

ATTACHMENT 2A

DOCKET Nos 50-277
50-278

FIRE ENDURANCE AND HOSE STREAM TESTS

on

WALL PENETRATION FIRE STOPS

DESIGN WP694

for

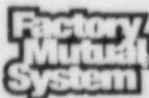
PHILADELPHIA ELECTRIC COMPANY

2301 MARKET STREET - N2-1

PHILADELPHIA, PENNSYLVANIA 19101

J.I. 0J8Q3.AC
(4990)

NOVEMBER 4, 1983



Factory Mutual Research

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on

WALL PENETRATION FIRE STOPS

DESIGN WP694

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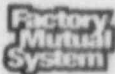
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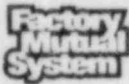
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WALL PENETRATION FIRE STOPS
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2301 MARKET STREET - N2-1
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GENERAL

This report describes the construction, the test procedure, and lists the results of fire endurance and hose stream tests conducted on ten through-penetration fire stops installed in a masonry wall. The test was conducted on May 23, 1983, at the National Gypsum Company Research Center, Buffalo, New York for Philadelphia Electric Company. The construction and fire test of the assembly were witnessed by a representative of Factory Mutual Research Corporation.

The object of this test program was to investigate the fire endurance properties of each through-penetration fire stop construction in terms of V and T ratings based on conditions noted in the Standard Method of Fire Tests of Through-Penetration Fire Stops, ASTM E814-81.

The penetration seal systems were exposed to fire for a 3-hour duration followed by the hose stream test.

DESCRIPTION OF MATERIALS

The materials used in the construction of the test assembly are described below:

Pipe Sleeves - Six and ten inch (152.4 and 254 mm) diameter standard weight steel pipes were used. The 6 in. (152.4 mm) pipe was furnished in two types - one type having 1/4 in. (6.35 mm) wall thickness with threads on the outside circumference at one end and another type with 5/16 in. (7.94 mm) wall thickness with no threads at either end. The 10 in. (254 mm) steel pipe had 3/8 in. (9.52 mm) wall thickness and was not threaded. All the pipes were 12 in. (304.8 mm) long.

Pipe Couplings - Standard weight steel couplings, 7-1/4 in. (184.2 mm) O.D., 4-1/4 in. (108.0 mm) long with approximately 5/16 in. (7.94 mm) wall thickness. The inside circumference was threaded along the entire length.

Pipe Plug - 6-1/2 in. (165.1 mm) O.D. and measured 3/4 in. (19.0 mm) thick at the outer edge having a 1-3/4 in. (44.5 mm) square nut shape top. The plugs appeared to be made of brass or bronze and were marked '106-1/2'. The wall thickness was approximately 1/8 in. (3.18 mm).

Electrical Cables - Two types of cables were used in some of the fire stops. The diameter and the cable marking are as noted:

- A. 10 AWG 2/C ROCKBESTOS 600 V FIREWALL III XHHW NEC TYPE TC (UL). The O.D. of the cable was measured to be approximately 0.500 in. (12.7 mm).
- B. 8 AWG 3/C ROCKBESTOS 600 V FIREWALL III XHHW NEC TYPE TC (UL) 1979 9B49. The O.D. of the cable was measured to be approximately 0.640 in. (16.3 mm).

Fill Materials - Several different fill materials were used in the various fire stops. They are described below:

- A. Ceramic Fiber - Used in loose form, manufactured by Babcock & Wilcox and designated as Kaowool.
- B. Silicone Foam - Dow Corning 3-6548 Silicone RTV Foam, a two component system.
- C. Polyurethane Foam - A two component system made by Insta-Foam Products Inc. and designated as No. 9.5 Froth Pak Kit indicated as having a designed density of 1.75 lb/ft³ (28 kg/m³).

Sealing Material - Quelpyre Mastic 703-B, trowelable, manufactured by Quelcor.

INSTALLATION OF FIRE STOPS

The pipe sleeves were installed in a nominal 12 in. (304.8 mm) thick concrete block wall with the block having been laid in a full mortar bed. The wall containing the fire stops was 10 ft (3.05 m) high by 10 ft (3.05 m) wide and the location of each fire stop is shown on Illustration 1. The voids between the concrete blocks and each pipe sleeve were filled with concrete and the cavity in each concrete block next to each sleeve was also filled with concrete. The end of each sleeve or coupling at the fire exposed side of the wall was flush with the wall surface except for Fire Stop F which extended 5 in. (127.0 mm) beyond the wall surface at the fire exposed side.

The construction of each fire stop penetration is shown on Illustrations 2 through 8. A description of each fire stop follows:

Fire Stop F contained nominal 10 in. (254 mm) diameter pipe. All other penetrations contained nominal 6 in. (152.4 mm) diameter pipe sleeves having the 1/4 in. (6.35 mm) wall thickness except Penetration G which used the pipe with the 5/16 in. (7.94 mm) wall thickness.

Fire Stop A - Nominal 6 in. (152.4 mm) diameter steel pipe with six cables, three of each type. The cables were placed at random within the sleeve. These cables were positioned near the bottom of the sleeve, but held away from the sleeve and separated from other cables by approximately 1/2 in. (12.7 mm) using pieces of Kaowool each measuring 1/2 in. (12.7 mm) thick by 1 in. (25.4 mm) long. These separators were placed approximately 1 in. (25.4 mm) in from the end of the sleeve. The cables extended 3 in. (76.2 mm) beyond each end of the sleeve.

This sleeve was then filled with polyurethane foam applied from the unexposed side with care to assure that the urethane is received below and between the cables using the kit dispenser -- see Illustration 2. The temporary dam which had been previously placed on the exposed side to hold the material in the sleeve, was removed. The excess urethane was cut off flush with the end of the sleeve at the unexposed side.

A 1/4 in. (6.35 mm) thick coating of Quelpyre Mastic 703-B was trowel applied to the fire exposed side in two 1/8 in. (3.18 mm) coats with approximately 5 hours allotted between applications.

Fire Stop B - Same construction details as Fire Stop A except the unexposed side of A is now the fire exposed side of B. This stop received an additional cable of the 2/C type.

Fire Stop C - Nominal 6 in. (152.4 mm) diameter steel pipe with a screwed coupling applied. The threaded plug was installed within the coupling and positioned so that its outside surface was flush with fire exposed wall surface. The Kaowool insulation was then placed with the sleeve from unexposed side for the full 11-5/8 in. (395.3 mm) depth of the wall. The end of the sleeve projected 2-7/8 in. (73.0 mm) beyond the unexposed side of the wall. No cables were contained in this penetration.

Fire Stop D - Same construction details as Stop C except the unexposed side of C is now the fire exposed side of D. End of sleeve flush with exposed side while the coupling projected 2-7/8 in. (73.0 mm) beyond unexposed side of wall.

Fire Stop E - Same construction details as Stop C with the exception that no Kaowool insulation was contained in the sleeve.

Fire Stop F - Nominal 6 in. (152.4 mm) diameter steel pipe with a screw applied coupling. End of the coupling projected 5 in. (127.0 mm) beyond fire exposed side of wall and was capped with a threaded plug. Six cables were placed within the sleeve, three of each type. Cables were placed near bottom of sleeve. The ends of the cables near the plug were held away from the plug approximately 1/2 in. (12.7 mm) with a piece of cured polyurethane. Also the cables were held approximately 1/2 in. (12.7 mm) away from sleeve and each other with pieces of cured polyurethane measuring 1/2 in. (12.7 mm) thick by 1 in. (25.4 mm) long. Polyurethane was installed as previously described for Fire Stop A and flush with unexposed side of wall. Ends of cables extended 6 in. (152.4 mm) beyond unexposed side.

Fire Stop G - Nominal 6 in. (152.4 mm) diameter steel pipe with end flush with fire exposed side of wall. Also six cables, three of each type, with cables sealed in polyurethane as described for Fire Stop A. The polyurethane was terminated 3 in. (76.2 mm) back from fire side of wall by using a temporary dam. This dam was removed and the 3 in. (76.2 mm) deep cavity was filled with Silicone RTV Foam after a temporary dam was placed at exposed side of wall. Silicone foam was mixed according to specifications and poured into the cavity. Temporary dam removed and foam trimmed flush with wall.

A paper cup sample of the silicone foam was taken during installation and the density was determined to be 27 lb per cu ft (432.5 kg per cu m).

Fire Stop H - Nominal 10 in. (254 mm) diameter steel pipe with end flush with fire exposed side of wall. Also six cables, three of each type, with cables sealed in polyurethane as described for Fire Stop A. The polyurethane was terminated 3 in. (76.2 mm) back from fire side of wall by means of a temporary dam. After the dam is removed this 3 in. (76.2 mm) deep cavity was filled with Kaowool which was installed flush with the fire side of the wall.

Fire Stop I - Same construction as Fire Stop A except that eighteen cables, nine of each type, were installed.

Fire Stop J - Same construction as Fire Stop B except that eighteen cables, nine of each type, were installed.

FIRE ENDURANCE TEST

This test and the hose stream test were conducted in accordance with the Standard Method of Fire Tests of Through-Penetration Fire Stops, ASTM E814-81. The standard test furnace of the National Gypsum Company for wall assemblies was used for the test.

METHOD:

The furnace temperatures were measured by eleven thermocouples symmetrically located in the furnace chamber as shown on Illustration 15. The unexposed surface temperatures of the wall, penetration seals and cables were measured with thermocouples as shown on Illustrations 16 through 19. Each thermocouple was covered with a dry asbestos pad, 2 x 2 in. (50.8 x 50.8 mm) to provide thermal insulation.

The furnace fire was started, exposing one side of the assembly to gas flames of controlled severity and extent in accordance with the Standard Time-Temperature Curve.

Throughout the fire exposure, observations were made to note the character of the fire and its control, the condition of the exposed and unexposed surfaces, and all developments pertinent to the performance of the assembly with reference to stability, passage of flame and generation of smoke.

RESULTS:

Character and Distribution of the Fire - The fire was luminous and well distributed throughout the furnace during the test. The furnace temperatures were controlled in accordance with the Standard Time-Temperature Curve as shown on Illustration 15.

