

**FIRE ENDURANCE TESTS
OF A WALL ASSEMBLY PROTECTED
WITH THE THERMO-LAG® 330-1
FIRE BARRIER SYSTEM**

TEST PLAN, Rev. 2

July 27, 1994

Prepared for:

Florida Power & Light Company
P.O. Box 4000
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9408240227-XA

ABSTRACT

This document consists of a Test Plan to describe the procedures and techniques to be utilized during the evaluation of a wall assembly protected with a Thermo-Lag[®]330-1 cladding.

The details and instructions contained herein will be followed in the performance of this test project.



Deggary N. Priest, President

7/27/94
Date



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TEST PLAN, Rev. 2

FIRE ENDURANCE TESTS OF A WALL ASSEMBLY PROTECTED WITH A THERMO-LAG® 330-1 FIRE BARRIER SYSTEM

1.0 SCOPE

This test plan describes the methods and guidelines to be utilized for the preparation of a test specimen, installation of a THERMO-LAG® 330-1 (hereafter referred to as "Thermo-Lag") Fire Resistive Barrier System and other raceway fire barrier materials as applicable, performance of fire endurance and hose stream tests, temperature monitoring, and all applicable documentation of these tasks and the test results. The test program will be performed under the auspices of Vectra Technologies, Inc. (hereafter referred to as "Vectra"), which will have total management responsibility for all aspects of this program.

2.0 OBJECTIVE

The objective of this test is to qualify a wall assembly clad with Thermo-Lag as meeting the requirements of ASTM E119-88 Standard Test Methods for Fire Tests of Building Construction and Materials (hereafter referred to as "E119") for a fire resistance rating of 1 hour (60 minutes).

3.0 ACCEPTANCE CRITERIA

The acceptance criteria for this test program will be in accordance with E119. The performance of the fire barrier system will satisfy these criteria provided the following conditions are met:

3.1 ASTM E119

Integrity – The wall shall have withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period of one hour.

Temperature – The average of all thermocouples installed on the unexposed surface of the wall assembly for test acceptance purposes under E119 as described in Section 6.7 shall not exceed 250°F above the average initial temperature. The maximum reading for any single thermocouple installed for test acceptance purposes under E119 shall not exceed a temperature rise of 325°F above its initial temperature.



Hose Stream Test - Following the fire endurance test, the test assembly shall be subjected to water hose stream tests as described in Section 7.2 of this Test Plan. The hose stream test shall be judged as successful if no openings develop in the wall assembly which permit a projection of water from the stream beyond the unexposed surface during the time of the hose stream test.

4.0 DEFINITIONS

- 4.1 Test Frame - A vertical, 10' x 10' (100 ft²) assembly (inside dimensions) designed to support the test item in position in front of the test furnace.
- 4.2 Test Assembly - The combination of the structural items, 24" x 24" blockout with penetrating steel sleeve duct assembly, thermocouples, protective cladding and test frame, all organized into a single assembly.
- 4.3 Fire Penetration Seal - Any fire stop seal systems which are required to be installed inside duct assemblies are not to be considered part of the test item under evaluation.
- 4.4 Thermocouple - An electrical assembly used to measure temperature, consisting of an electrically-welded, fused junction of dissimilar metals and their respective leads to the data acquisition system. The thermocouple leads are insulated with materials capable of withstanding the moisture and heat requirements of the test environment.
- 4.5 Fire Resistive Barrier System - A specific construction of devices, materials or coatings applied over the structural portion of the wall to protect against the effects of the fire exposure.

5.0 RESPONSIBILITIES

5.1 Florida Power & Light (FP&L)

- 5.1.1 Assume, through its contractor, total management responsibility of this test program and establish all required interface with the U.S. Nuclear Regulatory Commission (NRC) and industry utility representatives.
- 5.1.2 Provide all TSI Thermo-Lag barrier materials and steel primer paint for construction of the test assembly.



5.2 Vectra Technologies, Inc. (Vectra)

- 5.2.1 In coordination with FP&L, establish the criteria, guidelines, drawings, recommendations, etc., to govern the construction of the test assembly.
- 5.2.2 Provide Bill of Materials for all materials to be utilized in construction of the test assembly (not including TSI barrier materials).
- 5.2.3 In coordination with FP&L establish the criteria, guidelines, drawings, recommendations, etc., to govern the installation of the fire resistive barrier system materials to the test article.
- 5.2.4 Provide the specific fire barrier system installation procedures and training of Peak Seals, Inc. installation personnel.
- 5.2.5 Coordinate with FP&L to provide Thermo-Lag Fire Barrier System.
- 5.2.6 Provide scheduling of personnel, equipment and material necessary to perform the installation.
- 5.2.7 Coordinate all phases of the fire test preparation with the testing organization including approval of variations from the test methodology described herein.
- 5.2.8 Coordinate the application of the fire barrier system and penetration seal to the test article.
- 5.2.9 Coordinate and witness performance of the fire and hose stream testing.
- 5.2.10 Coordinate with OPL preparation of the Test Plan and assembly drawings, including review and documented (by separate correspondence) approval.
- 5.2.11 Coordinate with OPL, preparation of the Test Report including review, comments and final documented concurrence (by separate correspondence).

5.3 Peak Seals, Inc. (Peak Seals)

- 5.3.1 Provide qualified quality control personnel for this test program for the purpose of assuring that raceway fire barrier systems



and penetration seals as applicable are installed and documented in accordance with applicable Vectra procedures.

- 5.3.2 Provide qualified labor personnel for the construction and application of the fire resistive barrier system and penetration seal as applicable.
- 5.3.3 Provide the testing organization with all applicable fire barrier/penetration seal installation and QA/QC documentation.
- 5.3.4 Provide stainless steel banding and wing clips for fastening Thermo-Lag panels to the penetration sleeve and provide all penetration seal materials for the penetration (Promatec 45B Silicone Elastomer, ceramic fiber blanket, Marinite Board, Dow Corning 96081 Caulk).
- 5.3.5 Provide all tools required for installation of Thermo-Lag barrier materials and penetration seal

5.4 **Omega Point Laboratories, Inc. (OPL)**

- 5.4.1 OPL shall coordinate with Vectra to develop the Test Plan.
- 5.4.2 Provide and prepare the test furnace and test frame, and provide all required test instrumentation in accordance with Appendix B Quality Assurance Program and other applicable procedures.
- 5.4.3 Provide thermocouples and thermocouple calibration and instrumentation, furnace temperature probes, storage temperature and relative humidity recorder.
- 5.4.4 Procure, all materials (except Thermo-Lag and penetration seal barrier materials) as required to construct the test assembly. Such materials may include but are not limited to tools and equipment, fasteners, duct components and structural steel components as shown on drawings and listed in the Bill of Materials.
- 5.4.5 Assemble, install and document the installation of the duct system. Provide computer-generated drawings of the test article which clearly indicate dimensions, thermocouple locations, etc.
- 5.4.6 Observe and document the installation of all fire barrier system materials and penetration seals to the test article, and attendant instrumentation.



- 5.4.7 Conduct the fire endurance and hose stream tests.
- 5.4.8 Inspect and document the physical condition of the fire barrier system and fire penetration seal following completion of water hose stream tests.
- 5.4.9 Document the test parameters and provide a formal detailed written report of the test program and test results.
- 5.4.10 Provide VHS video and 35mm photographic coverage of the uncovered test item, appropriate portions of the fire barrier installation procedure, the clad test article prior to testing, the fire and hose stream tests, and the post-test disassembly of the test article.
- 5.4.11 Provide equipment for, monitor and document conditioning of fire barrier materials as described in Section 6.10, prior to the fire endurance testing.

