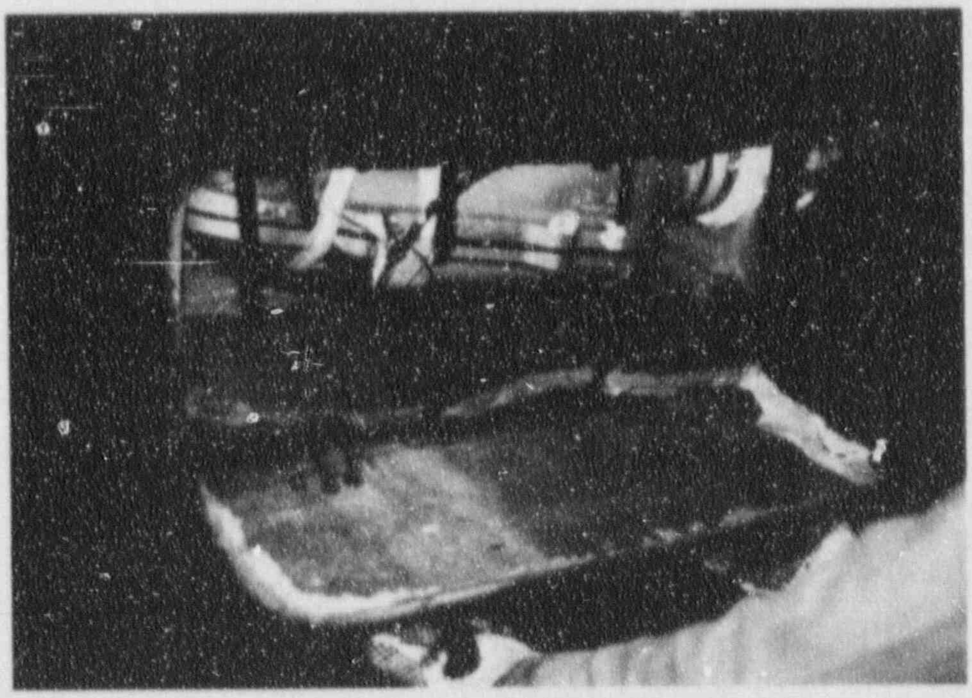
Outer layer removed from the top surface of the horizontal junction box.



Inner layer removed from the top surface of the horizontal junction box.

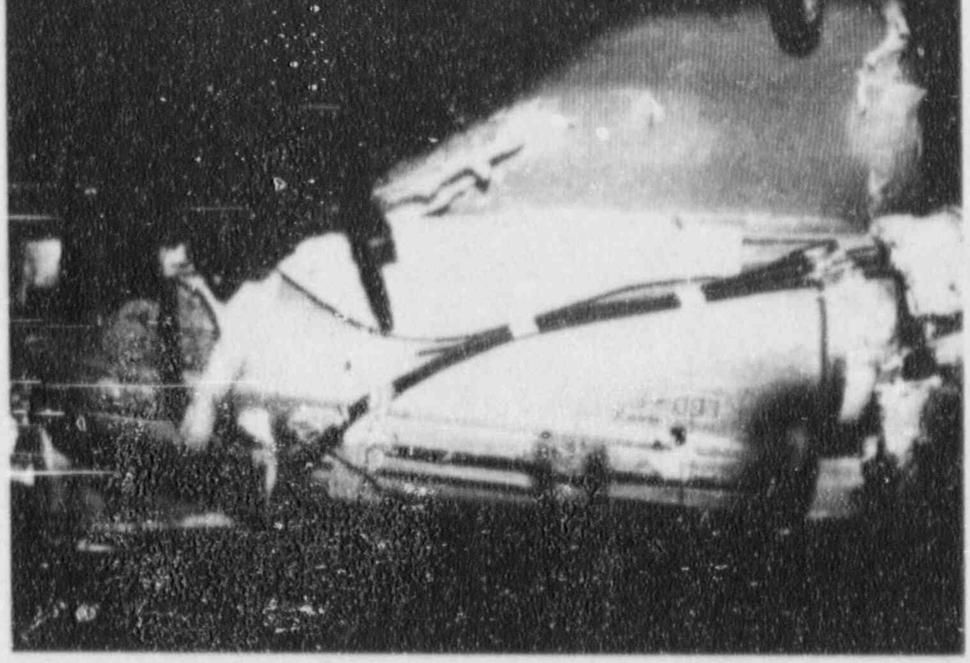


View of the inside of the inner layer piece removed from the top surface of the horizontal junction box.



Opening of the right rear LBD box.

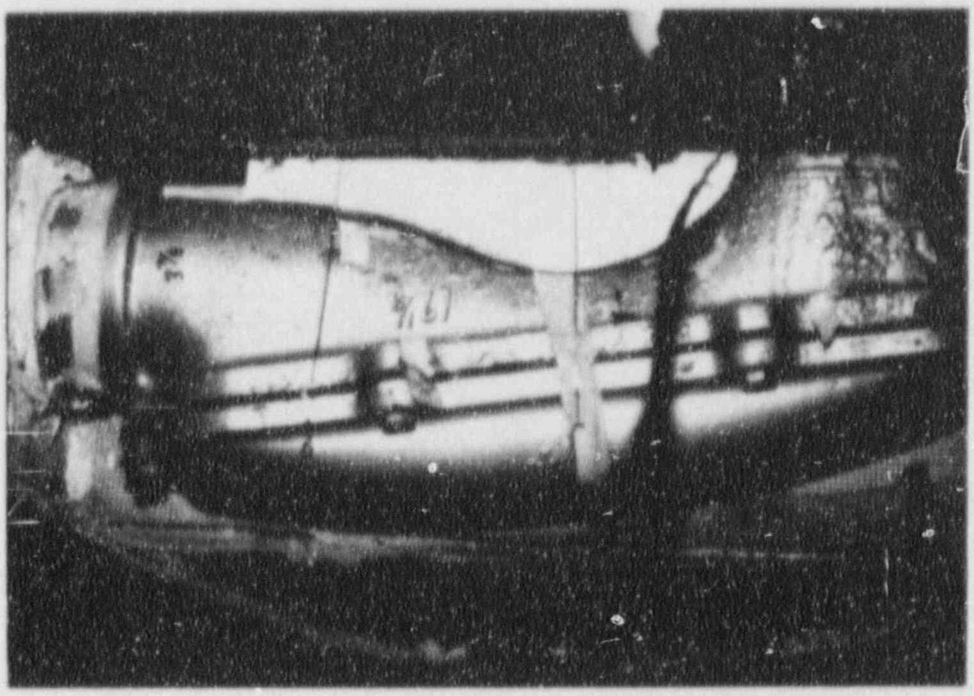
OMEGA POINT LABORATORIES



Interior view of the right rear LBD box.

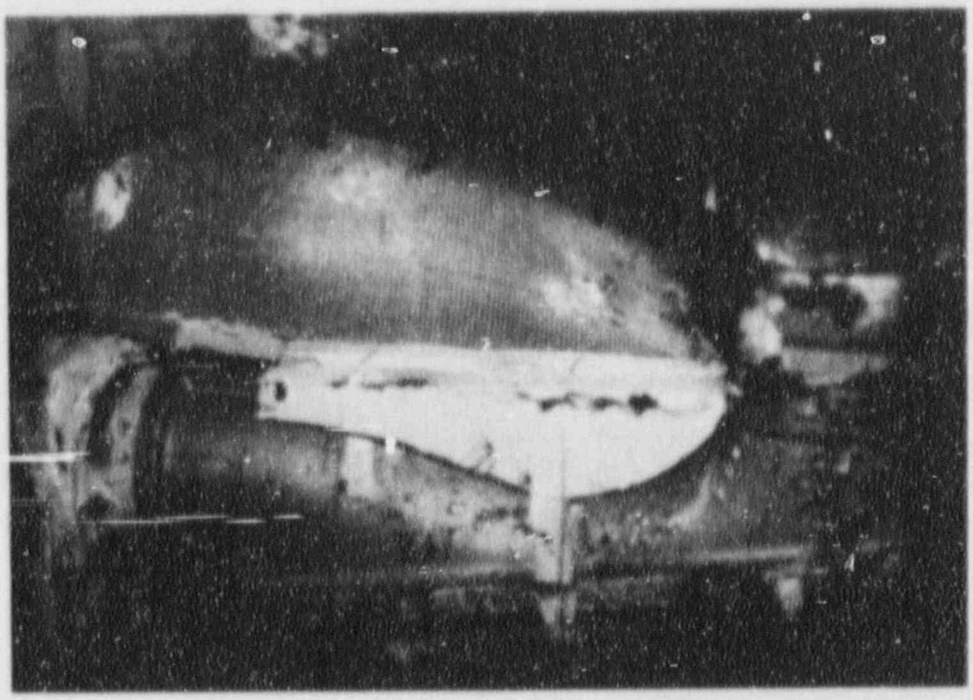
Opening of the right front LBD box.