Observations of the Exposed Surface - At 3 minutes of fire exposure, there were small intermittent flames coming from the cables at the bottom row of fire stops (Stops I, H and J). At 6 minutes, the cables in Stops I and H were flaming continuously. The flames were approximately 10 in. (254 mm) long. At 20 minutes, the cables in Stops A and B were flaming. At 35 minutes, the flaming of the cables in Stops I, H and J was reduced. At 55 minutes, a portion of the pipe plug at Stop F was melted away and small flames were coming from the stop.

At 1 hour, 25 minutes, Stop F was still flaming while at Stop H flaming had ceased. At Stop J small flames continued to issue and there appeared to be a small cavity in the seal material. Stops I and G had small flames coming from it. At this point it was difficult to determine if flames were coming from cables or seal material.

At 2 hours, 15 minutes there were small flames coming from Stop I, also a crack 1/4 in. (6.35 mm) wide was noted at the top of the stop located between the seal material and the steel sleeve. There were no flames coming from Stops F and H. At Stop J there was a slight amount of smoke, but no flames.

Most of the cable jackets had been consumed at this time and the smoke was too dense at the top of the furnace to observe these stops. At 2 hours, 55 minutes there were still small flames at Stop I where the cables meet the seal material. No further changes were noted on the exposed surface of the assembly for the remainder of the test.

See Illustration 20 for a view of the exposed surface after the fire endurance test.

Observations of the Unexposed Surface - At 8 minutes of exposure, there was a slight amount of smoke coming from around the cables at Stop B. By 15 minutes, there was a slight amount of smoke coming from Stops B, E and F. At 30 minutes, there was an increase of smoke at Stop F coming from between the pipe sleeve and the seal material.

At 50 minutes, the client desired not to continue the evaluation of Stop E. The open pipe sleeve was then packed with Kaowool. No rating was assigned to this fire stop.

At 55 minutes, all smoke from the fire stops had stopped except for I where a small amount of smoke was coming from between the cables. At 70 minutes, there was reduced smoke coming from Stop I. At 1 hour, 20 minutes, there was a slight amount of smoke coming from between and around the cables contained in Stops G, I and J. At 2 hours, 10 minutes, the smoke continued from Stops B, F, G, I and J.

At 2 hours, 20 minutes, there was a moderate amount of yellow smoke coming from Stop F. At 2 hours, 25 minutes, there was heavy smoke coming from Stop F and a small through-opening developed in the seal material of this stop. At 2 hours, 30 minutes, flames came through the unexposed side of Stop F at the top of the seal.

At 2 hours, 55 minutes, Stop I developed a small through-opening between the seal material and the steel sleeve at the top of the seal. The opening was from 1/8 to 1/4 in. (3.18 to 6.35 mm) wide. The fire in the furnace was visible through this opening; however, flames did not pass through this opening to the unexposed surface. No further changes were noted on the unexposed surface during the test.

See Illustration 21 for a view of the unexposed surface at 3 hours of exposure.

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The pressure in the furnace chamber was 0.04 in. of H₂O (9.96 Pa) below atmospheric pressure throughout the fire test. The pressure was measured at the center of the furnace.

Temperatures at Unexposed Side of Stops - The temperatures that developed during the test and the thermocouple locations are shown on Illustrations 16 through 19.

A T rating may be assigned each fire stop that satisfies the fire endurance and the hose stream requirements of the ASTM E814-81 Standard. The T rating is based on the transmission of heat through the fire stops during the rating period. The T rating is determined by the rise in temperature on the unexposed surface of the fire stop or on any penetrating item. The temperature rise cannot be more than 325°F (163°C) above the initial temperature. The initial temperature was established to be 75°F (24°C) due to recalibration of the equipment.

HOSE STREAM TEST

The same wall containing the fire stops used for the Fire Endurance Test was subjected to the hose stream application after 180 minutes of fire exposure.

METHOD:

The exposed and unexposed surfaces before the hose stream test are shown on Illustrations 20 and 21.

Immediately after fire exposure of 180 minutes the assembly was subjected to the impact, cooling and eroding action of a hose stream for 90 seconds. The stream was delivered through a National Standard Playpipe having a 1-1/8 in. (28.6 mm) diameter discharge tip. The distance from the tip of the nozzle to the wall assembly was 20 ft (6.1 m) less 2 ft (609.6 mm) due to the angle of the nozzle with respect to the center of the wall. The pressure was 30 psi (207 kPa) measured at the nozzle base and the hose stream was applied uniformly over a 7-1/2 ft (2.29 m) high by 8 ft (2.44 m) wide surface area of the wall assembly with the fire stops centered within this area.

Throughout the test, observations were made to note the general condition of the test assembly resulting from the hose stream application, and all other results considered pertinent to the performance of the fire stops.

RESULTS:

Observations During the Hose Stream Test - During the hose stream test water projected beyond the unexposed side of Stops A, B, F and I. Water did not project beyond the unexposed side of Stops C, D, G, H and J.

Observations After the Hose Stream Test - The appearance of the exposed and unexposed surfaces of the assembly after the application of the hose stream and subsequent cooling are shown on Illustrations 22 and 23.

Fire Stop B - At the fire exposed side most of the seal material had been eroded. At the unexposed side the stop was intact except the water stream had caused the mastic material to pull away from the steel sleeve at the top creating an opening for water to project through the stop.

Fire Stop C - There was no noticeable change at the unexposed side of the stop. On the exposed side some of the pipe plug had deteriorated and the Kaowool was visible behind the plug.

Fire Stop D - There was no noticeable change on the unexposed side of the stop. On the exposed side some of the Kaowool was either dislodged or pushed back within the sleeve.

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Fire Stop E - Evaluation of this stop was terminated at 50 minutes by the Client. See discussion under heading -- Observations of the Unexposed Surface.

Fire Stop F - The pipe plug had disintegrated and there was no polyurethane present, however, the cables remained in the opening.

Fire Stop G - There was no through-opening in the seal. At the unexposed side the polyurethane was discolored. On the exposed side a majority of the silicone material had been removed.

Fire Stop H - There was no through-opening in the seal and no noticeable change at the unexposed side except a small area of discoloration of the seal near the cables. On the exposed side a large amount of seal material had been removed.

Fire Stop I - There was a through-opening of the seal; however, most of the material had been removed from the stop. The cables remained in the sleeve.

Fire Stop J - There are no through openings in the seal and no noticeable changes of the stop at the unexposed side. At the exposed side a large cavity existed where the seal material had eroded.

CONCLUSIONS

Fire Stops C, D, G, H and J satisfied the fire endurance and hose stream requirements of the ASTM E814-81 Standard of Through-Penetration Fire Stops for a 3 hour F rating.

Fire Stops A, B, F and I failed to satisfy the requirements of the ASTM E814-81 Standard for a 3-hour F rating.

The fire testing of Fire Stop E was terminated at 50 minutes into the test by the Client. No rating was assigned to this penetration.

Fire Stops C, D, G, H and J achieved T ratings based on the transmission of heat through the fire stops during the rating period. The T rating is determined by the rise in temperature on the unexposed surface of the fire stop or on any penetrating item. The temperature rise cannot be more than 325°F (163°C) above the initial temperature which was established at 75°F (24°C). Stops C and D achieved 3 hour T ratings; G and J achieved 1 hour T ratings and H achieved a 2 hour T rating.

PRACTICABILITY:

To obtain the desired protection, it is necessary to specify the composition and thickness of materials, and the methods of construction as described in this report.

PRODUCT UNIFORMITY:

Factory Mutual Research Corporation makes no judgement of product uniformity solely as a result of ASTM E814 fire tests. Product uniformity depends in part on manufacturing facilities and procedures which would be inspected under Factory Mutual's Audit of Manufacturing and Quality Control, and on a written agreement in force between both the product manufacturer and Factory Mutual.