5.5 Laboratory Quality Assurance/Quality Control

- 5.5.1 Receive, inspect, and record all test article and fire barrier materials. Verify the quality control documentation (lot numbers, etc.) of the fire barrier system materials used in the test program. Receive, inspect and log the physical characteristics of materials as appropriate.
- 5.5.2 Verify and document that the materials used and construction of the test article comply with applicable drawings.
- 5.5.3 Witness the processes utilized in the installation of the fire barrier system and penetration seal materials, and suitably document observations in event logs, inspection reports, etc.
- 5.5.4 Inspect and document the instrumentation of the test article.
- 5.5.5 Provide written calibration documentation of all thermocouples, measurement devices and data acquisition systems used in this test program.
- 5.5.6 Provide Personnel Certifications and Qualifications.
- 5.5.7 Document Quality Assurance/Quality Control inspections on Laboratory checklists or traveler packages for the test assembly.



5.5.8 Document moisture content of the test article between completion of construction and testing with a Delmhorst Moisture Meter (see 6.8.4).

6.0 PREREQUISITES

6.1 General Test Configuration Requirements

The wall and penetration designs used in this test program shall be representative of configurations in use and shall be specified and designed by FP&L and its contractors.

6.2 Traceability Requirements

To insure that the materials used in this test are representative of those in actual use, all aspects of traceability as required by the Laboratory QA Program shall be applied. Structural steel (3"x3"x3/8" steel angle), fasteners (1/4" bolts, washers and nuts), duct steel (1/4" steel plate), welding materials and thermocouple pads shall be excluded from the traceability requirements. OPL will maintain all pertinent documentation for the program.

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

6.3 Dimensioned Drawings

6.3.1 All test articles shall conform to the dimensioned drawings provided by Vectra. All changes to these drawings shall be made by revision or design change "redline" process in accordance with applicable Vectra procedures. Final revisions of all drawings shall be delivered to OPL for inclusion into or use in preparing final test reports. Final, dimensioned drawings for test report purposes will be prepared by Vectra.

6.3.2 OPL will prepare drawings of installed barrier materials on the test assemblies. These drawings will identify all joints, dimensions, material types, grade techniques, etc. Final drawings will be prepared by OPL.

6.4 Test Configuration

6.4.1 General

The test article shall be sufficiently secured to the test frame and sealed by Laboratory personnel, in accordance with



instructions and drawings. The test frame will consist of a steel frame, lined with concrete masonry, with inside dimensions of 10 ft x 10 ft.

6.4.2 Test Article

The test article will be constructed in accordance with drawings provided by Vectra. Installation of fire resistive barrier materials will be in accordance with applicable drawings provided by Vectra and documented as described in Section 6.3.

6.5 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: $\pm 1.1^{\circ}\text{C}$) electrically welded thermojunctions, with Teflon[®] insulation. Calibration will consist of manufacturer-supplied (and audited as Class A Vendor as defined in OPL Quality Assurance Procedures Manual, Rev. B) 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 requirements:

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

ASME E119 Qualification Thermocouples

Temperature readings shall be taken at not less than nine points on the unexposed surface of the test wall. Five of these shall be symmetrically disposed, one to be approximately at the center of the specimen, and four at approximately the center of its quarter sections. The other four or more shall be located at the discretion of OPL, with agreement by Vectra. None of the thermocouples shall be located nearer to the edges of the test specimen than 12 inches. None of the thermocouples shall be located over fasteners.

All temperatures shall be measured with thermocouples placed under flexible pads (Ceraform 126, manufactured by Manville Specialty Products, $6 \pm 1/8$ inches x $6 \pm 1/8$ inches by 0.375 ± 0.05 inches thick, all other details being as described in the E814 standard) held firmly against the surface and fit closely about the thermocouple. The



thermocouple leads under the pads shall be electrically insulated with heat- and moisture-resistant coverings.

At least one thermocouple shall be placed at each of the following locations on the unexposed surface of the penetration seal assembly. Additional temperature measurements may be made at the discretion of OPL, with agreement by Vectra.

At least one point on the unexposed surface of the wall assembly that is a minimum of 1 inch from the opening.

All temperatures shall be measured with thermocouples placed under flexible pads (Ceraform 126, manufactured by Manville Specialty Products, 2 ± 0.04 inches x 2 ± 0.04 inches by 0.40 ± 0.05 inches thick) held firmly against the surface and fit closely about the thermocouple. The thermocouple leads under the pads shall be electrically insulated with heat- and moisture-resistant coverings.

6.6 Installation of the Fire Barrier system to the Test Articles

Fire Resistive Barrier System materials shall be installed by Peak Seals, Inc. in accordance with applicable design drawings to be issued by Vectra. Details of the Fire Barrier System configurations including fasteners, orientation of structural ribs, etc., shall be documented in the final test report.

6.7 Fire Seal Installation

Upon completion of the fabrication and installation of the fire barrier systems to the test article (or prior to, depending upon the situation), the duct opening in the test article shall be sealed by Peak Seals, Inc., in accordance with applicable design drawings.

Failure of the fire seal shall not necessarily constitute a failure of the wall assembly. The type of fire seal used shall be as specified by Vectra.

6.8 Preburn Inspection

6.8.1 Prior to the commencement of the fire endurance test, a thorough check of the test assembly and associated equipment (including data recording equipment) and completion of applicable Laboratory QA/QC checklists shall be performed and documented by the testing laboratory.

6.8.2 Vectra shall inspect the Fire Barrier System for surface defects, etc. prior to test.



- 6.8.3 Written approval of the construction, assembly, installation and instrumentation will be supplied by Vectra and the Laboratory prior to performance of the fire exposure test (a sign-off sheet for this purpose will be supplied by the Laboratory).
- 6.8.4 Prior to commencement of the fire endurance test, the completed test specimen shall be equilibrated with the laboratory environment. The moisture content of the Thermo-Lag Fire Barrier Materials shall be documented at regular intervals prior to the fire endurance test to demonstrate establishment of equilibrium conditions. A Delmhorst, Model DP hand held meter (or equivalent), suitably calibrated, shall be used for measurement of moisture content.

7.0 PROCEDURE

7.1 Fire Endurance Test

- 7.1.1 The protected test article shall be exposed to the standard time/temperature curve found in ASTM E119-88 for a minimum period of one hour.
- 7.1.2 The testing organization (OPL) 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.

7.2 Water Hose Stream Tests

- 7.2.1 Immediately following the fire endurance test, accessible surfaces of the protected test article shall be subjected to a fog nozzle water hose stream test. The hose stream shall be delivered through a 1-1/2" adjustable stream fog nozzle, adjusted to a 30° fog pattern at a minimum of 75 psi and 75 gallons per minute. The nozzle shall be a maximum of 5' - 0" from the surface of the test assembly and the hose stream shall be applied for a period of five minutes.
- 7.2.2 Immediately following the fog nozzle hose stream test and inspection, accessible surfaces of the protected test article shall be subjected to a second water hose stream test. The hose stream shall be delivered from a distance of 20 feet, through a 2-1/2 inch hose discharging through a National Standard Playpipe



of corresponding size equipped with a 1-1/8" discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure at the nozzle shall be 30 psi and shall be applied for a period of one minute. Proper safety precautions shall be exercised.

7.3 Fire Protective Barrier & Penetration Seal Inspection

7.3.1 During and following each Water Hose Stream Test a visual inspection will be conducted of the fire protective barrier including all material and seams. The condition of the cladding will be documented, including any locations where there is evidence of burn through or opening of the barrier, on a "Barrier Inspection Data Sheet." All inspection data will be recorded in the final test report.