OMEGA POINT LABORATORIES

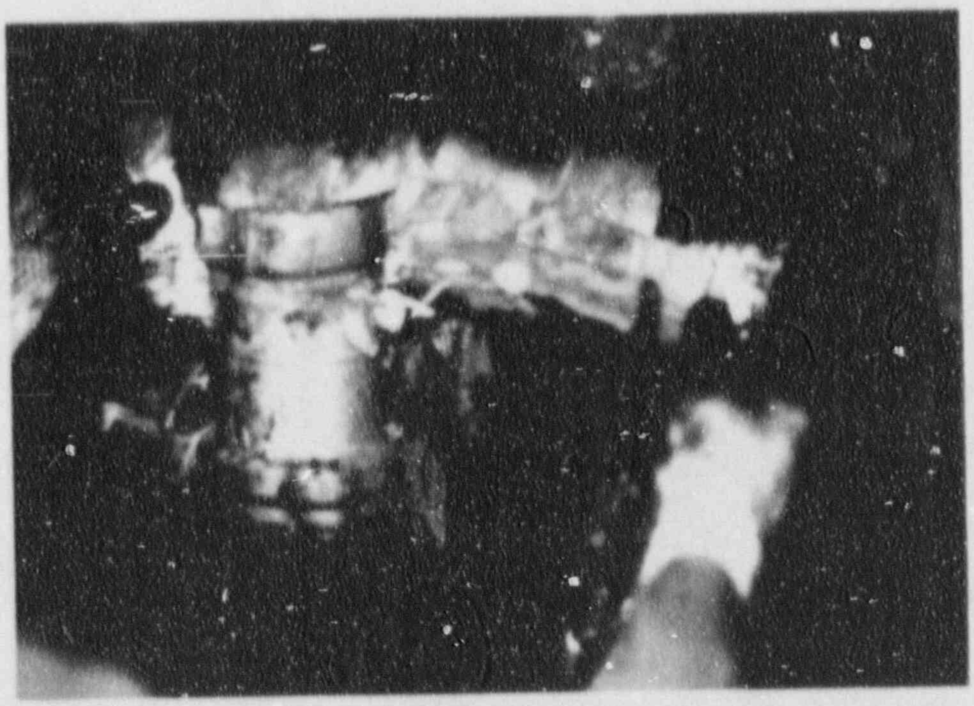


Interior view of the right front LBD box.

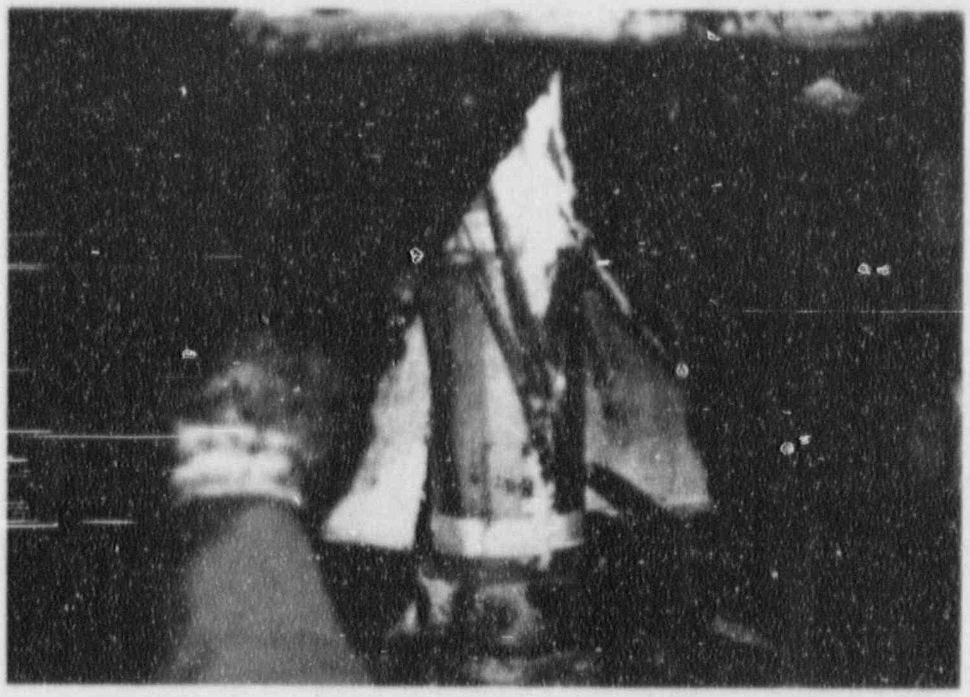
Inside view of bottom of right front LBD box.



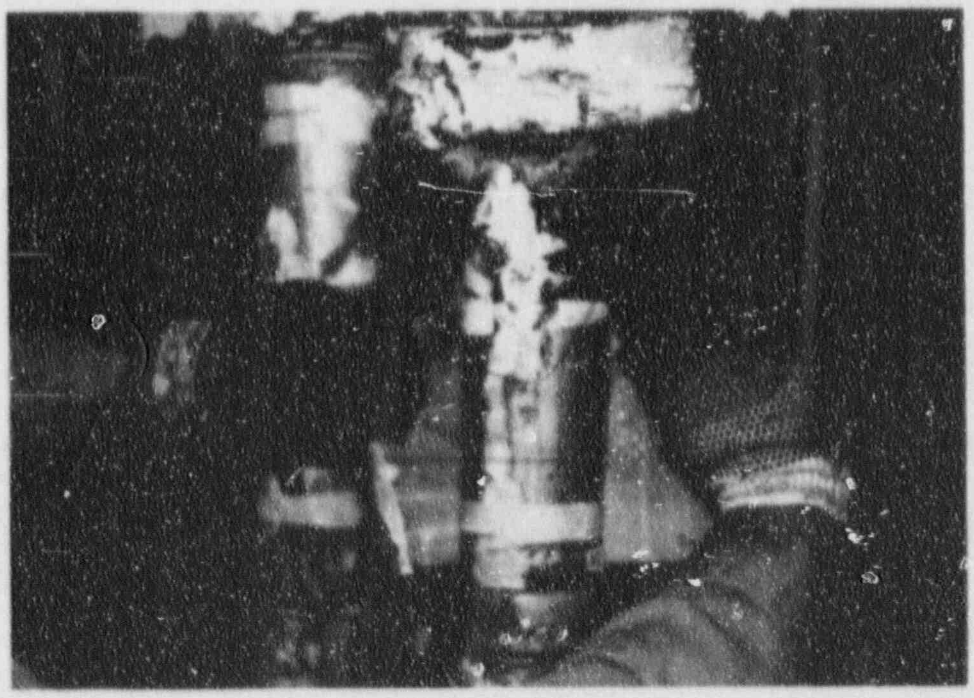
Inside view of top of right front LBD.