ILLUSTRATION 1

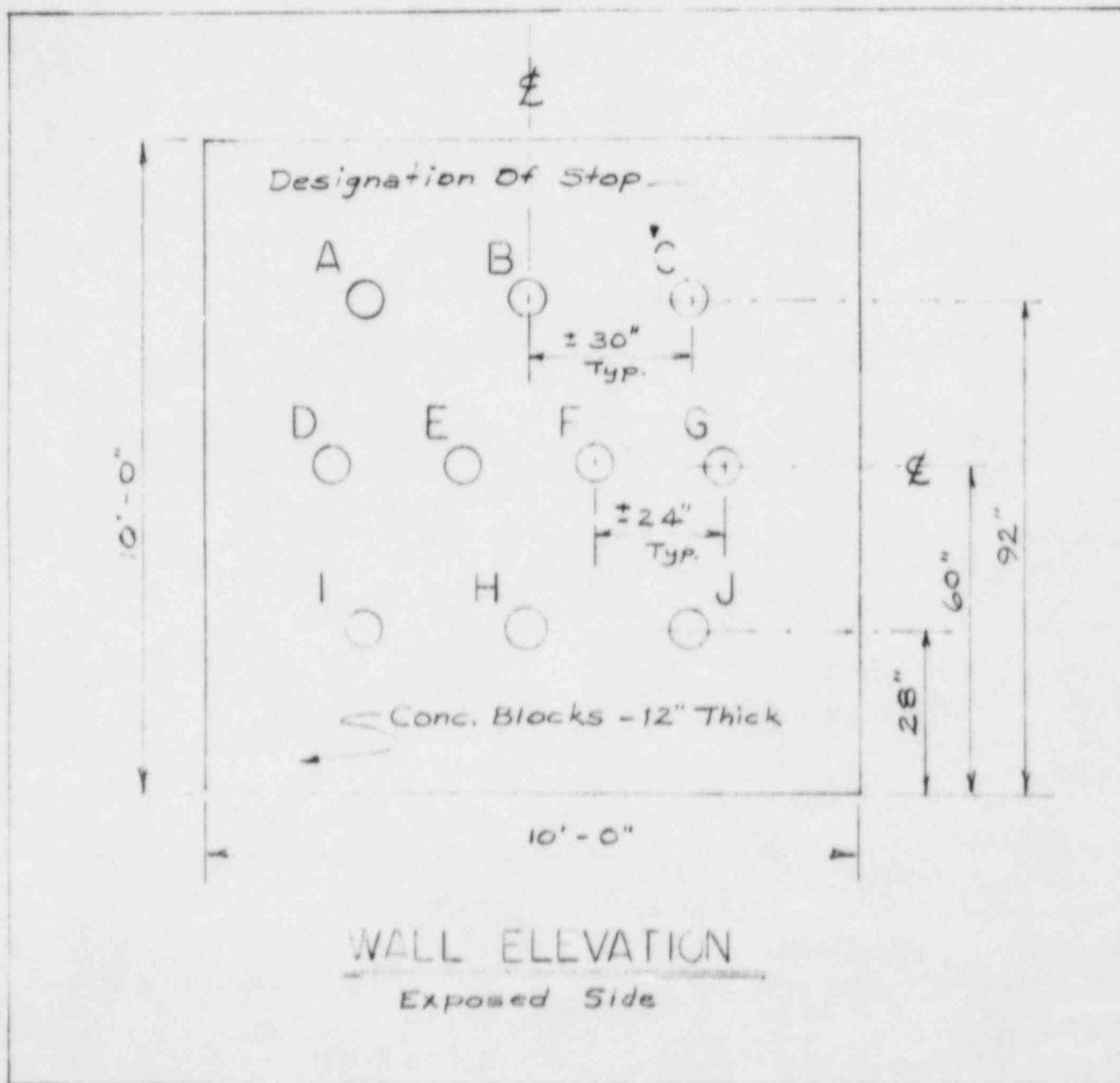


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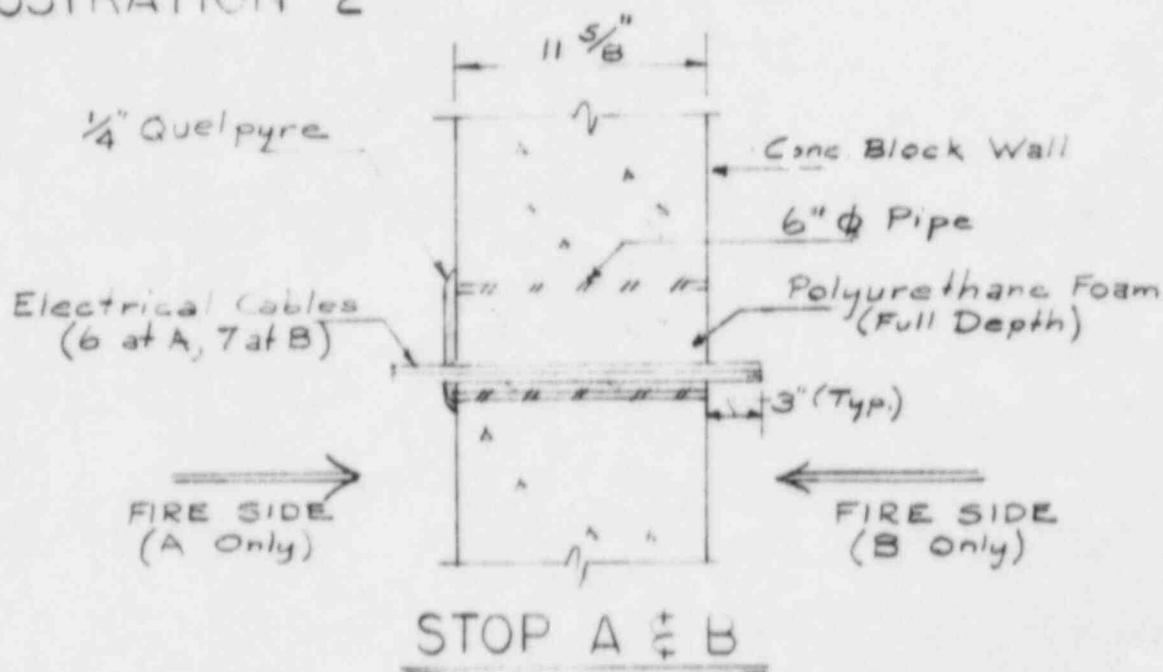


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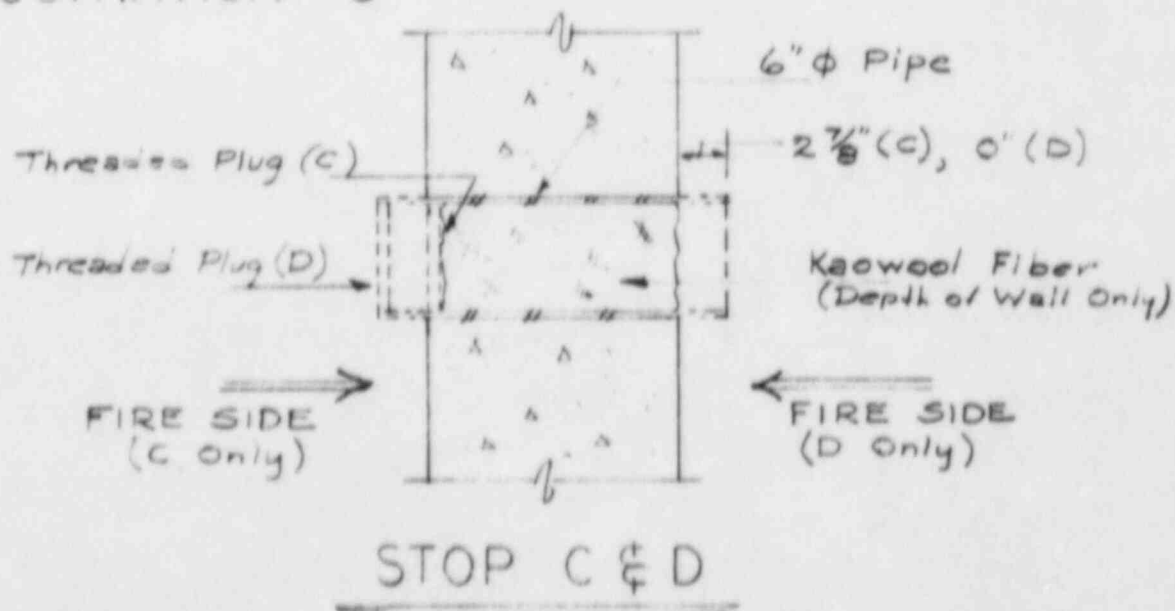


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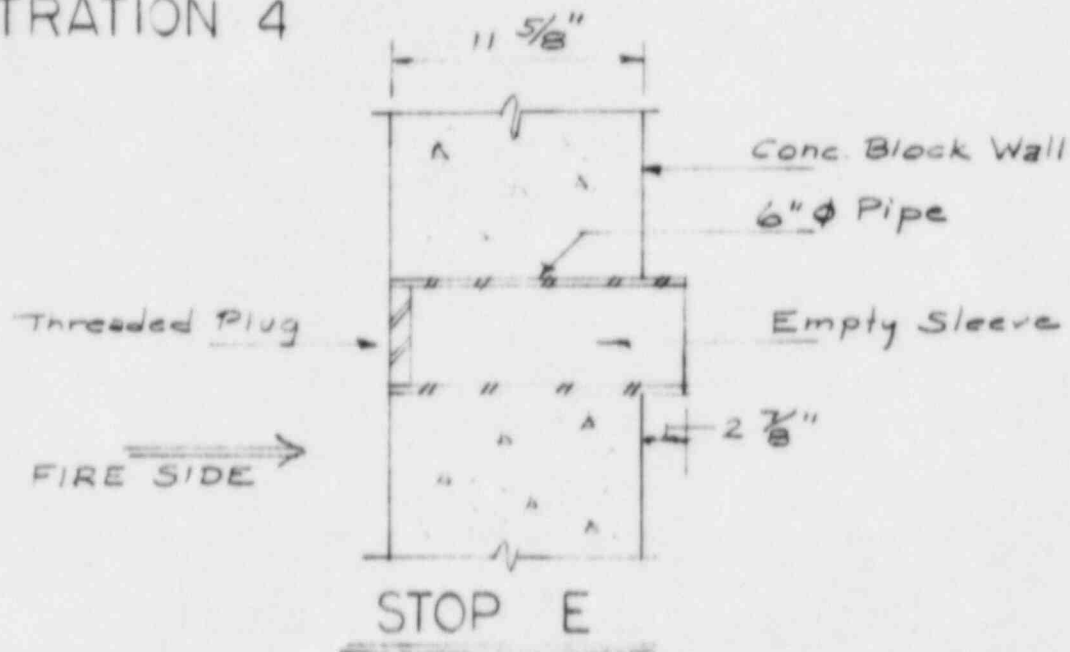


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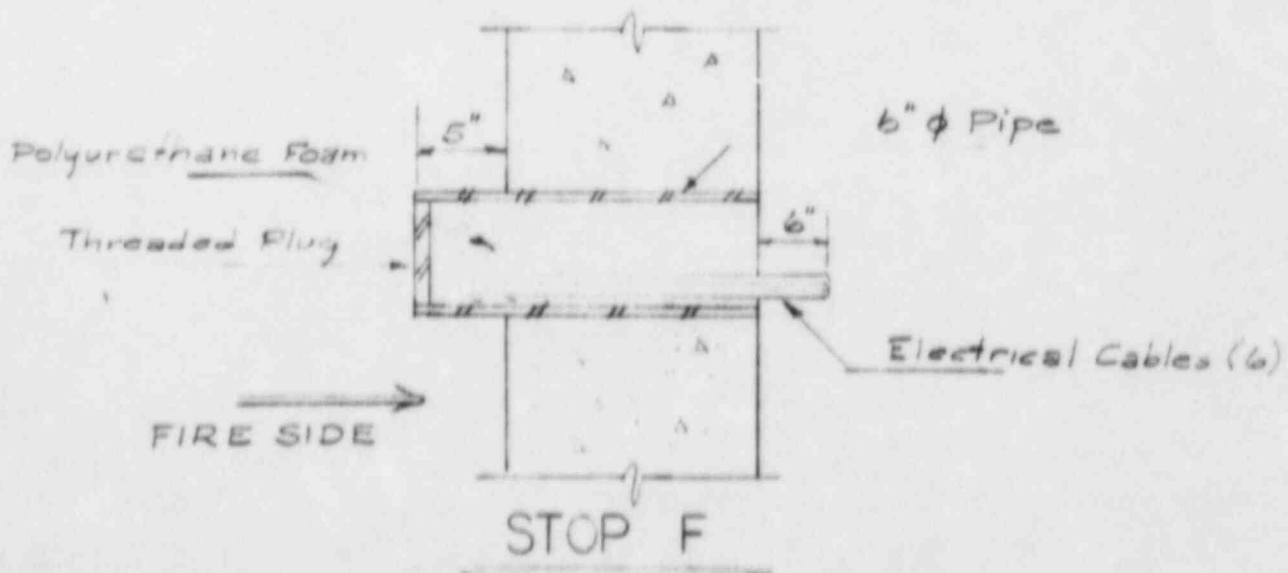