8.0 DATA SYSTEMS

- 8.1 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 and displayed 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). The test report will contain thermocouple data at one minute intervals.
- 8.2 Monitoring of all thermocouples will be terminated upon completion of the fire endurance test.

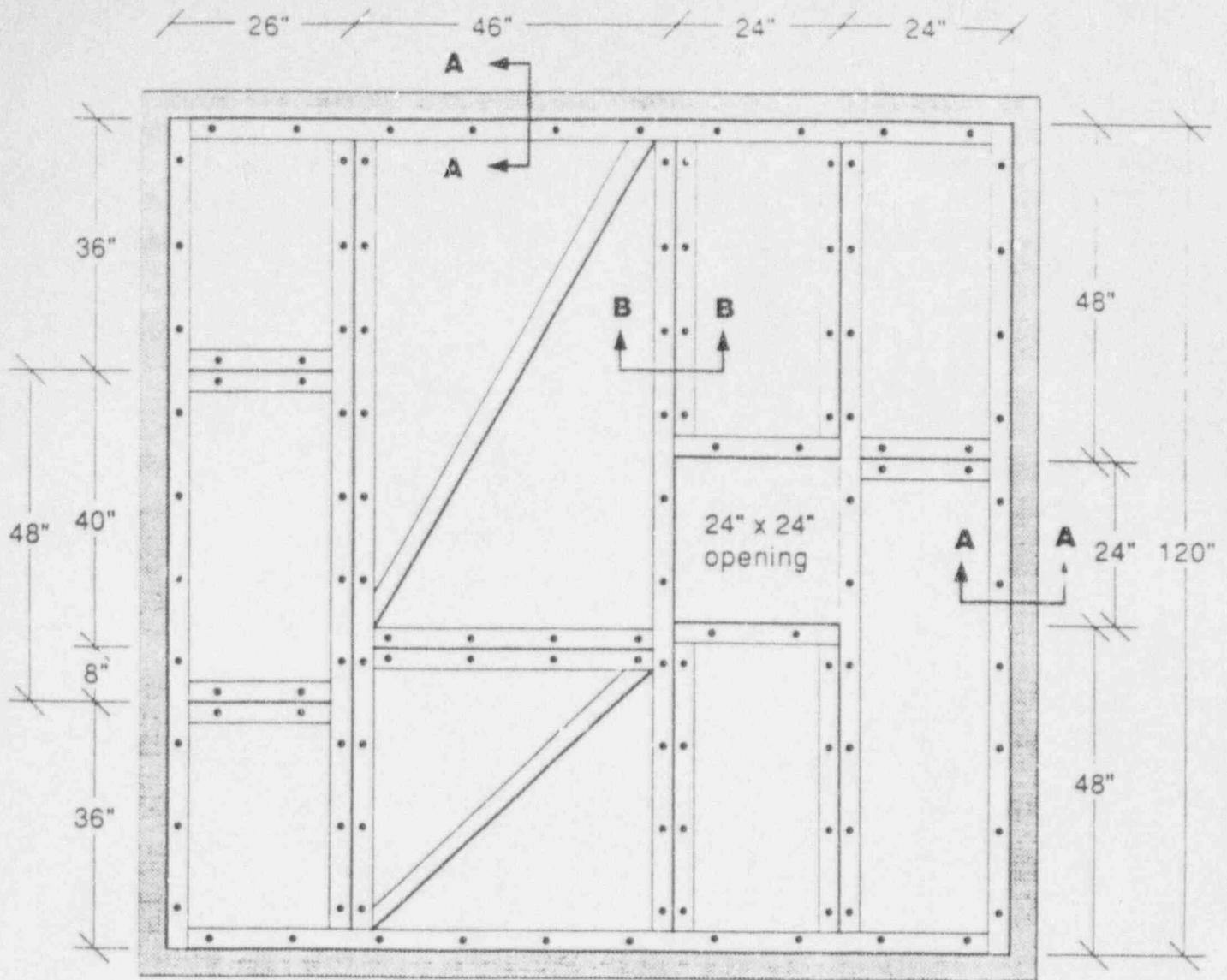
9.0 FIRE TEST REPORT

- 9.1 The Laboratory will submit a report on the results of the test and thermocouple data.
- 9.2 The Laboratory will assemble the final test report, containing the collected data and required quality control documentation.
- 9.3 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) Quality control records for:
 - Test article construction
 - Qualification and certification for installation and inspection personnel
 - Identification and installation of fire barrier material
 - Thermocouple locations
- i) Computer printout and graphic results of the fire endurance test
- j) All raw data including thermocouple measurements
- 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) Post test fire protective barrier and fire penetration seal inspection records and results





ELEVATION VIEW
FROM EXPOSED SIDE

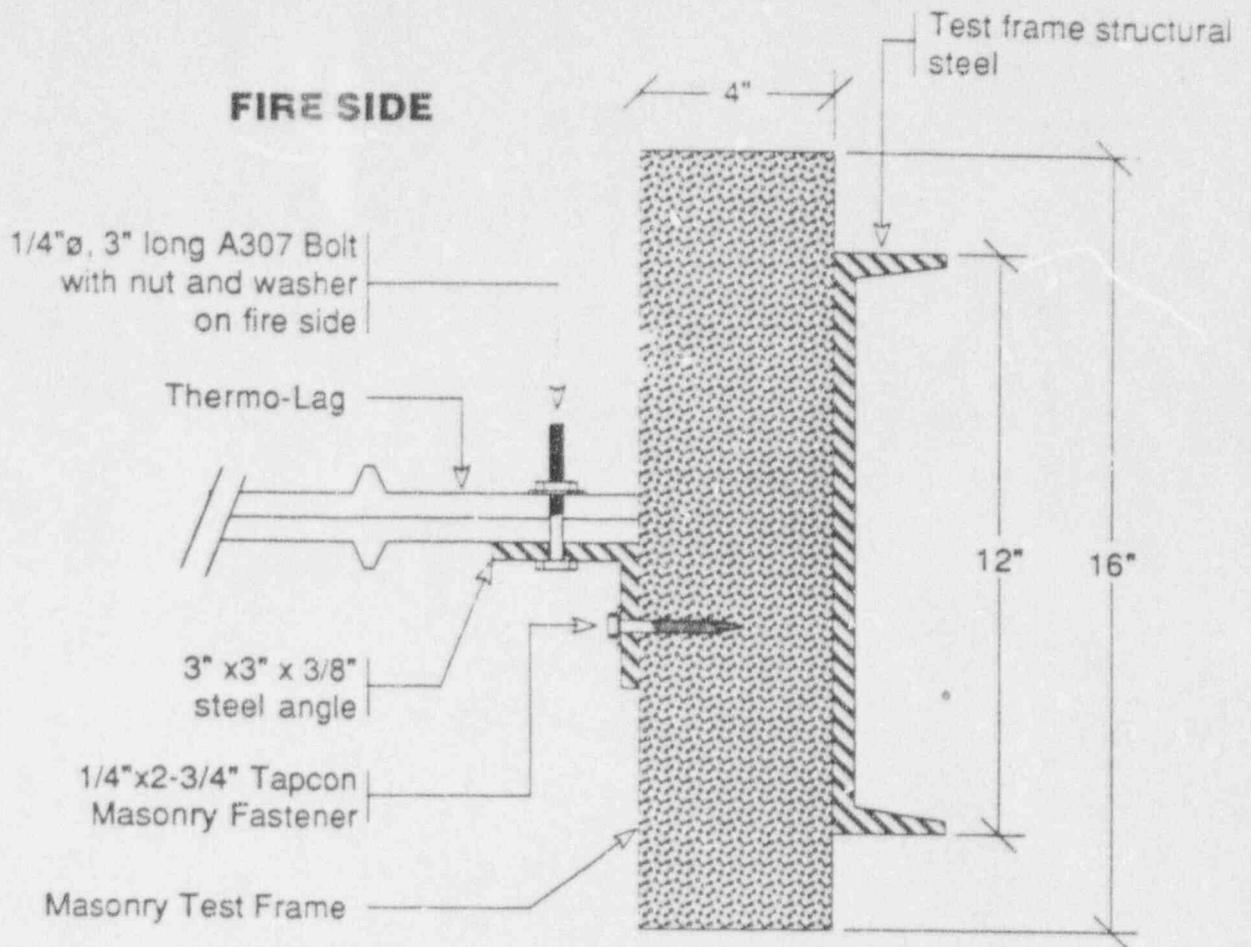
NOTE:

All structural steel shown on this drawing consisted of 3" x 3" x 3/8" steel angle, including the seismic bracing angles. Where two angles are shown back to back, they were welded along the joint on their flat sides (exposed surface of the wall) with nominal 3/16" fillet welds. The 24" x 24" opening contained a 24" x 24" steel duct section, passing through the wall horizontally, at a 45° angle to the wall plane (not shown on this drawing).

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 1 Test Article -- ELEVATION VIEW	
Drwn by: D.N. Priest	Date: 7/26/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 1/2"=1'



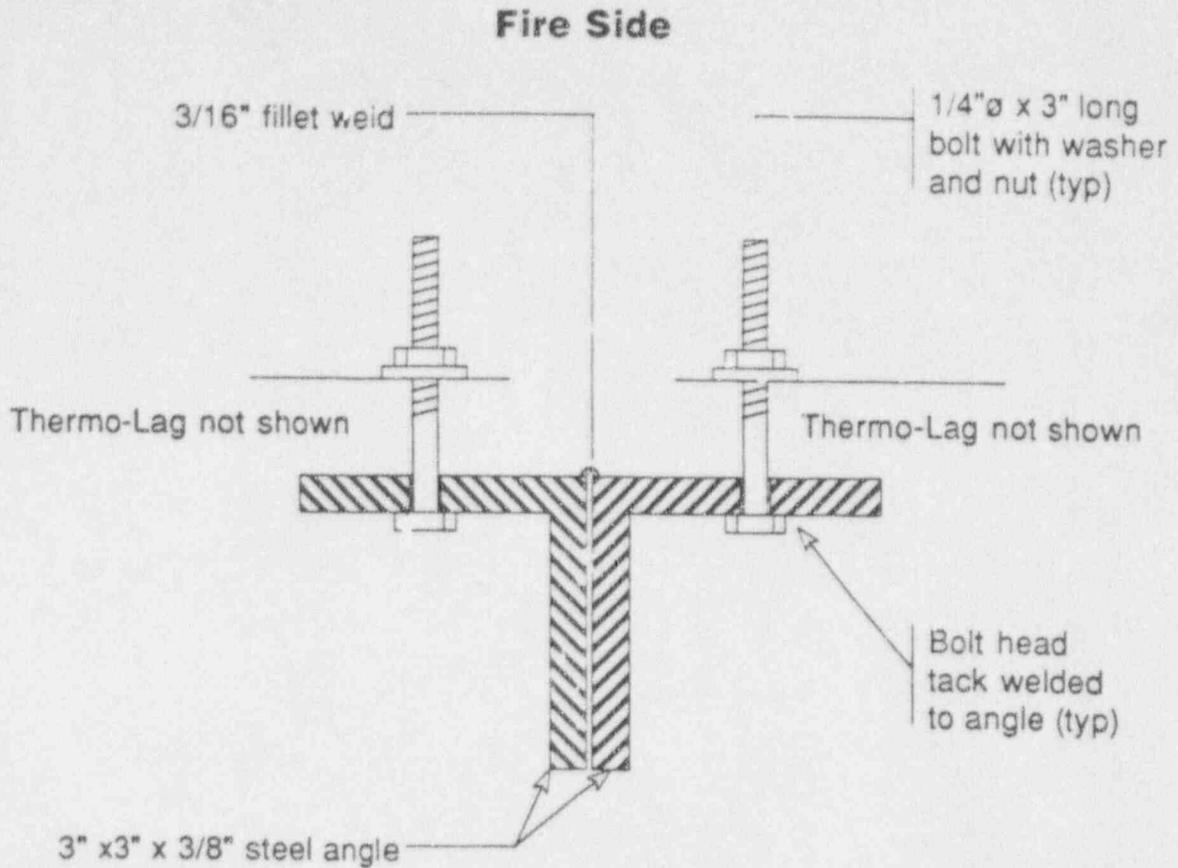


SECTION A-A
PERIMETER STEEL ATTACHMENT
TO MASONRY

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 2 Section A-A	
Drwn by: D.N. Priest	Date: 7/14/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 3"=1'