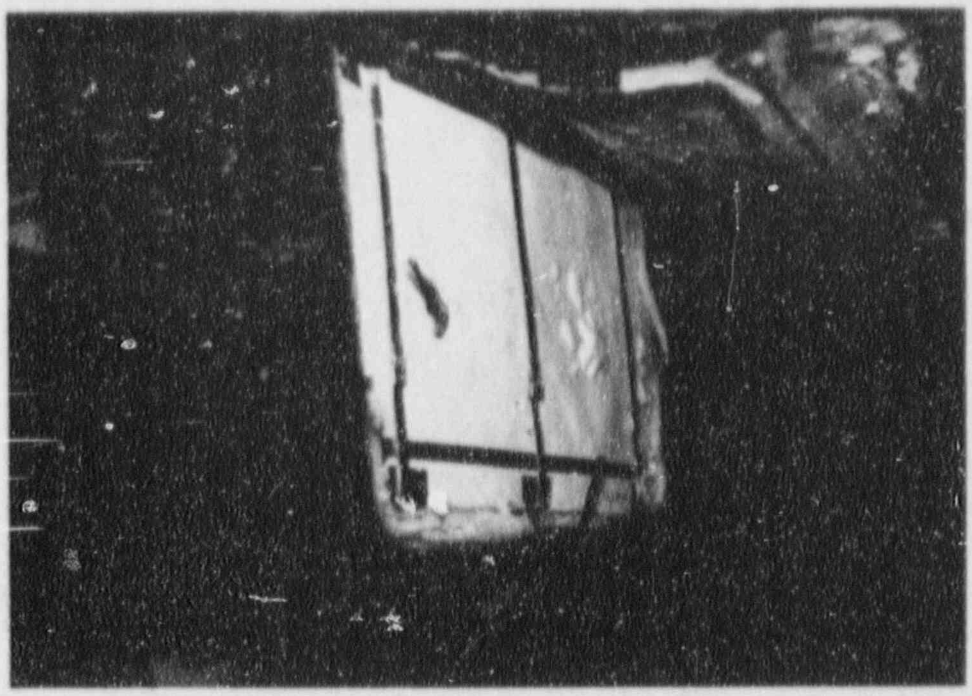
Overlay collar at condulet exit point on right front condulet.



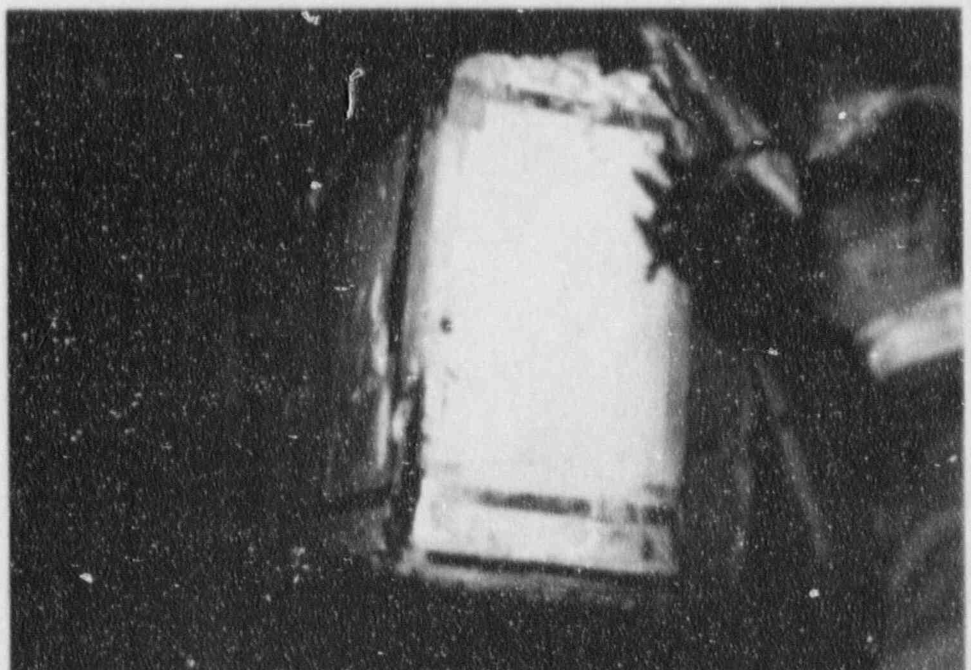
Vertical conduit section between right front condulet and vertical junction box.



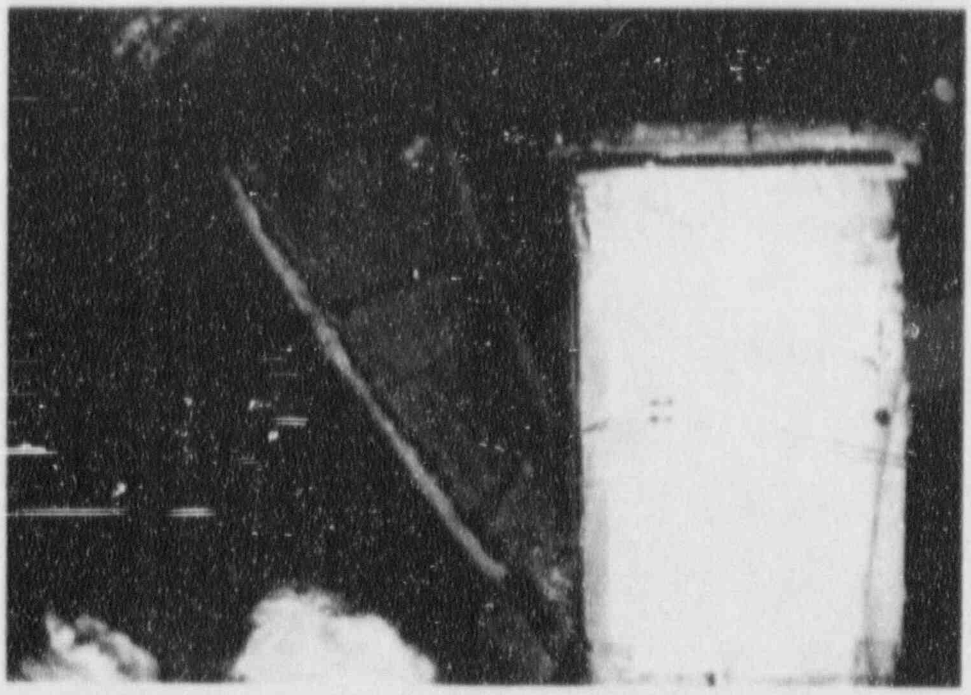
Vertical conduit section between right rear condulet and vertical junction box.



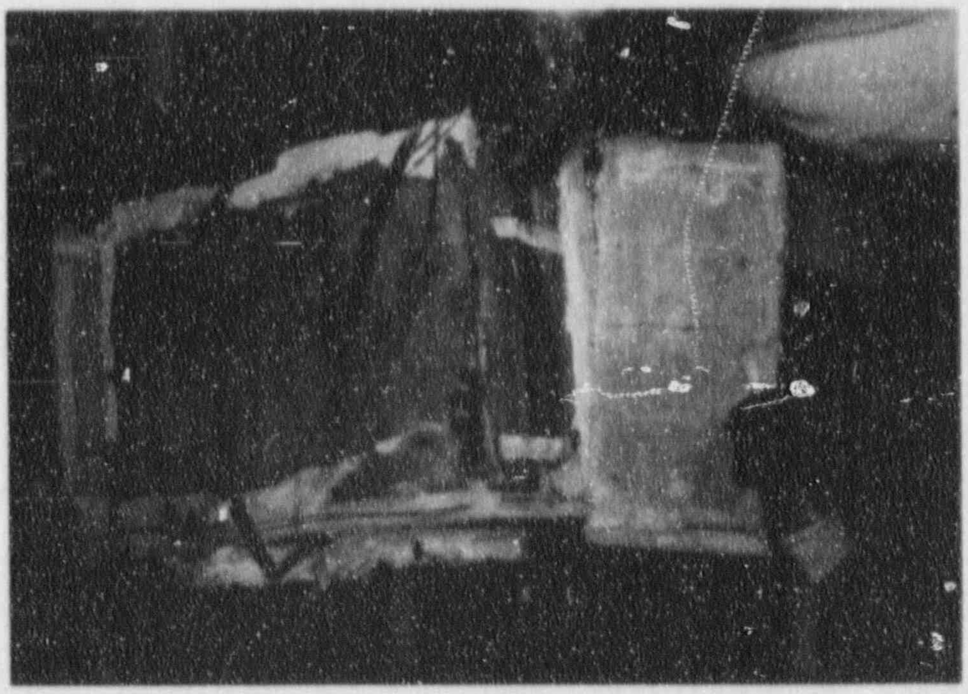
Outer layer removed from right surface of vertical junction box.



Outer layer removed from front surface of vertical junction box.



Outer layer removed from left (interior) surface of vertical junction box.



Inner layer removed from right and rear surfaces of vertical junction box.

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Inner layer removed from front surface of vertical junction box.

Inner layer removed from left (interior) surface of vertical junction box.