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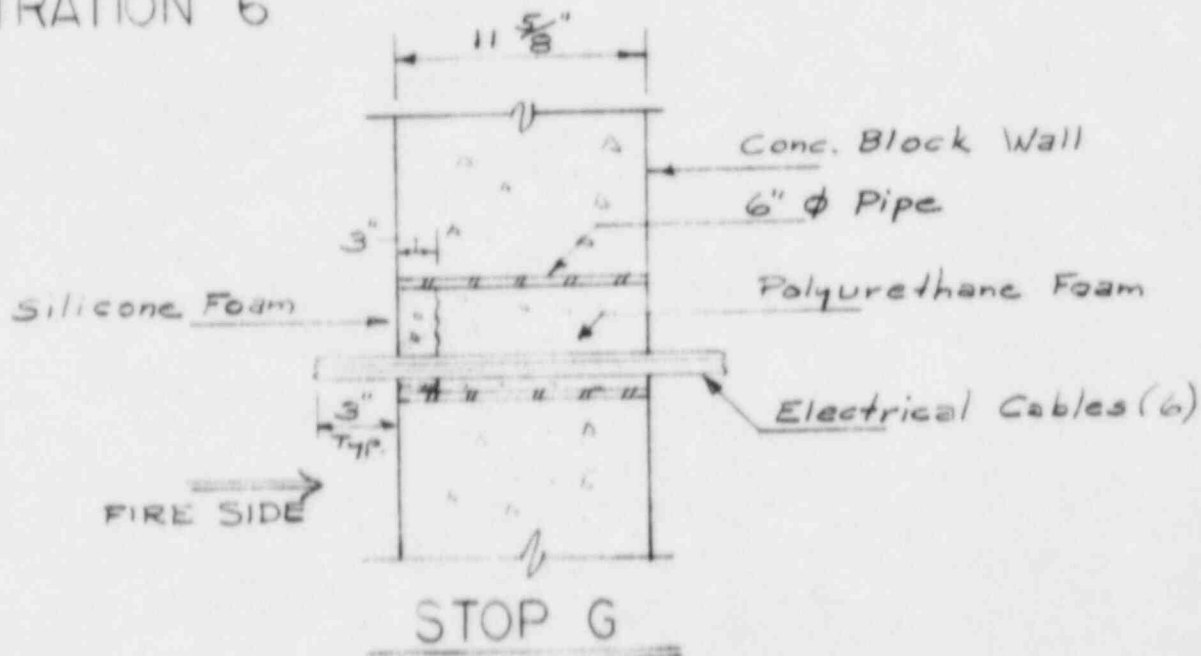


ILLUSTRATION 7

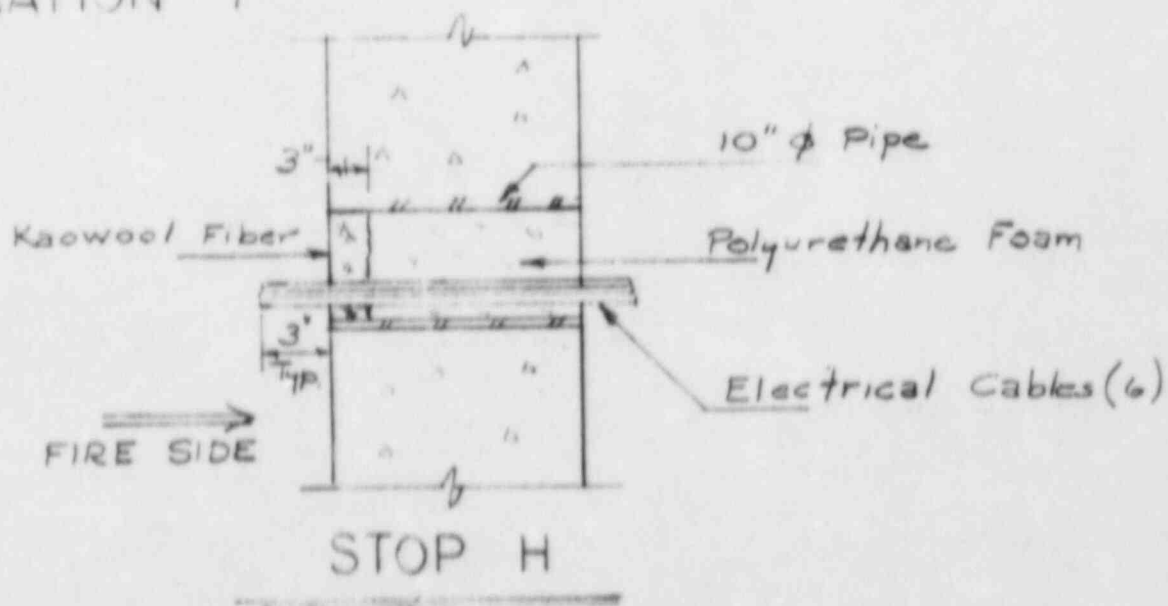


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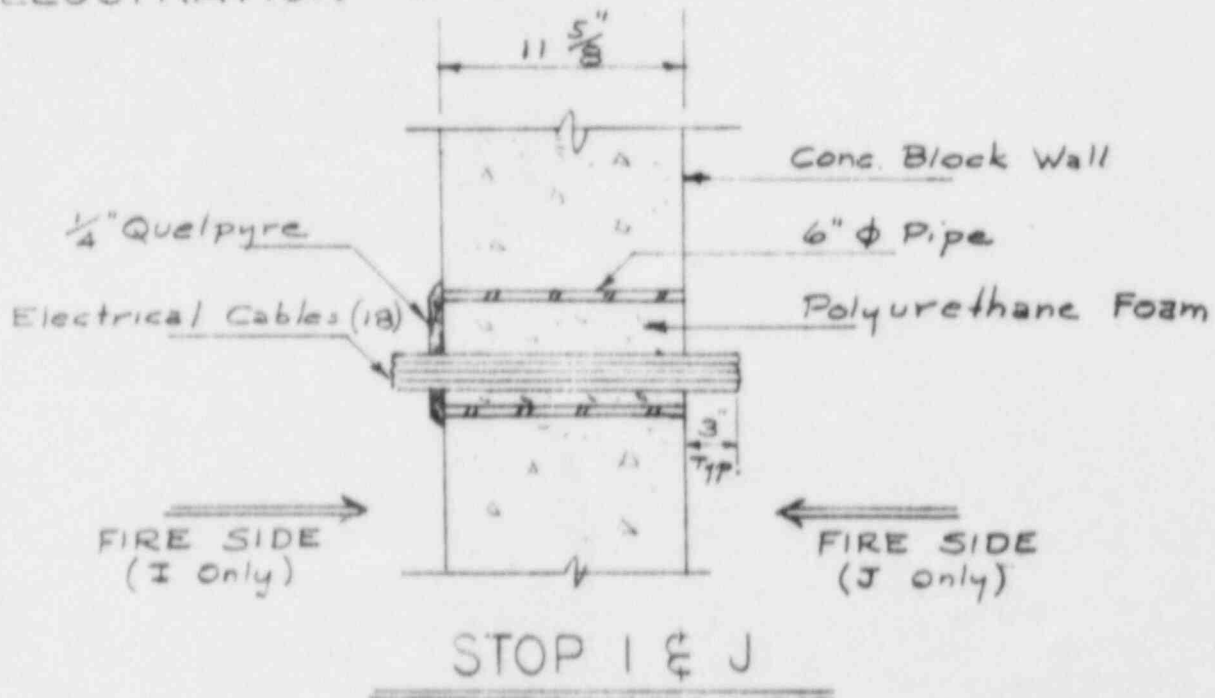


ILLUSTRATION 11

Installation of
Polyurethane Foam



(3912-3)

ILLUSTRATION 12

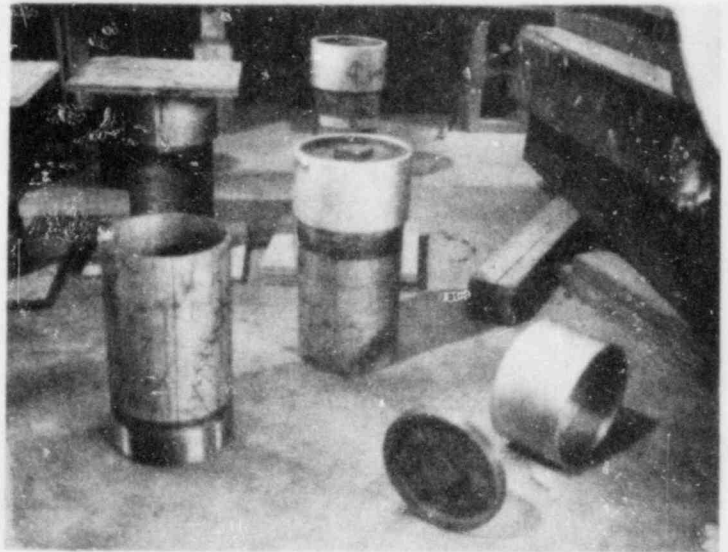
Installation of
Quelpyre Mastic



(3912-4)

ILLUSTRATION 9

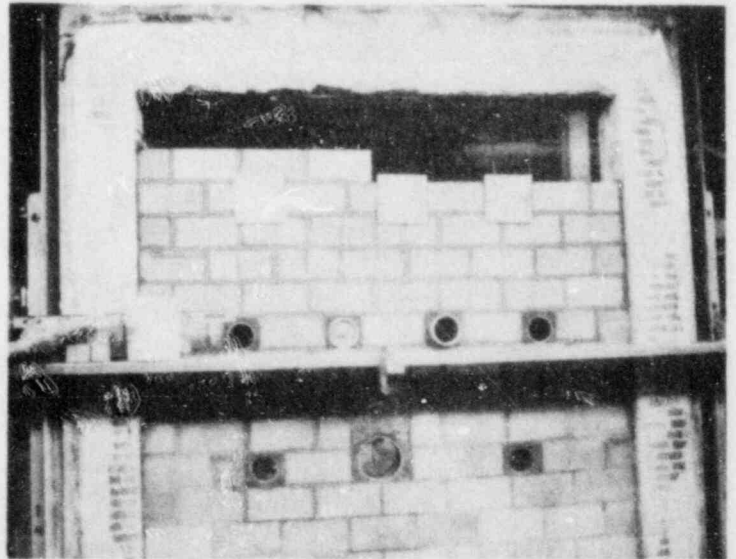
Nominal 6 in.
dia. pipe sleeves, pipe
couplings and pipe plugs