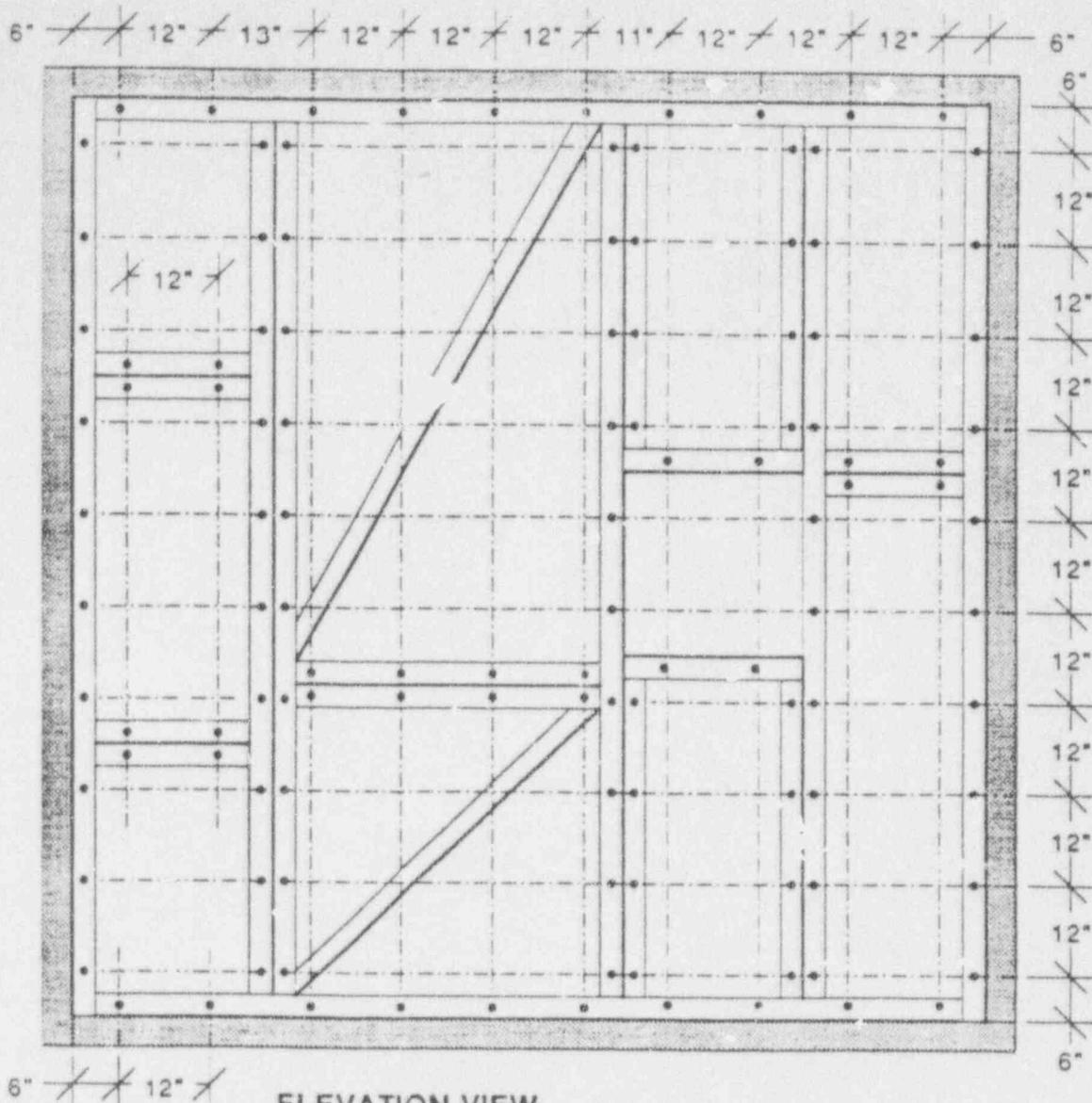


SECTION B-B
 Typical Steel Framing
 Between Panels

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 3 Section B-B	
Drawn by: D.N.Priest	Date: 7/14/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 1:2





ELEVATION VIEW
FROM EXPOSED SIDE

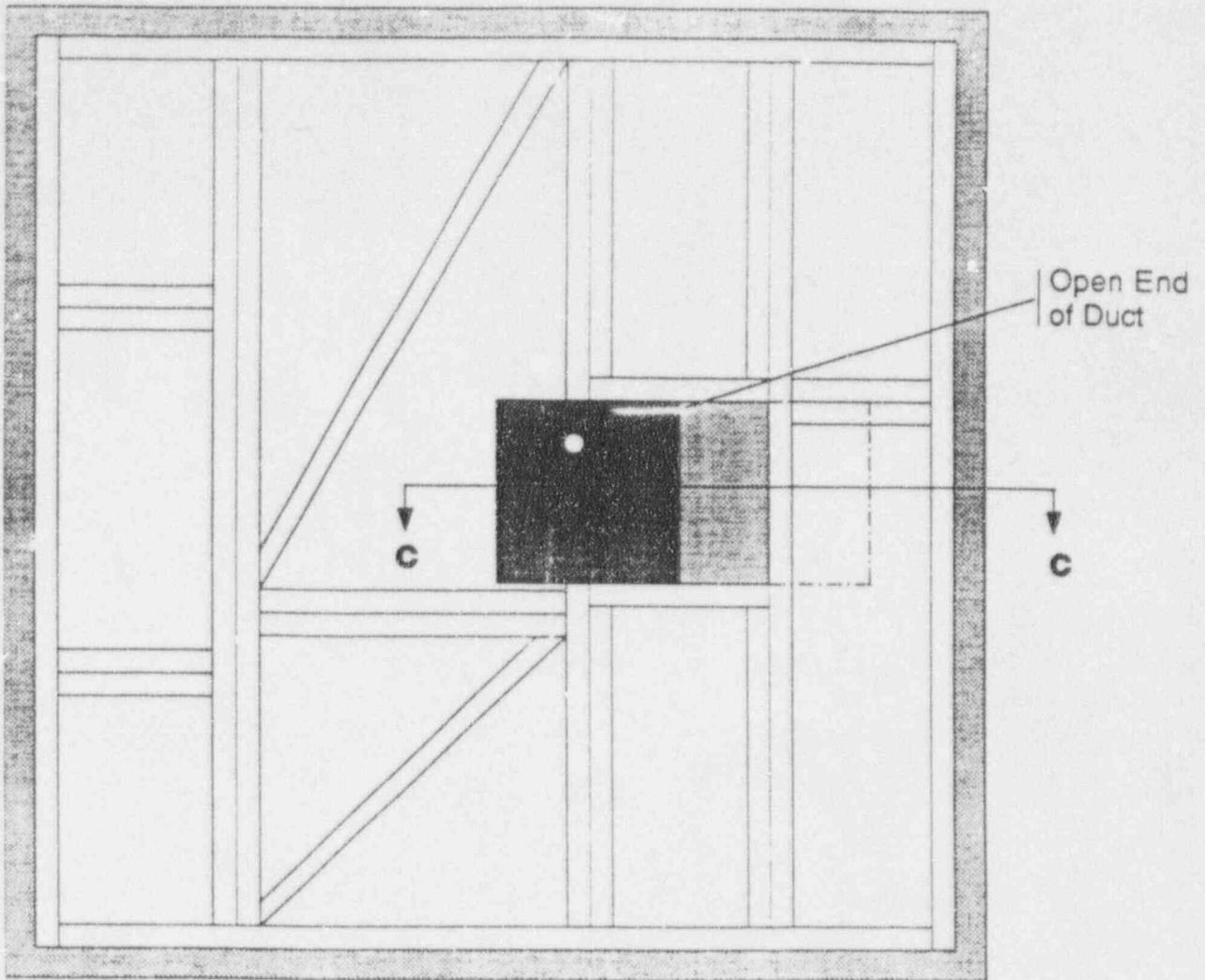
NOTE:

The fasteners were placed through 5/16" ϕ holes drilled in the structural angle at the locations shown. 1/4" ϕ 3" long bolts were then placed through each hole (from the unexposed side to the exposed side) and the hex heads welded to the 3" x 3" angle. The intent was to space the fasteners 12" o.c. along the perimeter of each Thermo-Lag Panel.

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 4 Fasteners – ELEVATION VIEW	
Drwn by: D.N. Priest	Date: 7/26/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 1/2"=1'