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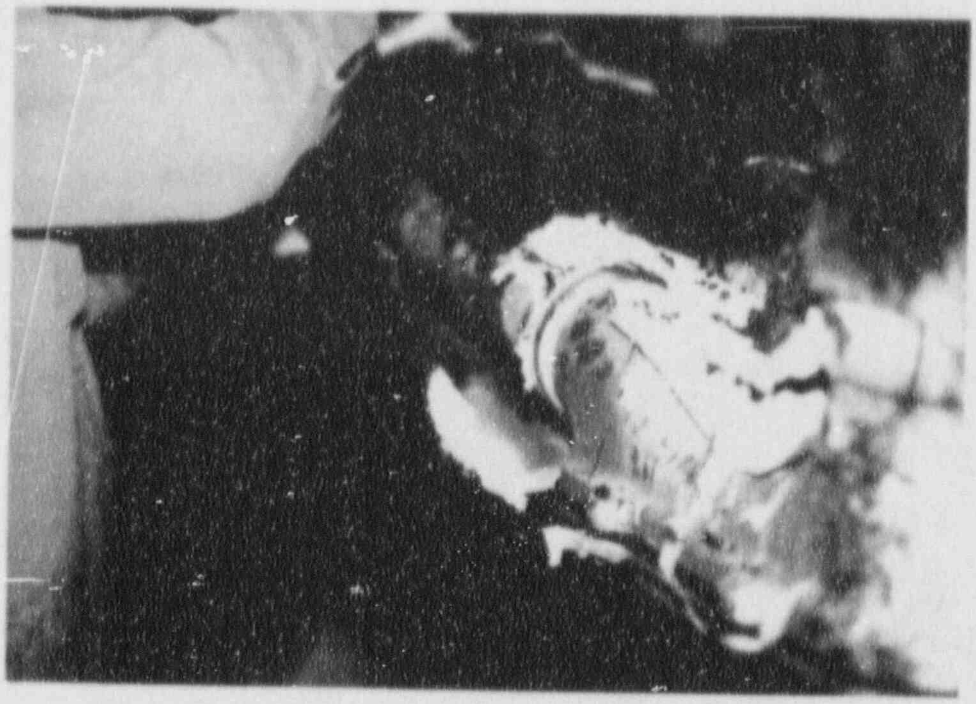

View of front right condulet and conduit between condulet and horizontal junction box.

View of front right horizontal conduit run.

View of right rear horizontal conduit run.

Opening of left front LBD box.

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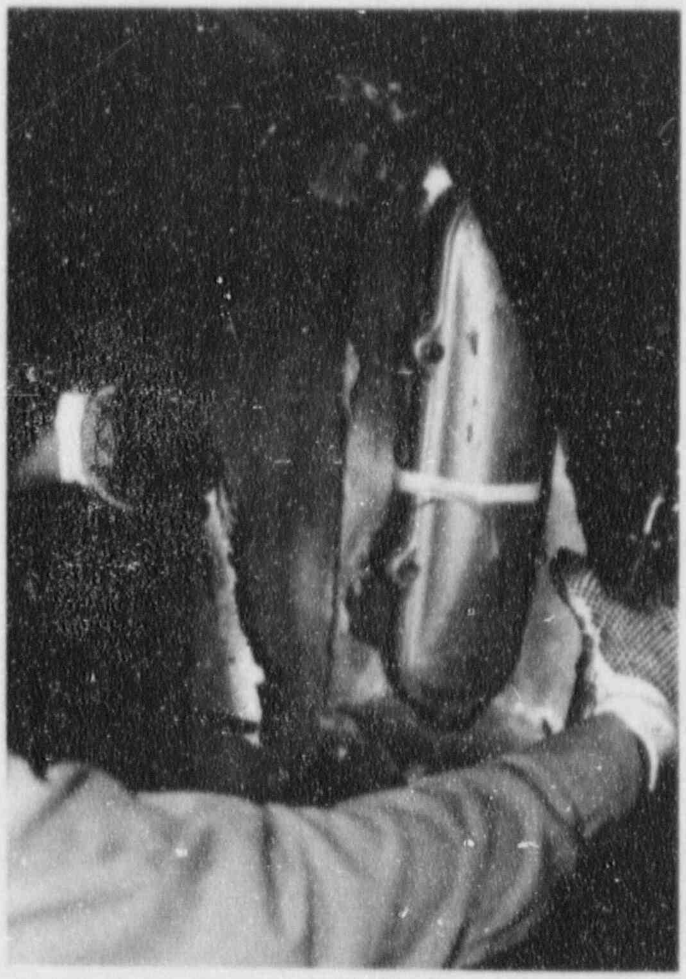
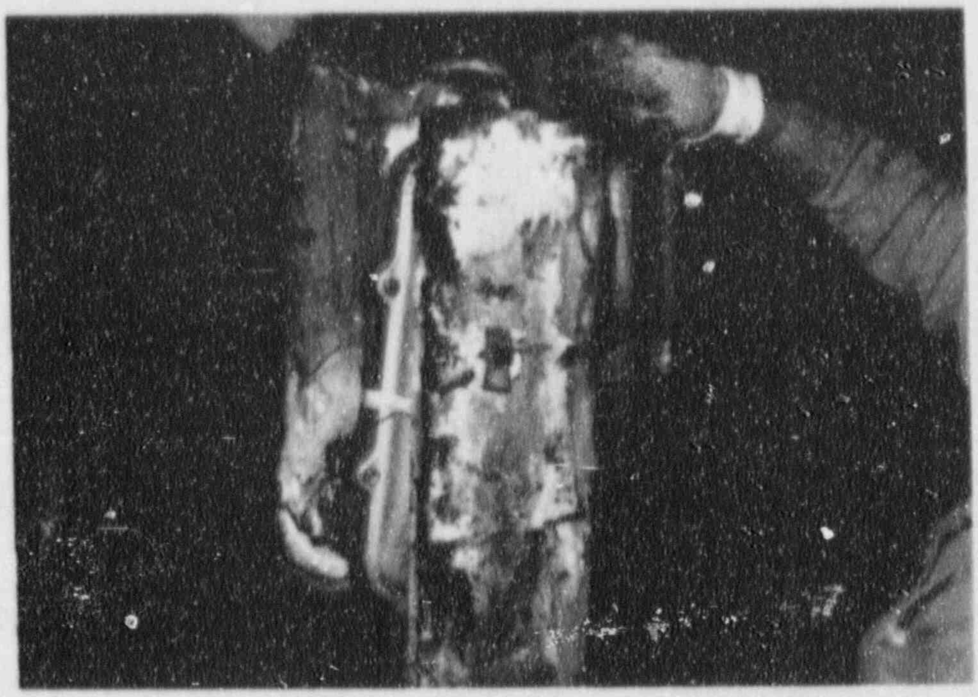
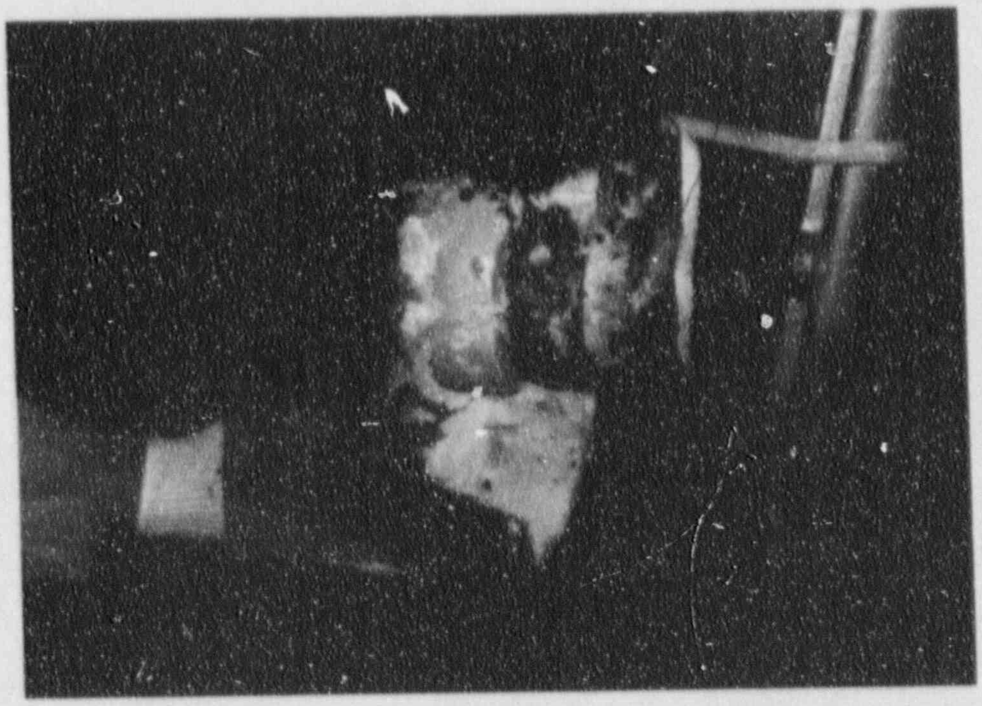


Opening of the left rear LBD box.