(3912-1)

ILLUSTRATION 10

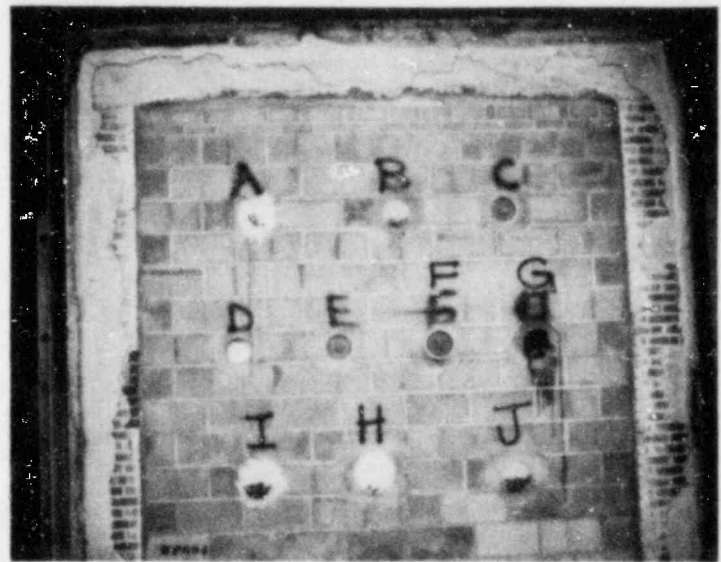
Exposed Surface During
Installation of
Penetration Seals



(3912-2)

ILLUSTRATION 13

Exposed Surface Before
Fire Endurance Test



(3912-5)