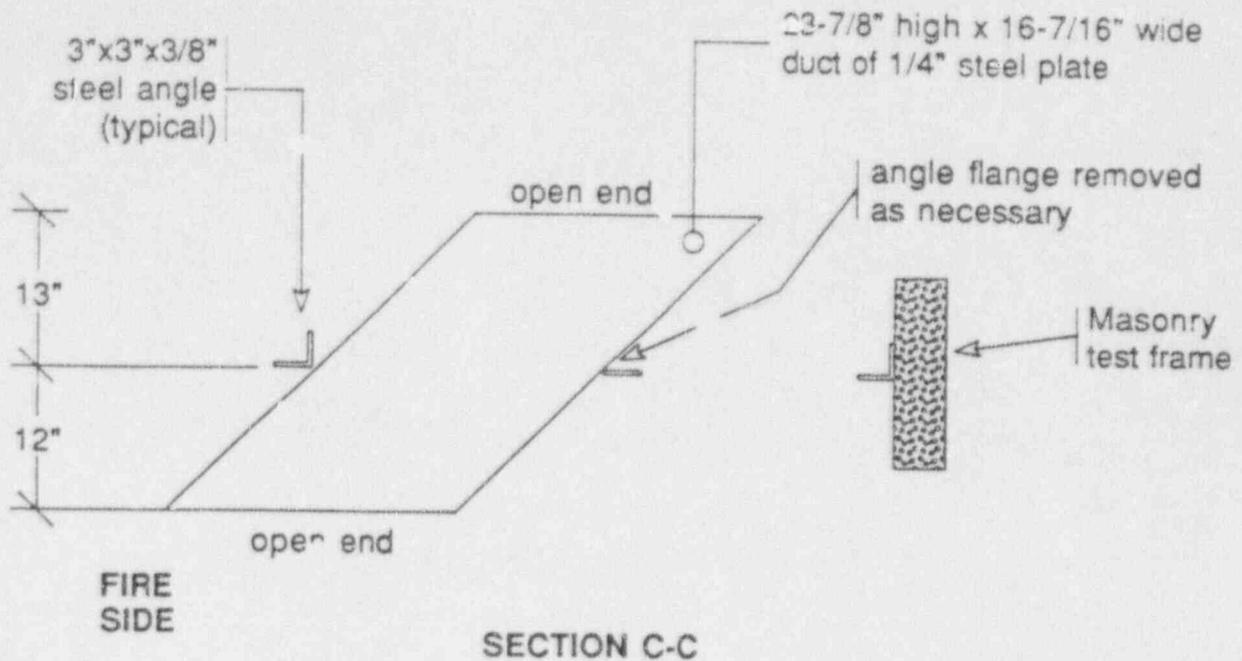
**ELEVATION VIEW
FROM EXPOSED SIDE**

NOTE:
A 23-7/8" high, 16-7/16" wide duct, constructed of continuously-welded 1/4" steel plate passed through the wall assembly at a 45° angle, entering horizontally level and angling towards the left as it penetrated the wall assembly (see also Figs. 6 & 7 for further details).

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 5 Duct Details – ELEVATION VIEW	
Drwn by: D.N. Priest	Date: 7/13/94
App'v by:	Date:
Vectra	
Approval:	Date:

Scale: 1/2"=1'





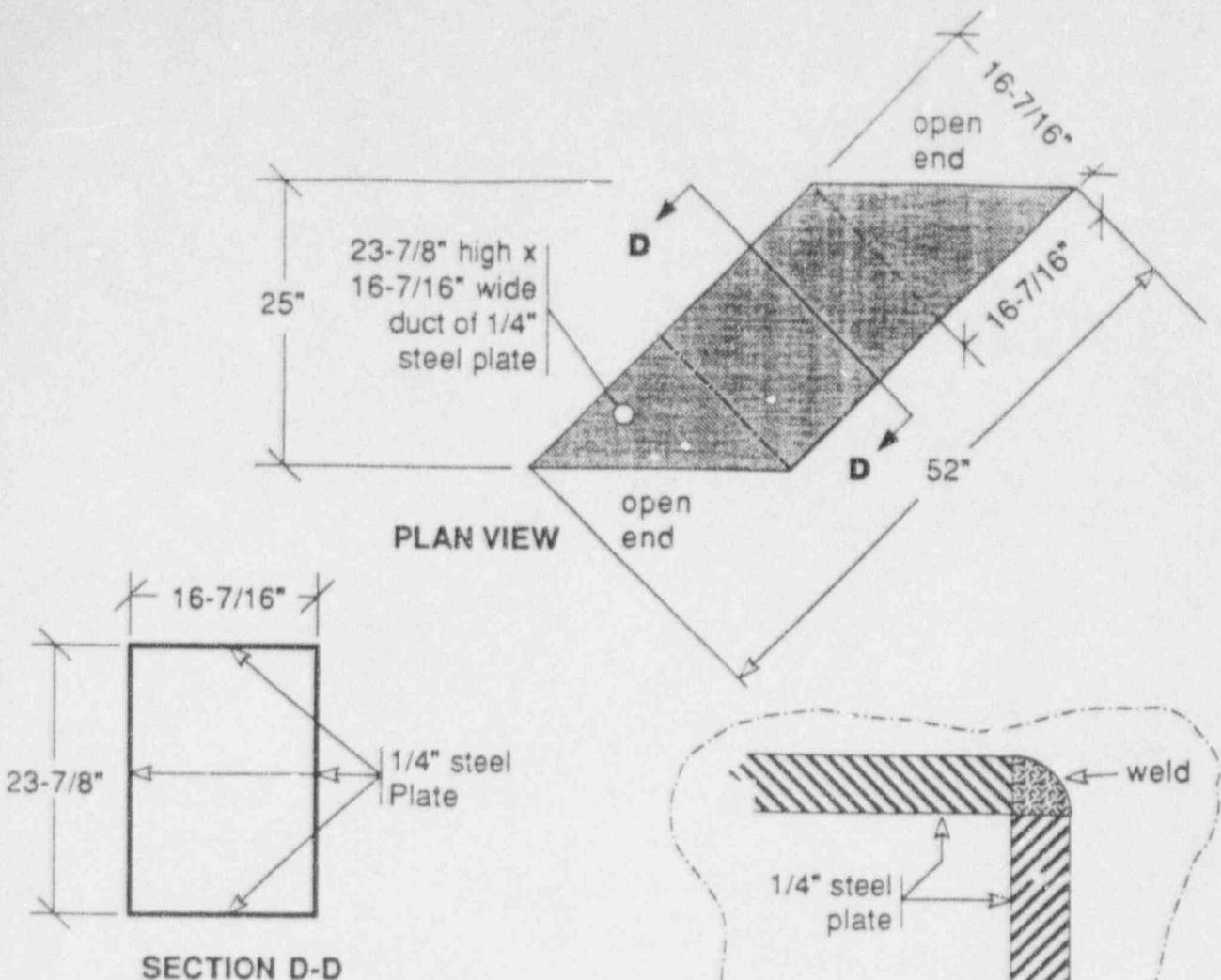
NOTE:

The steel duct was passed through the 24" x 24" opening, turned so that it entered at an angle of 45° to the wall and positioned so that it extended 13" from the exposed surface of the steel supports (leaving it nominally 12" out from the clad wall into the fire). The duct was then continuously welded to the 3" x 3" x 3/8" steel angle framework. The right side of the angle was removed as necessary to accommodate the duct.

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 6 Section CC Duct Cross Section	
Drwn by: D.N. Priest	Date: 7/26/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 3/4"=1'





NOTE:

The duct section was constructed of 1/4" steel plate, with continuous welds along all corners. Both ends were left open. The duct was continuously welded to the 3" x 3" x 3/8" steel angle wall structural elements, with no other support. To construct the duct, two pieces were cut to 23-3/8" x 60" and two were cut to 15-15/16" x 60" and assembled to those interior dimensions (see Detail 1 above). The completed duct was then installed into the wall, and the exposed and unexposed ends cut to 45° as required.

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 7 Duct Construction Details	
Drwn by: D.N. Priest	Date: 7/26/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 3/4"=1'