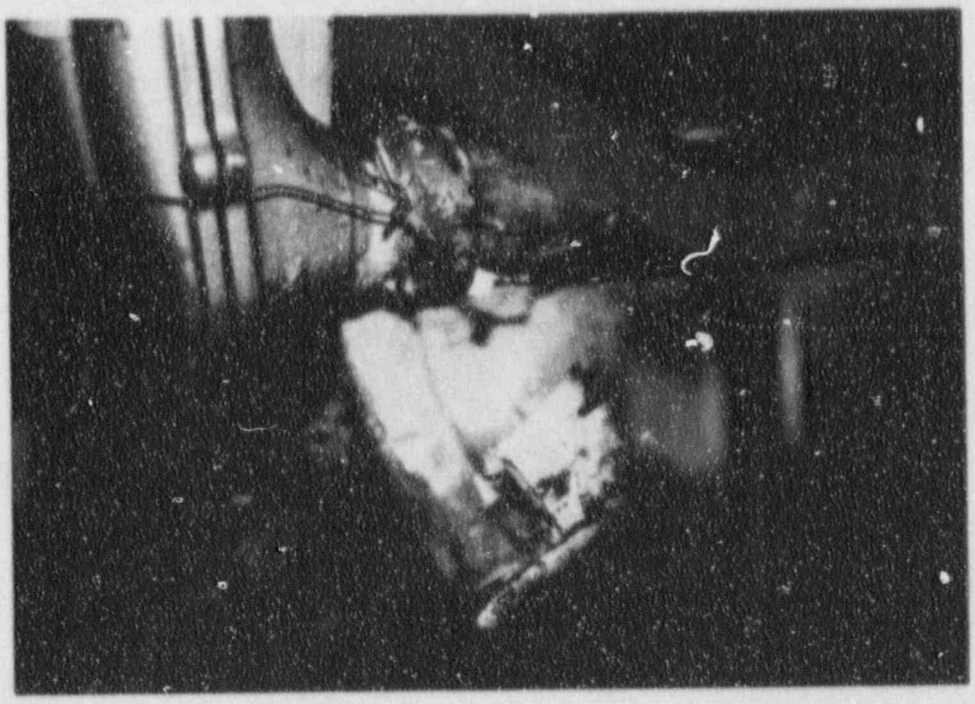


View of piece between left condulets.

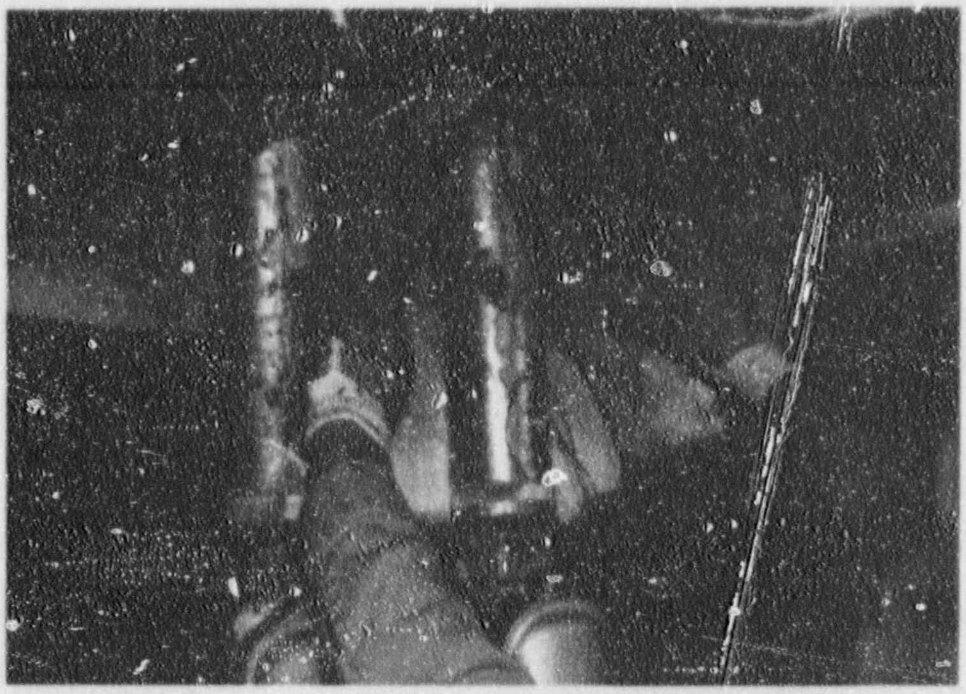


Collar at entry point of left rear condulet.

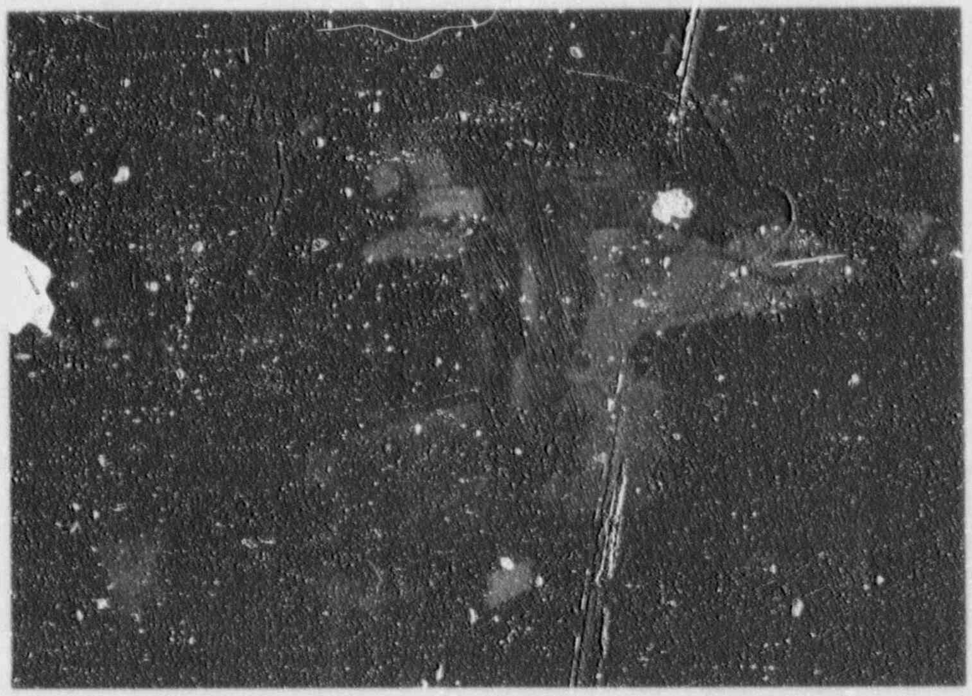
View of left rear horizontal conduit run.



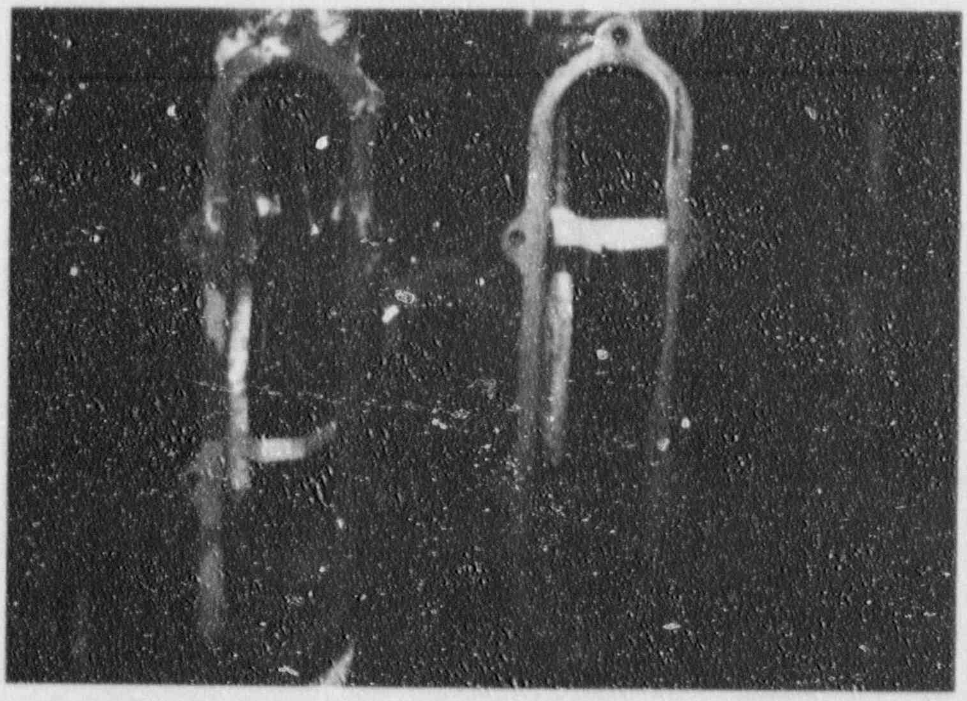
View of left front condulet and horizontal conduit run.