ILLUSTRATION 14

Unexposed Surface Before
Fire Endurance Test

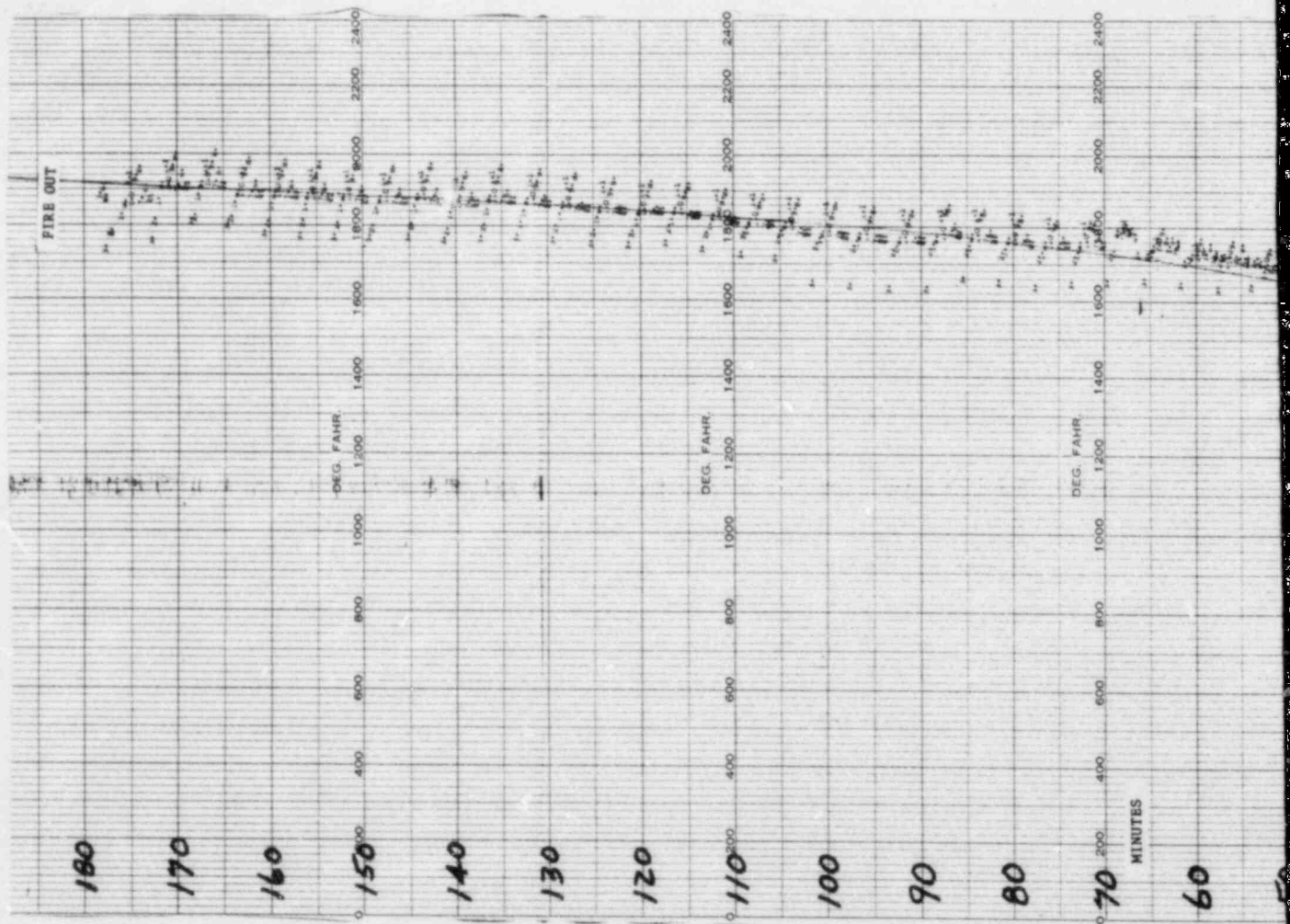


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RESEARCH CORPORATION

Page 19

TEMPERATURES

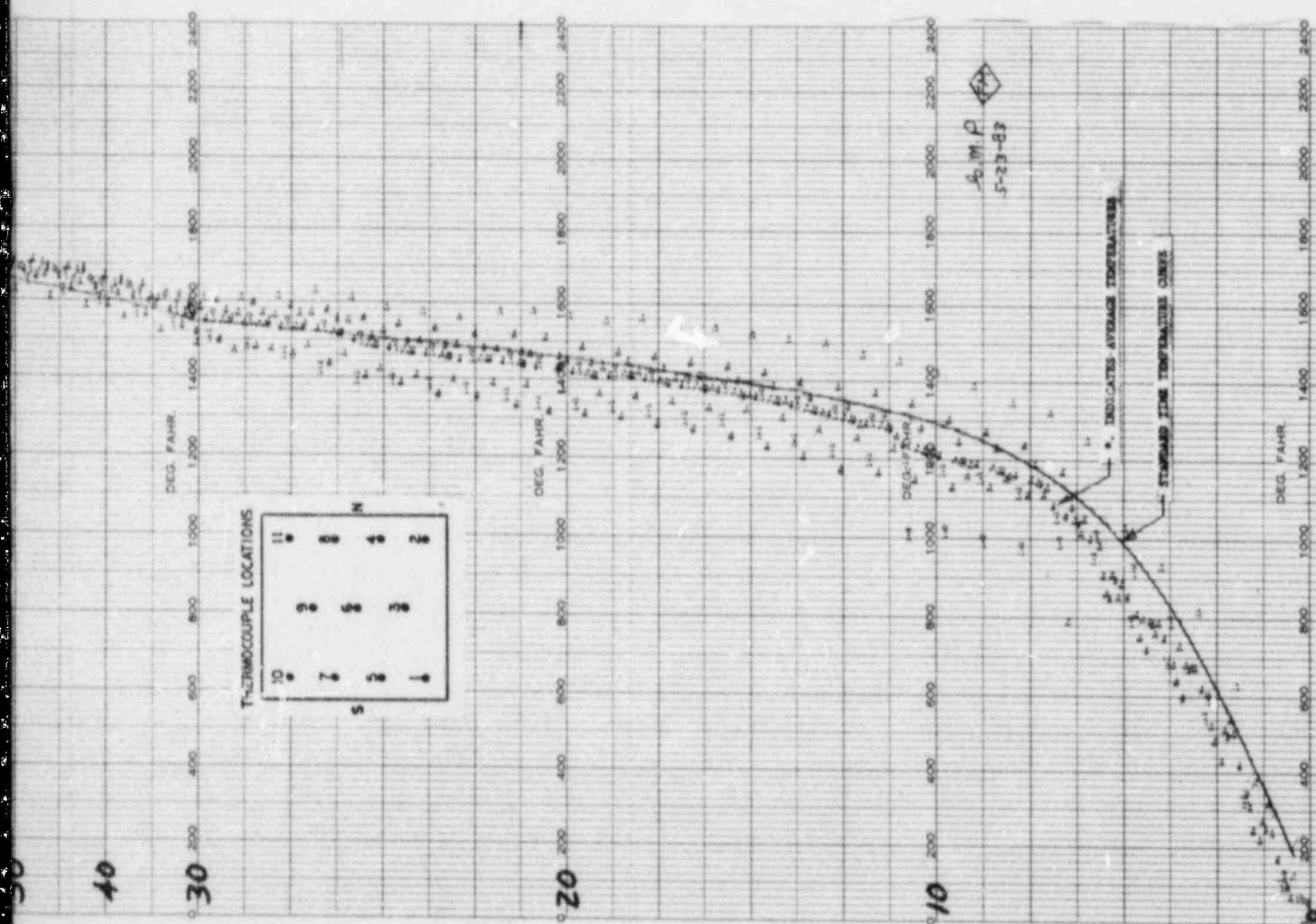
DURANCE TEST

23, 1983

ELECTRIC COMPANY

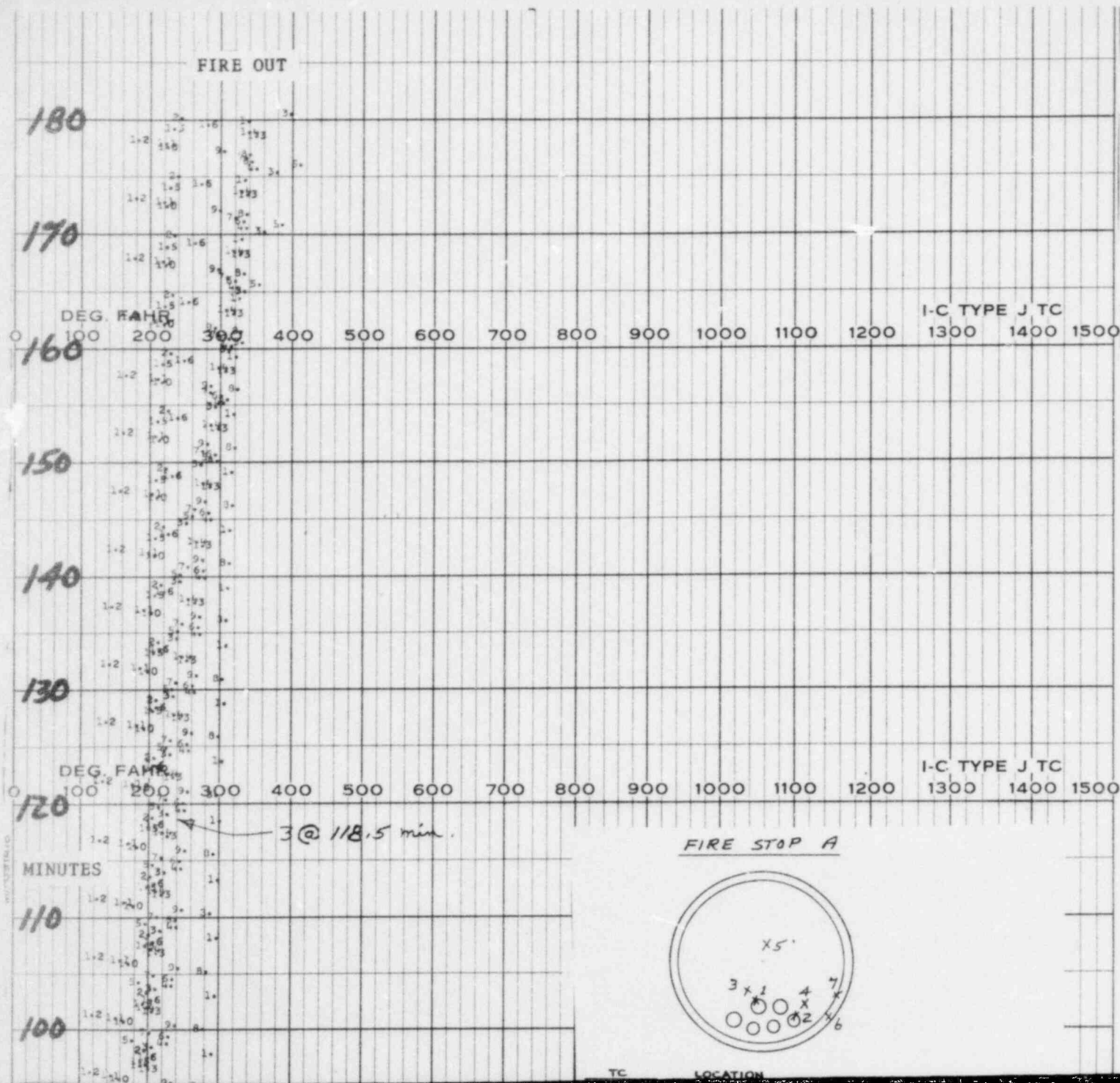
Illustration 15

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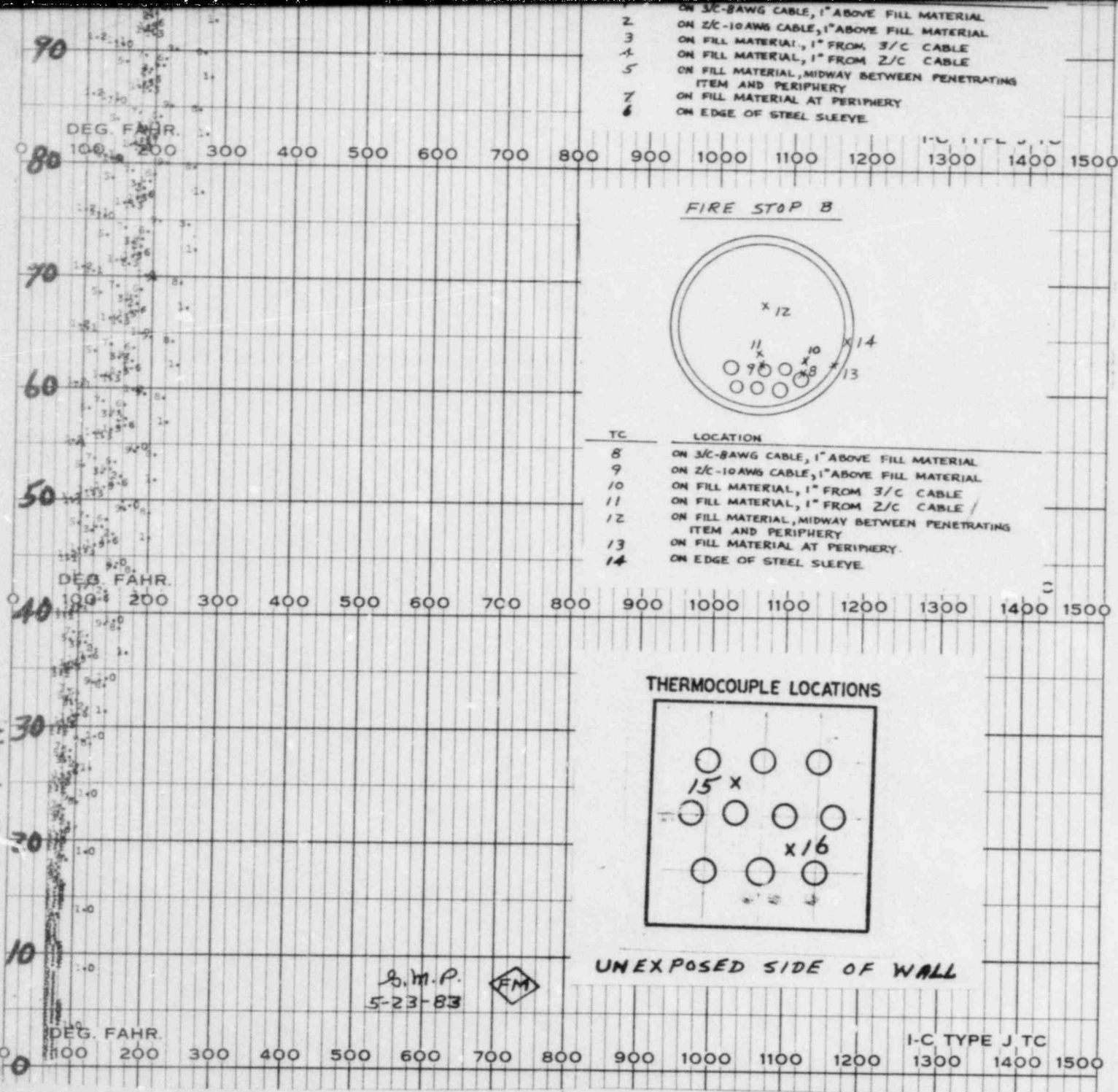
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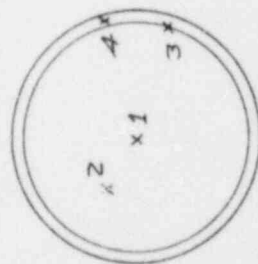
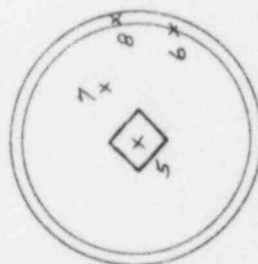
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Also Available On
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FIRE STOP D

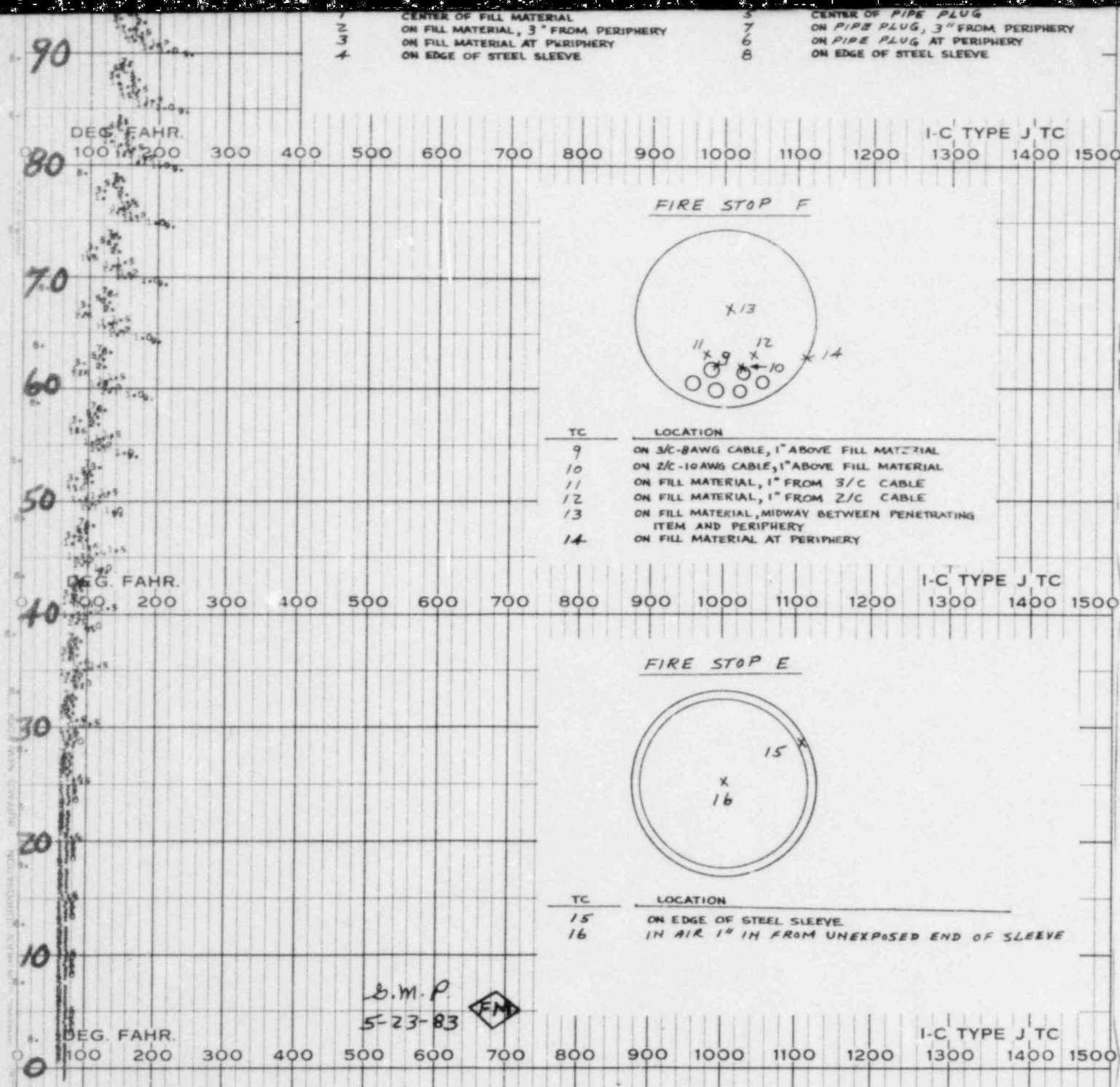
FIRE STOP C

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110.3 min.