SUBJECT

TEST TRAY

PROJECT

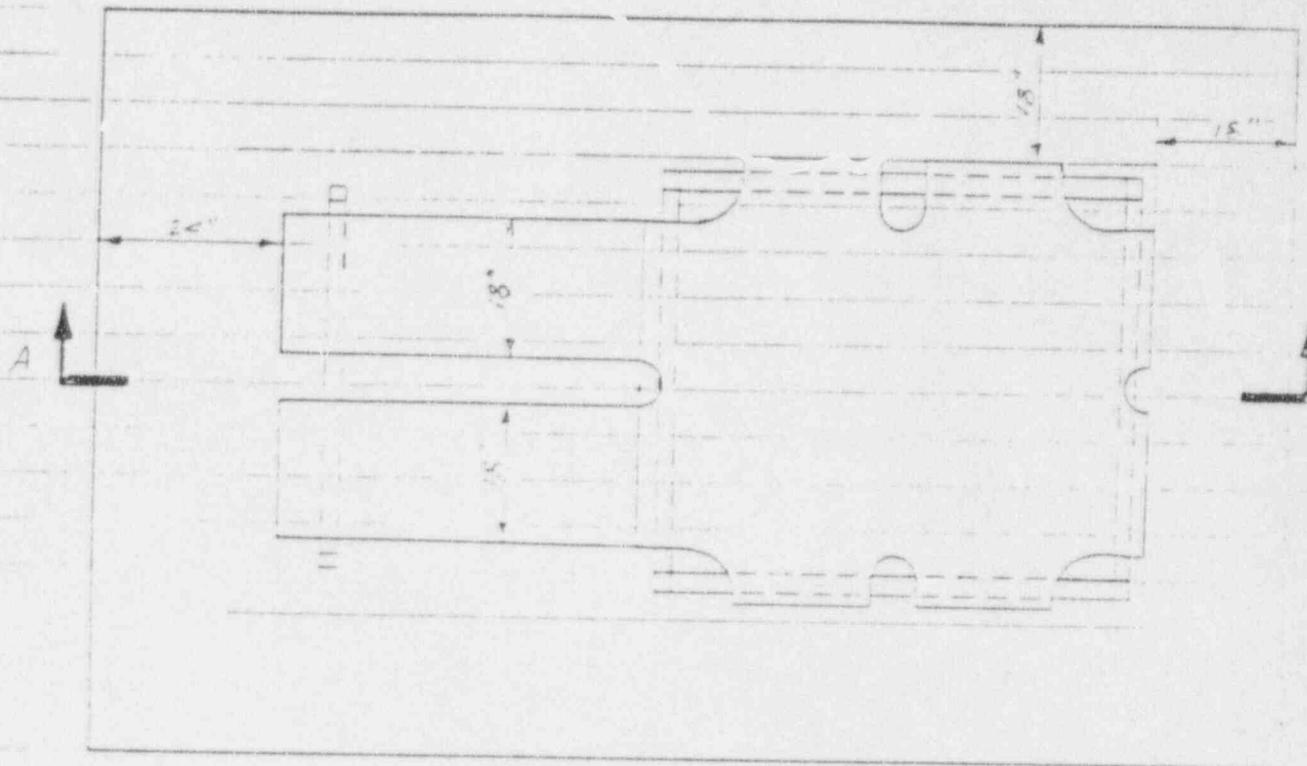
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COMPLETED BY

DATE

CHECKED BY

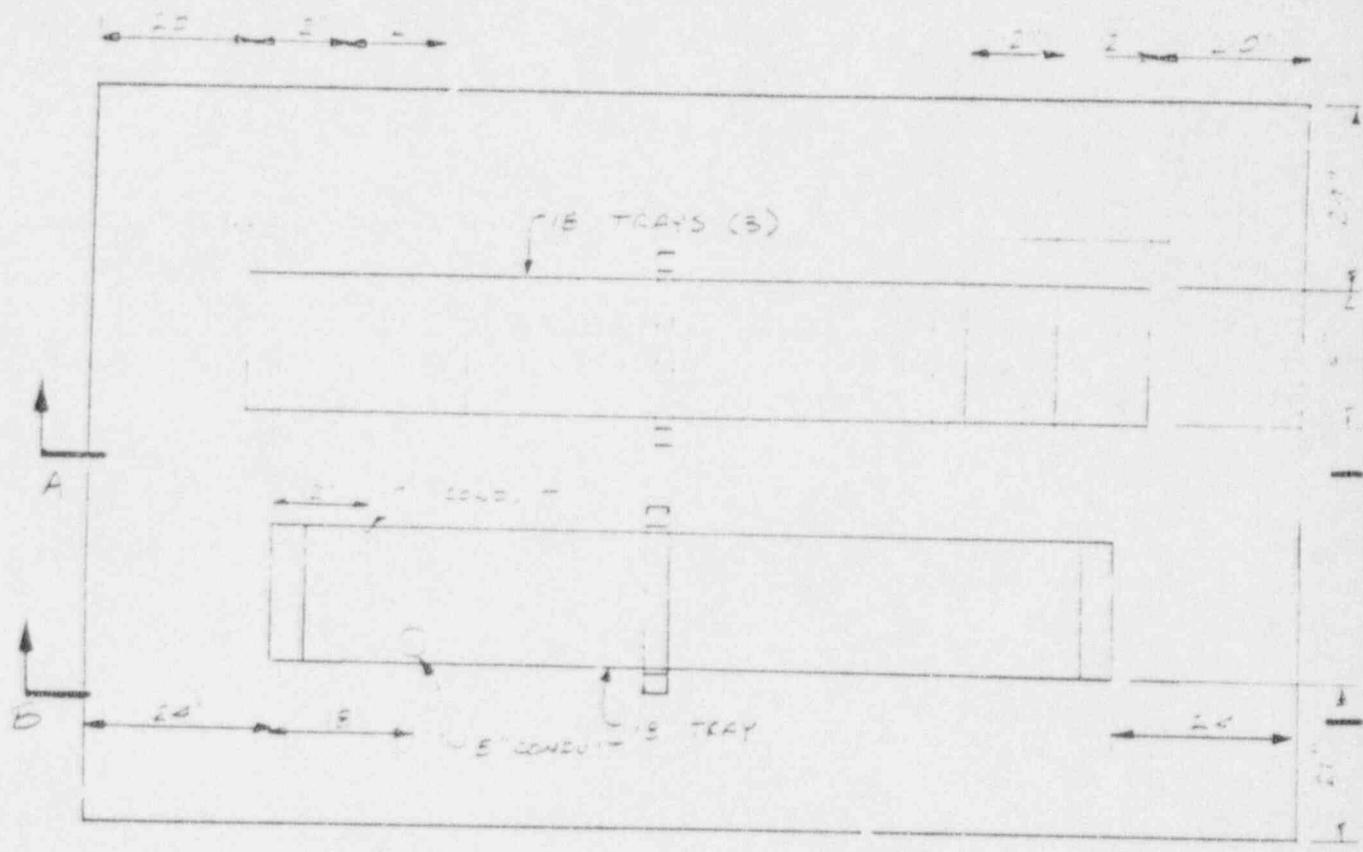
DATE



PLAN VIEW
SPECIAL TRAY

SUBJECT TEST TRAY PROJECT ...