View of left vertical conduit runs.

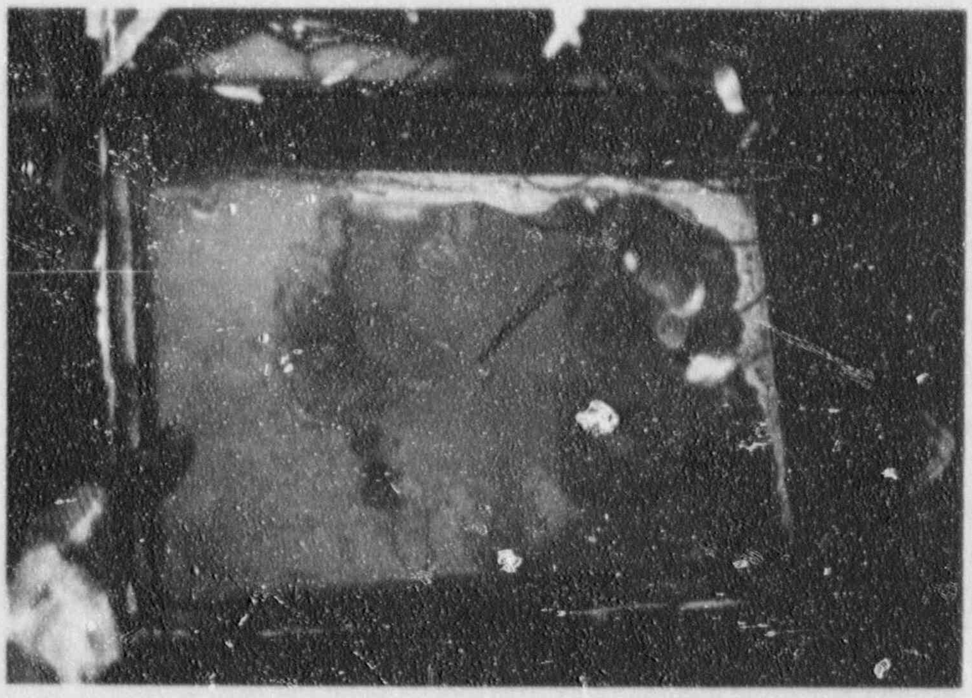


Collars at entry point on left side of horizontal junction box.

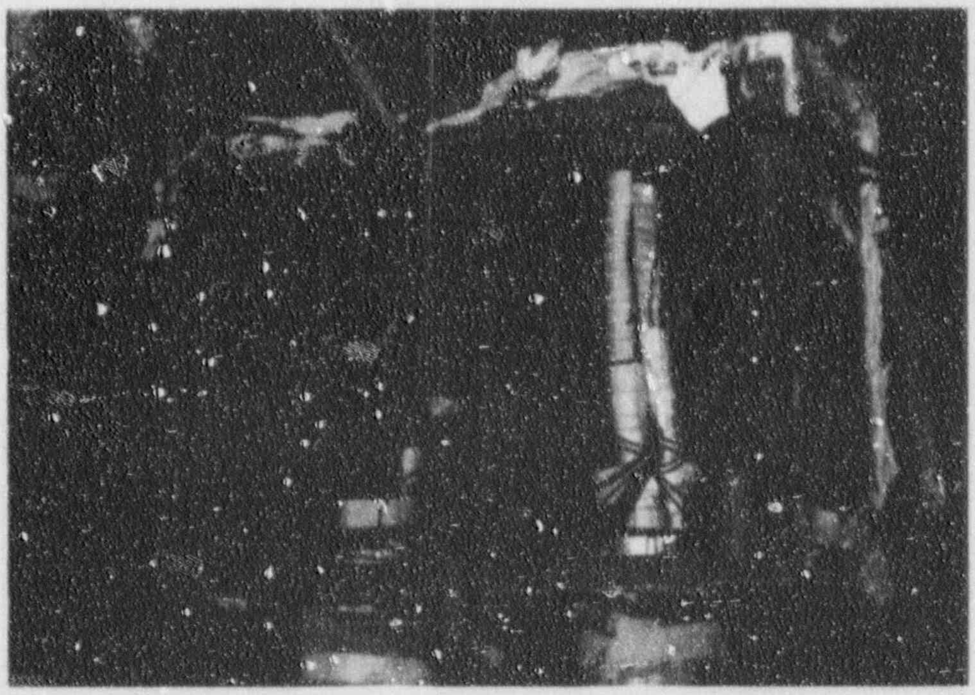


View of cables inside left side condulets.

View of cables inside right side condulets.



Interior view of horizontal junction box.



Interior view of vertical junction box.

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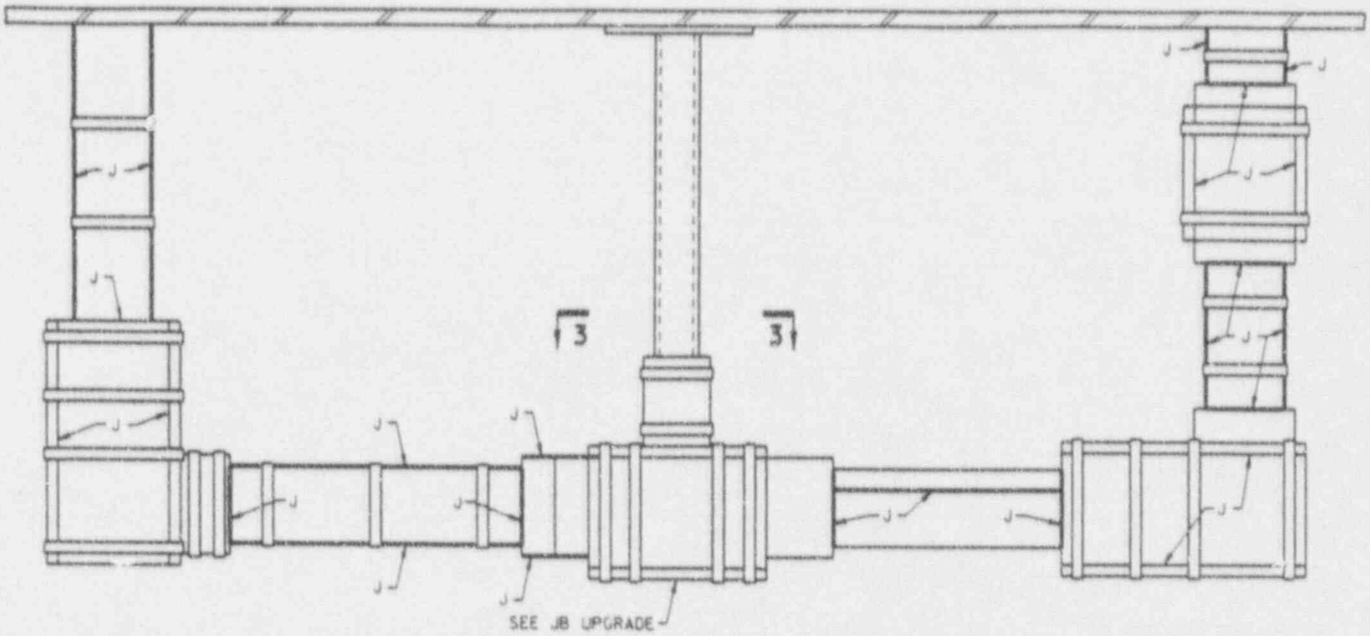
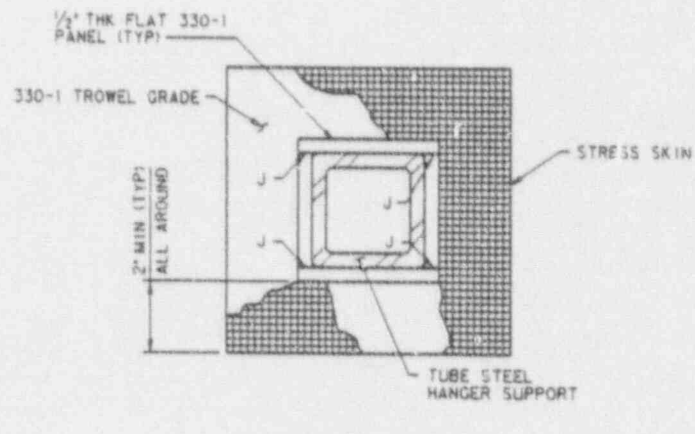
Appendix J