110.3 min.

TI APERTURE CARD

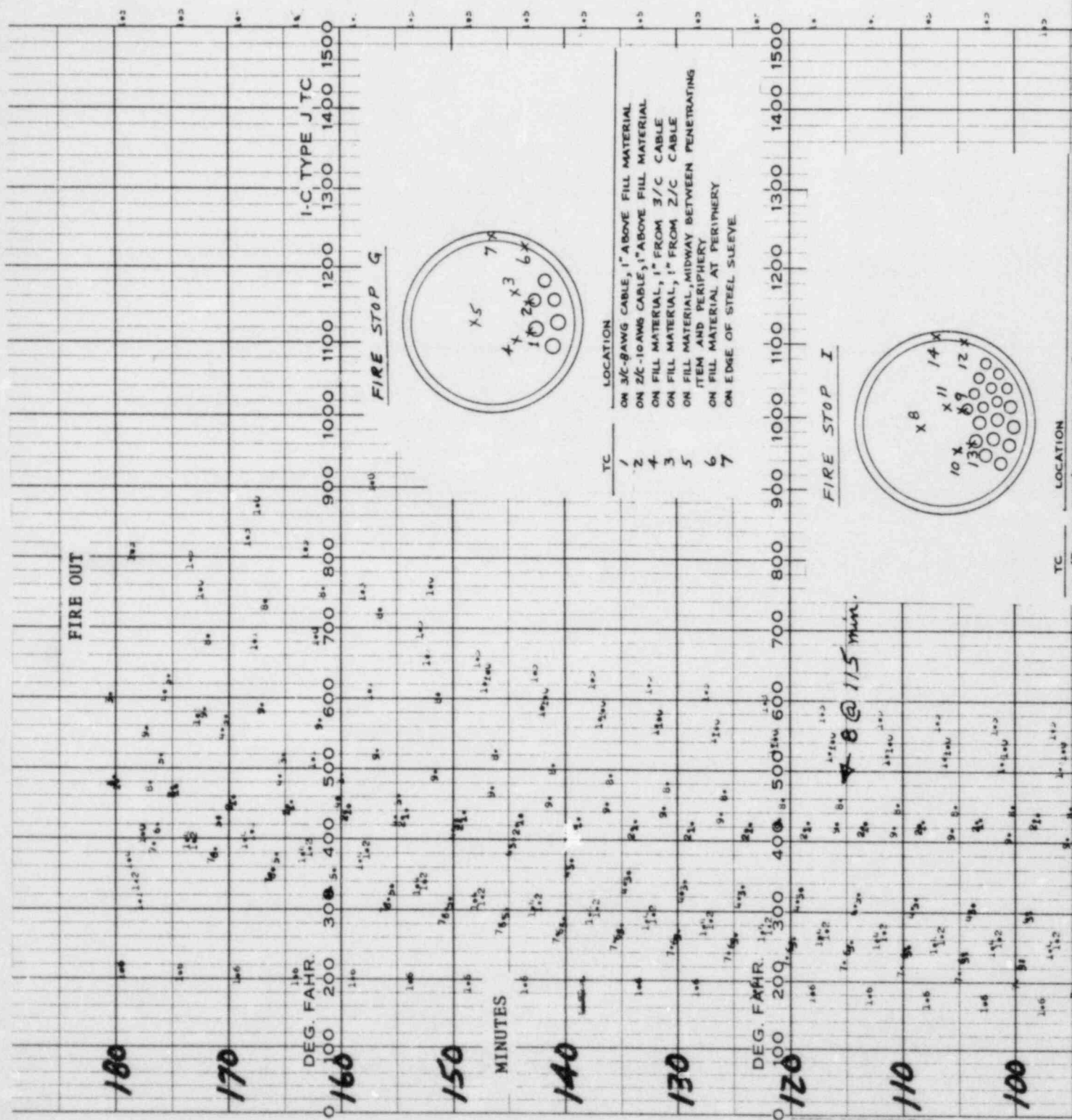


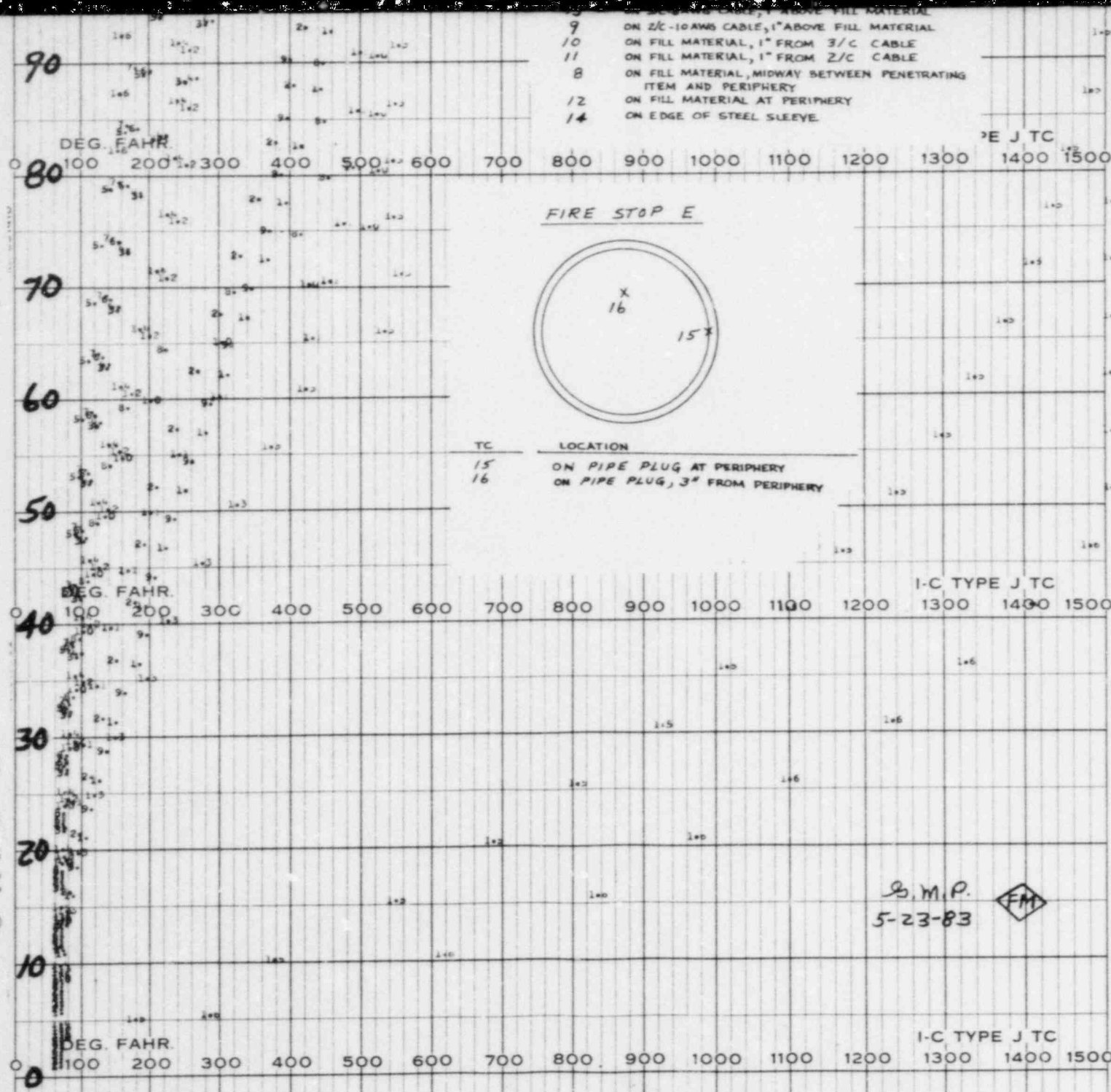
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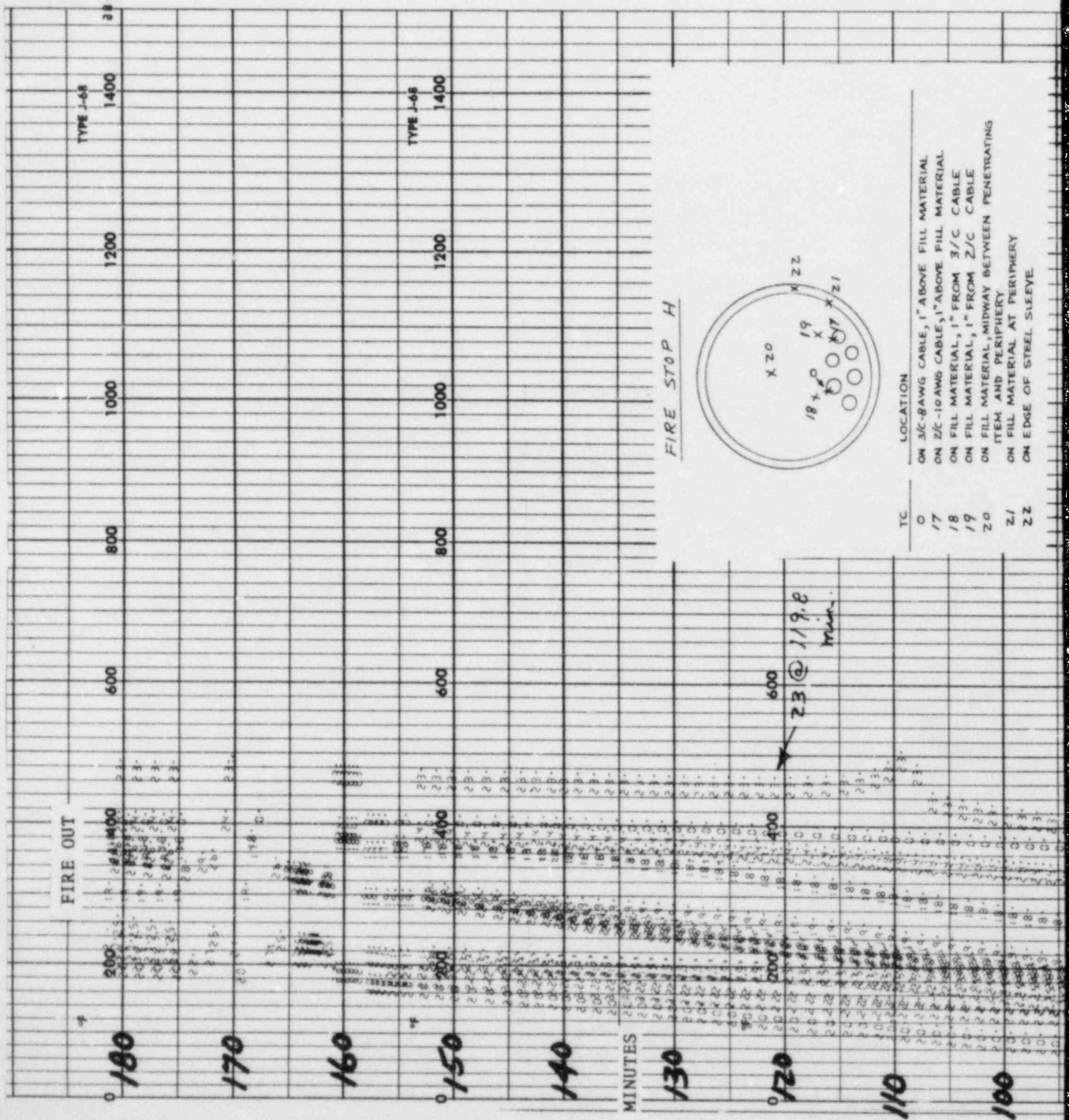