COMPLETED BY _____ DATE _____ CHECKED BY _____ DATE _____



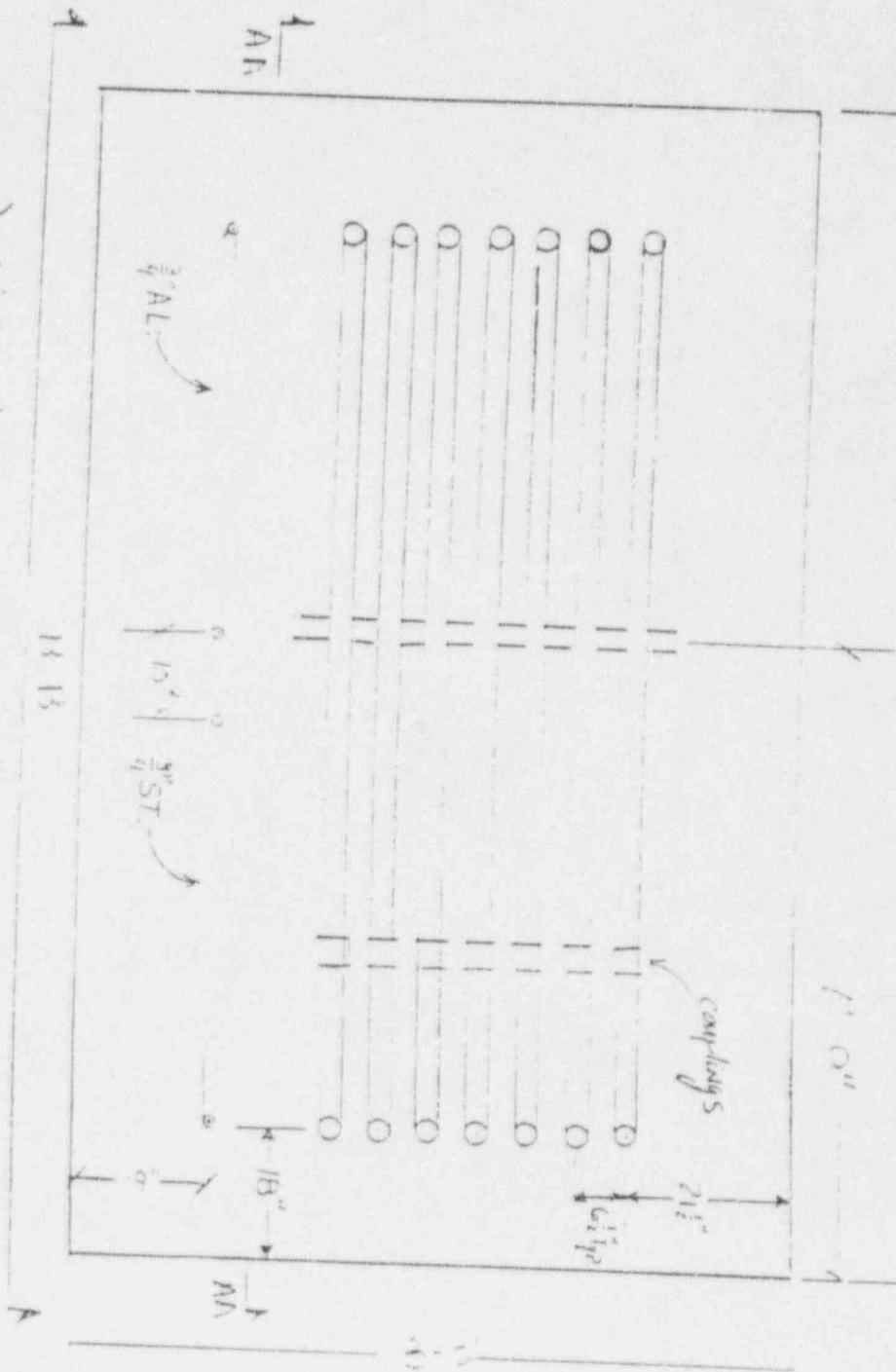
PLAN VIEW

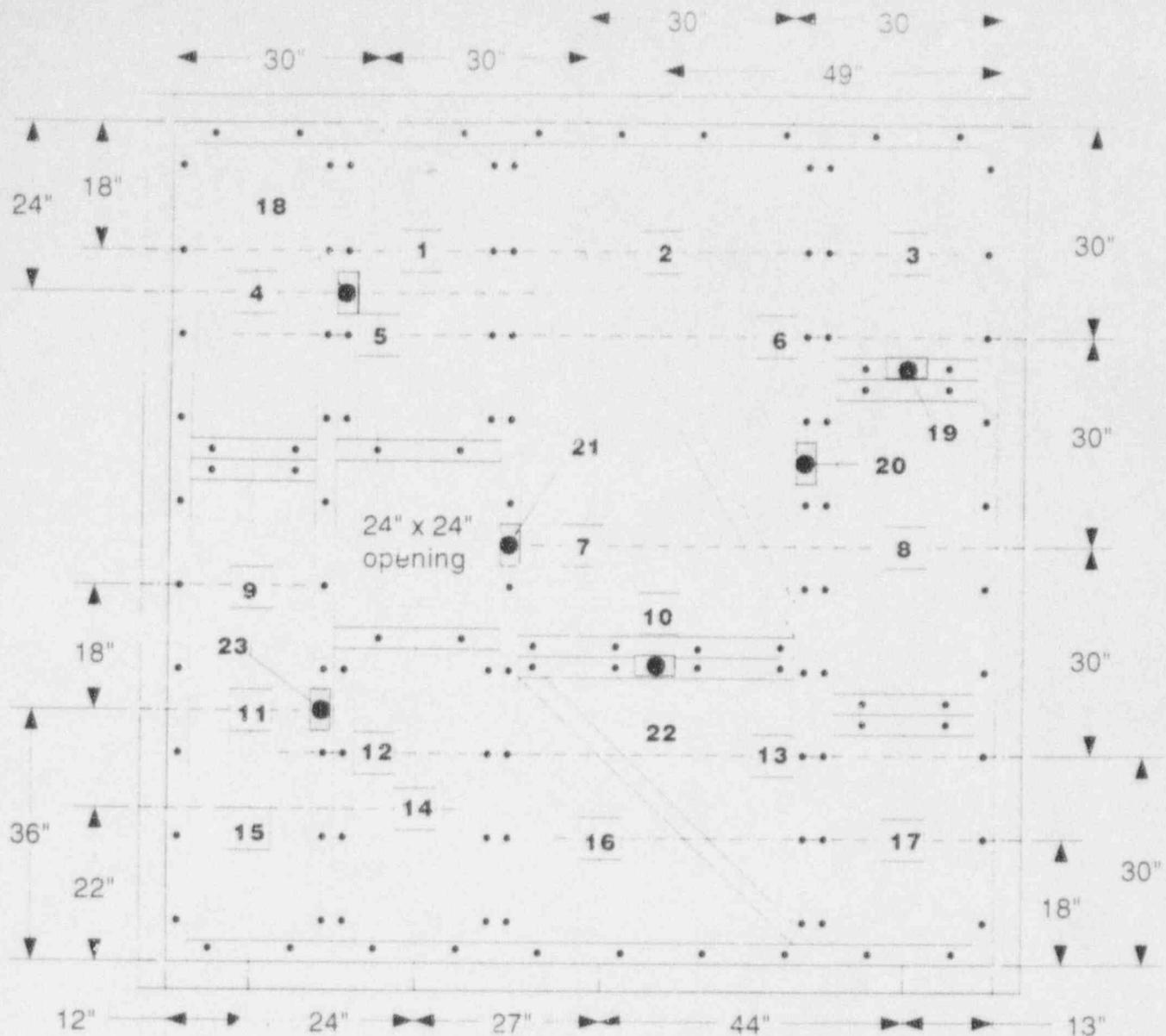
Large Ganged Conductors

Test Deck #7
Steel Deck - Horiz. 2 -

[Signature]

7) 4' Steel Conducts. Spaced $6\frac{1}{2}''$ ON Σ
Plan View





**ELEVATION VIEW
FROM UNEXPOSED SIDE**

NOTE:

Thermocouple Nos. 1 through 17 were placed directly on the unexposed surface of the Thermo-Lag and covered with the 6" x 6" felted mineral fiber pads specified by the E119 standard. Thermocouple Nos. 18 through 23 were placed on the Thermo-Lag covering the steel angle and covered with mineral pads cut to 6" x 2-1/2", and are considered "engineering," or information-only thermocouples. These will not be used in assessing performance, but are for engineering purposes only.

OMEGA POINT LABORATORIES, INC. Project No. 14980-97261	
Florida Power & Light	
Fig. 8 Thermocouple Placements	
Drwn by: D.N. Priest	Date: 8/2/94
App'd by:	Date:
Vectra	
Approval:	Date:

Scale: 1/2"=1'