THERMO-LAG® INSTALLATION DETAILS

SCHEME 10-1
2-3" DIA CONDUITS W/JUNCTION BOX



ELEVATION

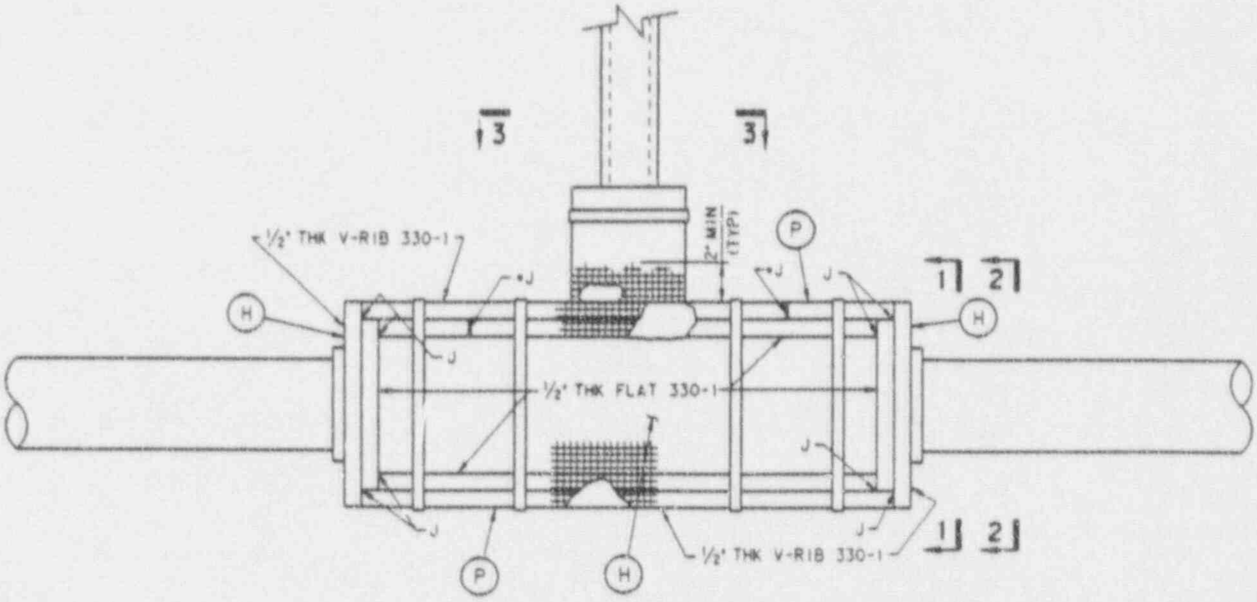


SECTION 3-3

TU ELECTRIC CPSES GLEN ROSE, TEXAS		
FIRE TEST ASSEMBLY		
DWG. NO.	SH. NO.	REV.

TLAG00005.10N

SCHEME 10-1



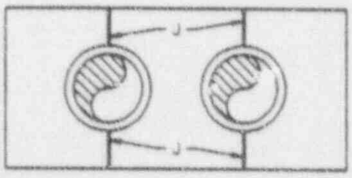
TYPICAL JUNCTION BOX UP GRADE
EXCEPT AS NOTED

ALL OUTSIDE JUNCTION BOX PANEL JOINTS HAVE STRESS SKIN OVERLAY

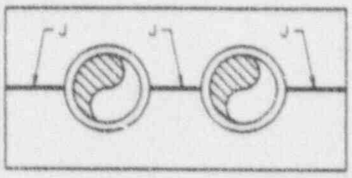
* THESE JOINTS ARE APPLICABLE ONLY WHERE HANGER SUPPORT PLATE ATTACHES TO JUNCTION BOX TOP FACE

(H) DENOTES V-RIB EXTENDING HORIZONTAL

(P) DENOTES V-RIB EXTENDING PARALLEL TO RACEWAY



SECTION 1-1
V-RIB 330-1 PANEL JOINTS
OUTSIDE LAYER



SECTION 2-2
FLAT 330-1 PANEL JOINTS
INSIDE LAYER

TU ELECTRIC CPSES GLEN ROSE, TEXAS
FIRE TEST ASSEMBLY
DWG. NO. / SH. NO. / REV.

TLAG00005.12N

Appendix K

NUCLEAR REGULATORY COMMISSION LETTER

OMEGA POINT LABORATORIES

510

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

October 29, 1992

Docket No. 50-446

Mr. William J. Cahill, Jr.
Group Vice President, Nuclear
TU Electric
400 North Olive Street, L.B. 81
Dallas, Texas 75201

Dear Mr. Cahill:

SUBJECT: THERMO-LAG ACCEPTANCE METHODOLOGY FOR COMANCHE PEAK STEAM ELECTRIC STATION - UNIT 2

The NRC staff has completed a review of TU Electric's submittal dated September 24, 1992, "Confirmatory Testing of Thermo-Lag Fire Barrier System at CPSES." A meeting was held on October 27, 1992 between NRC and TU Electric, where you updated your fire barrier testing acceptance criteria. The enclosure to this letter provides the revised acceptance criteria you proposed at that meeting.

This letter informs you of the results of the staff review of your criteria. Final NRC staff review of your fire barrier acceptance testing will be documented in a future safety evaluation.

Your acceptance criteria, including the use of a fog hose stream test in accordance with NUREG-0800, is acceptable based on the following conditions:

1. The NRC maintains that the temperature measured on the external surface of the raceway should not exceed 325°F. Your criteria, submitted in your September 24, 1992 letter, states that cable temperatures are to be maintained below 325°F[1] as measured by thermocouples installed at six-inch intervals on cables close to the inside of the protective envelope.

   In your previous tests, the raceway, in addition to the cables, was instrumented with thermocouples. These thermocouples provide a better indication of barrier unexposed side thermal performance during the fire test. You have stated that you will be monitoring various raceway locations in these upcoming tests; however, in reviewing your criteria as submitted in your September 24, 1992 letter, we could not determine how you propose to evaluate the barrier's thermal performance using the raceway thermocouples.

---

[1] The 325°F temperature condition was established by allowing the internal temperature on the raceway surface to rise 250°F above ambient laboratory air temperature, assumed to be 75°F, during the fire test.

In the October 27, 1992 meeting, we discussed this concern and your staff indicated that the cable tray side rail and the external conduit temperatures would be used to determine the temperature acceptance of the fire barrier system. In addition, your staff agreed, for cable trays, to also use the cable thermocouple temperature readings to supplement the raceway thermocouples in assessing the thermal performance of the fire barrier system.

With respect to determining the temperature acceptance criteria, the NRC staff considers thermocouple averaging acceptable, provided similar series of thermocouples (e.g., cable tray side rail) are averaged together. It was determined that the temperature performance of the cable tray fire barrier would be based on temperature averages (i.e., the thermocouples on each side rail, and the thermocouples on each of the three instrumented cables) and would be independently evaluated against the temperature acceptance criteria. In addition, it was agreed that averaging the thermocouples on the external conduit surface would be used to evaluate the thermal performance of the conduit fire barrier system. It is our understanding that your temperature acceptance criteria would find the test results in deviation if the average temperature of any thermocouple series exceeds the 250°F plus ambient condition or if any single thermocouple exceeds 30 percent above the maximum allowable temperature rise (i.e., 250°F + 75°F = 325°F, above ambient) during the test. If this occurs, under your criteria a visual inspection of the cables for signs of thermal damage is required. Any sign of thermal cable damage would be a deviation to the fire barrier requirements which would require the functionality of the cabling to be demonstrated by testing.