Also Available On
Aperture Card

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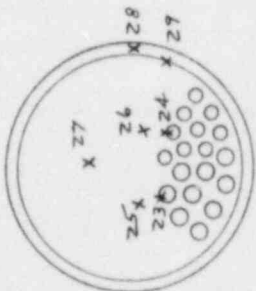
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UNEXPOSED SURFACE
FIRE ENDURANCE
MAY 23,
PHILADELPHIA ELE



TI
APERTURE
CARD

FIRE STOP J



TC	LOCATION
23	ON 3/8" BAWG CABLE, 1" ABOVE FILL MATERIAL
24	ON 2/8" BAWG CABLE, 1" ABOVE FILL MATERIAL
25	ON FILL MATERIAL, 1" FROM 3/8" CABLE
26	ON FILL MATERIAL, 1" FROM 2/8" CABLE
27	ON FILL MATERIAL, MIDWAY BETWEEN PENETRATING ITEM AND PERIPHERY
28	ON FILL MATERIAL AT PERIPHERY
29	ON EDGE OF STEEL SLEEVE

TYPE J-68

1400

1200

1000

800

600

400

200

0

TYPE J-68

1400

1200

1000

800

600

400

200

0

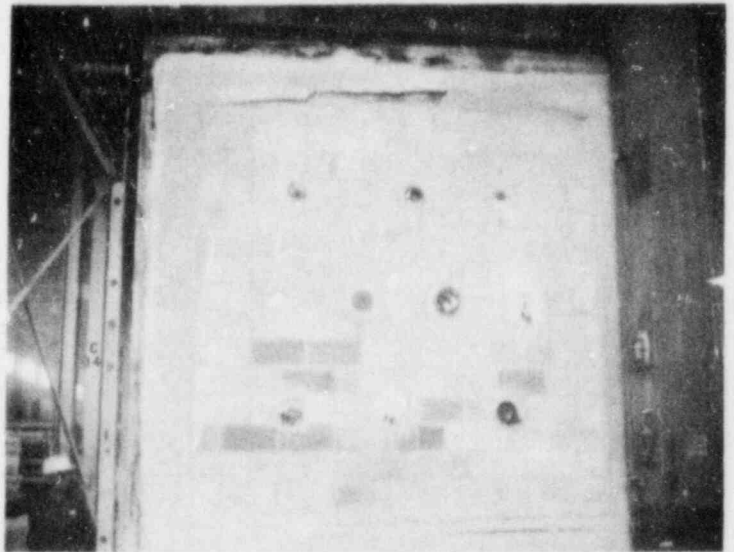
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Also Available On
Aperture Card

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ILLUSTRATION 20

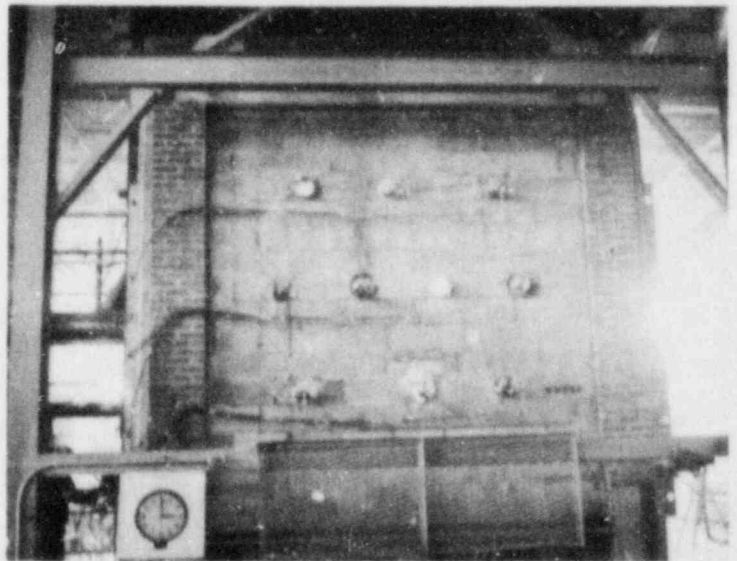
Exposed Surface After
Fire Endurance and
Before Hose Stream Test



(3912-7)

ILLUSTRATION 21

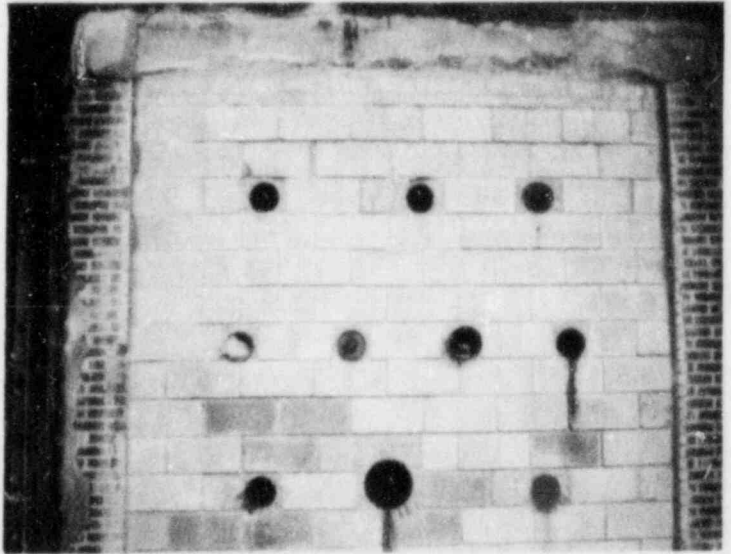
Unexposed Surface at
Three Hours of
Fire Exposure



(3912-8)

ILLUSTRATION 22

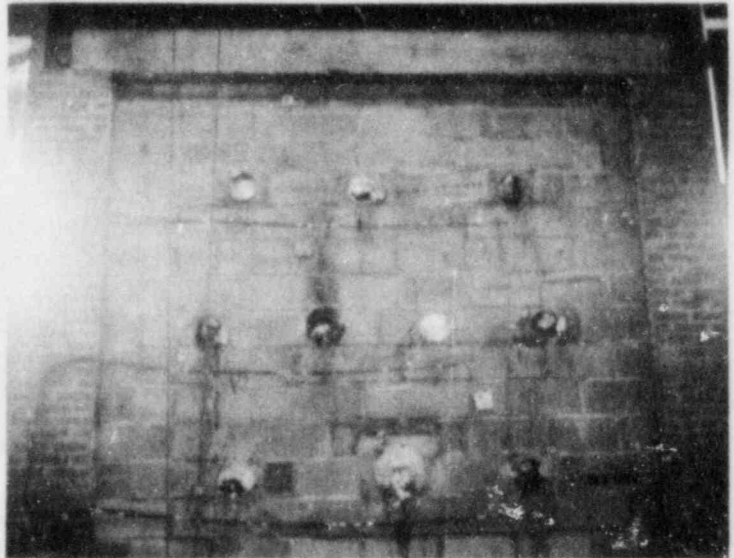
Exposed Surface After
Fire Exposure and
Hose Stream Test



(3912-9)

ILLUSTRATION 23

Unexposed Surface After
Fire Exposure and
Hose Stream Test



(3912-10)

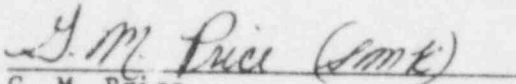
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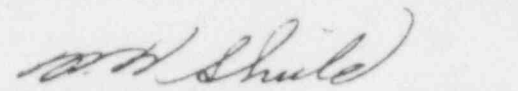
TEST BY:

Fire Technology Group
National Gypsum Co., Gold Bond Building Products Division
Design WP 694-3 Hour

REPORT, TECHNICAL SUPERVISION OF
CONSTRUCTION AND FIRE TEST BY:


G. M. Price
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