2. Your barrier inspection criteria, submitted in your September 24, 1992 letter, allows burnthrough no greater than one-half square inch. In the October 27, 1992 meeting, your staff revised its position on burnthrough. In this meeting your staff indicated that any burnthrough is now a deviation requiring cable functionality testing. If burnthrough occurs, based upon visual examination and notwithstanding the size of the defect, the NRC views the fire barrier as deviating from the fire barrier requirements and would require that cable functionality be demonstrated.

3. Your visual cable acceptance criteria, submitted in your September 24, 1992 letter, stated that none of the following attributes should be identified: jacket swelling, splitting, or discoloration; shield exposed; or jacket hardening. The NRC staff has determined that the following attributes also indicate thermal degradation: jacket blistering, cracking or melting; conductor insulation exposed, degraded, or discolored; and bare copper conductor exposed. It is our understanding that your criteria for visual cable acceptance will include all of the above attributes.

4. Your acceptance methodology calls for a megger test after the cable has been installed in the raceway, continuity measurements during the test, and a subsequent megger test immediately following the test. At the October 27, 1992 meeting, you provided additional details and clarification regarding your proposed testing to demonstrate cable functionality. Additionally, you stated that you may use loss-of-coolant-accident (LOCA) cable qualification test results in evaluating cable functionality at elevated temperatures.

At the October 27, 1992 meeting, the NRC staff described the following tests which can be used to demonstrate functional performance of cables where there are signs of thermal damage to cables or where barrier burnthrough or openings occur:

The megger tests (pre-fire, during the fire [if performed], and immediately after the fire test conditions) should be done conductor-to-conductor for multiconductor and conductor-to-ground for all cables. The minimum acceptable insulation resistance (IR) value, using the test voltage values for various system voltages is determined by using the following expression:

$$\text{IR (Mega-ohms)} \geq \frac{\{[(1 \text{ Mega-ohm per KV}) + 1] * 1000(\text{ft})\}}{\text{Length (ft)}}$$

In addition, an AC or DC high potential (Hi-Pot) test for power cables greater than 1000 volts should be performed after the post fire megger tests to assess the dielectric strength. This test provides assurance that the cable will withstand the applied voltage during and after a fire. The high potential test should be performed for a five minute duration at 60 percent of either 80 volts/mil AC or 240 volts/mil DC (e.g., 125 mil conductor insulation thickness X 240 volts DC X 60% = 18,000 vdc).

The table below summarizes the megger and Hi-Pot test voltages which, when applied to power, control and instrumentation cables, would constitute an acceptable cable functionality test.

TYPE	OPERATING VOLTAGES	MEGGER TEST VOLTAGE	HIGH POTENTIAL TEST VOLTAGE
POWER	≥ 1000 volts	2500 VDC	60% x 80 V/mil(AC) 60% x 240 V/mil(DC)
	< 1000 volts	1500 VDC	NONE
INSTRUMENT AND CONTROL	≤ 250 vdc ≤ 120 vac	500 VDC	NONE

In addition, at time intervals (at least once) during your one-hour fire exposure test, a megger test should be performed for instrumentation cables in order to assure that the cable will maintain sufficient insulation resistance levels necessary for proper operation of instruments. LOCA temperature profiles may be used to evaluate cable functionality instead of megger testing during the fire test. If this approach is taken, you should ensure that the LOCA temperatures bound the fire temperature profile, by including cable operating temperatures. Additionally, in determining the insulation resistance levels required for nuclear instrumentation cables, an assessment of the minimum insulation resistance value (e.g., one mega-ohm) and its potential impact on the functionality of these cables should be evaluated.

The NRC concludes that performance of your proposed testing, with the additional megger and Hi-Pot testing described above, would constitute an acceptable set of tests to demonstrate that any fire barrier test deviations, should they occur, will not affect the capability of the protected cable to perform its safety function. Other tests or combination of tests for cable functionality, different from those described above, would require NRC review and approval.

5. Discussions with your staff indicate that CPSES power and instrument cable meets IEEE-383 and is all thermoset insulation type. Additionally, you have stated that installation procedures prohibit cabling to extend above cable tray side rails. When you submit your next test summary, confirm these facts in writing.

In summary, your criteria, as supplemented with the above conditions, ensures that adequate cable and barrier tests will be performed. Satisfactory results from these tests (raceway/cable temperature <325°F and no barrier burnthrough) constitutes a satisfactory basis for rated fire barrier qualification. Where the temperature criteria is not met and cable inspection criteria results in deviation(s), and/or barrier inspection results in deviation(s), your criteria calls for subsequent cable functionality testing. Also, as discussed at the October 27, 1992 meeting, since no cabling greater than 1000 volts is being subjected to the fire tests, additional testing would be required on this voltage class to demonstrate functionality should test deviations warrant cable functionality verifications. NRC review of your test deviation(s), should they occur, will be included in the staff's safety evaluation of your fire barrier acceptance testing.

The NRC staff plans on observing your upcoming testing. Further, we request that you meet with the NRC following completion of this next set of testing to review test results.

Sincerely,

Suzanne C. Black

Suzanne C. Black, Director
Project Directorate IV-2
Division of Reactor Projects III/IV/V
Office of Nuclear Reactor Regulation

Enclosure:
TU Revised Acceptance Criteria

cc w/enclosure:
See next page

cc w/enclosure:
Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 1029
Granbury, Texas 76048

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Mrs. Juanita Ellis, President
Citizens Association for Sound Energy
1426 South Polk
Dallas, Texas 75224

Owen L. Thero, President
Quality Technology Company
Lakeview Mobile Home Park, Lot 35
4793 East Loop 820 South
Fort Worth, Texas 76119

Mr. Roger D. Walker, Manager
Regulatory Affairs for Nuclear
Engineering Organization
Texas Utilities Electric Company
400 North Olive Street, L.B. 81
Dallas, Texas 75201

Texas Utilities Electric Company
c/o Bethesda Licensing
3 Metro Center, Suite 610
Bethesda, Maryland 20814

William A. Burchette, Esq.
Counsel for Tex-La Electric
Cooperative of Texas
Jorden, Schulte, & Burchette
1025 Thomas Jefferson Street, N.W.
Washington, D.C. 20007

GDS Associates, Inc.
Suite 720
1850 Parkway Place
Marietta, Georgia 30067-8237

Jack R. Newman, Esq.
Newman & Holtzinger
1615 L Street, N.W.
Suite 1000
Washington, D. C. 20036

Chief, Texas Bureau of Radiation Control
Texas Department of Health
1100 West 49th Street
Austin, Texas 78756

Honorable Dale McPherson
County Judge
P. O. Box 851
Glen Rose, Texas 76043

CABLE FUNCTIONALITY TESTING

TEST SEQUENCE	TU ELECTRIC PROPOSAL	JUSTIFICATION
DURING FIRE TEST	CONTINUITY TEST AT 12VDC	- UL 1724 RECOMMENDS THAT LOW VOLTAGE SHOULD BE USED ON CIRCUIT DURING FIRE TESTING - LABORATORY PERSONNEL SAFETY REQUIREMENTS - LOGISTICS OF MEGGERING ALL CONDUCTORS DURING THE ONE HOUR FIRE TEST RESTRICTS INTERMITTENT TESTING - FUNCTIONALITY OF CABLE AT ELEVATED TEMPERATURE MAY BE CONFIRMED BY LOCA TEST RESULTS PROVIDED CABLE JACKET TEMPERATURES DID NOT EXCEED LOCA QUALIFICATION TEMPERATURES
AFTER HOSE STREAM TEST	HOT MEGGER TEST - INSTRUMENTATION CABLE 500VDC - CONTROL/LOW VOLTAGE CABLE AT 1500VDC	- ACCEPTANCE CRITERIA BASED ON MOST LIMITING INSTALLATION (5 M) - ACCEPTANCE CRITERIA FOR CONTROL/LOW VOLTAGE CABLE BASED ON DC EQUIVALENT TEST VOLTAGES OF RATED AC VOLTAGE (1500VDC)

Test Sequence

Build Sample
Megger

Fire Test
Measure
Continuity
Temperature

Fog Nozzel Test
Hot Megger
Fire Barrier Inspection
Functionality Tests *
Visual Cable Inspection *

*** If Required**