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DOCKET NOS 50-277
50-278

ASTM E814-81

FIRE ENDURANCE AND HOSE STREAM TESTS

on

FLOOR PENETRATION FIRE STOPS

DESIGN FC 350

for

PHILADELPHIA ELECTRIC COMPANY

2301 MARKET STREET - N2-1

PHILADELPHIA, PENNSYLVANIA 19101

J.I. 1J2Q7.AC
(4990)

MARCH 14, 1984

Factory Mutual System

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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 five through-penetration fire stops installed in a concrete floor. The test was conducted on November 4, 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 F 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 - Nominal 6 in. (152.4 mm) diameter standard weight steel pipes. The wall thickness of the pipes was ¼ in. (6.35 mm) and they were each 12 in. (304.8 mm) long except one sleeve length was 8 in. (203.2 mm).

Electrical Cables - The following cables were used in Fire Stops A and B with the designation of each cable used in this report shown. The cable marking and diameter are as noted:

Designation	Cable Description
No. 2:	10 AWG 2/C ROCKBESTOS 600V FIREWALL III with an outside diameter of 0.50 in.
No. 3:	BRAND-REX 9/C #14 600V with an outside diameter of 0.625 in.
No. 4:	14 AWG 7/C ROCKBESTOS 600V FIREWALL III with an outside diameter of 0.535 in.
No. 5:	ROCKBESTOS RSS-6-208B with an outside diameter of 0.40 in.
No. 6:	ROCKBESTOS 1978-8A1094 with an outside diameter of 0.60 in.
No. 8:	14 AWG 12/C ROCKBESTOS 600V FIREWALL III with an outside diameter of 0.70 in.
No. 10	No writing on outside jacket. PVC jacket with 19 conductors and an outside diameter of 0.55 in.

Conduit - Nominal 2 in. (50.8 mm) diameter standard weight steel conduit.

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. 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 0.75 lb/ft^3 (28 kg/m^3).

C. Grout - Embeco 636 Grout manufactured by Master Builders, Div. of Martin Marietta.

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

INSTALLATION OF FIRE STOPS

The five fire stops were installed in a 8 in. (203.2 mm) thick concrete floor. Each fire stop contained a nominal 6 in. (152.4 mm) diameter steel pipe sleeve.

The test assembly containing the fire stops was 6 ft. - 10 in. (2.08 m) square and the location of each unit is shown on Illustration 1.

The construction of each fire stop penetration is shown on Illustrations 2 through 5. A description of each fire stops follows:

Fire Stop A - Nominal 6 in. (152.4 mm) diameter pipe sleeve embedded within the 8 in. (203.2 mm) thick concrete floor. One end of the sleeve was flush with the unexposed surface of the concrete and the other end projected 4 in. (101.6 mm) beyond the fire exposed surface of the concrete. The stop contained six cables of the following type: two No. 2 cables and one each of Nos. 5, 6, 8 and 10 cables.

The two No. 2 cables were 4 ft. - 8 in. (1.42 m) long and extended 12 in. (304.8 mm) below the exposed surface of the floor. All the other cables were 2 ft. (609.6 mm) long and extended 10 in. (254.0 mm) below the exposed side of the floor.

The ASTM E814-81 Standard specifies that the penetrating items must project 12 in. (304.8 mm) beyond the exposed surface and 3 ft. (914.4 mm) beyond the unexposed surface of the floor. The 4 ft. - 8 in. (1.42 m) long cables satisfy this requirement but the 2 ft. (609.6 mm) long cables do not.

The cables were located in the center area of the sleeve and were individually wire tied to steel railings located about 5 in. (127.0 mm) above the unexposed surface for the shorter cables and about 2 ft. 9609.6 mm) above the unexposed surface for the longer cables.

The fire exposed end of the sleeve was packed with Kaowool to a depth of 2 in. (50.8 mm). Kaowool was also packed between the cables to keep them separated about ½ in. (12.7 mm) at the fire side.

The remaining volume of this sleeve was then filled with polyurethane foam applied from the unexposed side employing the use of the Froth Pak Kit dispenser. Care was used to assure that the urethane was received between the cables. A temporary dam had been placed at the unexposed end of the sleeve to prevent the Kaowool from being displaced. After the foam cured, the dam was removed and the excess urethane was cut flush with the end of the sleeve. No temporary dam was used at the unexposed side.

A ¼ in. (6.35 mm) thick coating of Quelpyre Mastic 703-B was trowel applied to the unexposed side in two 1/8 in. (3.18 mm) coats with approximately 3 hours allotted between applications. The edge of the mastic was feathered and extended about ½ in. (12.7 mm) beyond the outside edge of the sleeve.

Fire Stop B - Same construction details as Fire Stop A except this stop contained more cables. The stop contained 18 cables of the following type: ten No. 2 cables, one No. 3, one No. 4, three No. 5, two No. 6 and one No. 10. Seven of the No. 2 cables were 4 ft. - 8 in. (1.42 m) long while all other cables contained in this stop were 2 ft. (609.6 mm) long. They extended below the exposed surface of the floor in the same manner as described in Fire Stop A.

See the discussion of different cable lengths noted under Fire Stop A.

Fire Stop C - Same construction details as Fire Stop A except a 2 in. (50.8 mm) diameter steel conduit was located in center of stop in lieu of cables. The conduit was 4 ft. - 8 in. (1.42 m) long with one end extended 12 in. (304.8 mm) below the exposed surface of the floor. The exposed end of the conduit has a cap welded to it while the unexposed end remained was open. At the unexposed side the conduit was welded to two steel rails positioned at each side of the conduit and located about 5 in. (127.0 mm) above the concrete surface.

Fire Stop D - Same construction details as Fire Stop A except no cables were contained in this stop.

Fire Stop E - Nominal 6 in. (152.4 mm) diameter pipe sleeve embedded into 8 in. (203.2 mm) thick concrete floor. The sleeve was 8 in. (203.2 mm) long and one end was flush with the unexposed surface of the floor.

The fire exposed end of the sleeve was packed with 6 in. (152.4 mm) of Kaowool. The top 2 in. (50.8 mm) of the sleeve was filled with Embeco 636 Grout. The grout material was prepared with sufficient water so that the mixture would stick together when molded by hand into a ball and without exuding water under slight pressure. The grouted surface was covered with a damp cloth for two days following its installation. The sleeve was grouted 37 days before the fire test.

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 floor assemblies was used for the test.

METHOD:

The furnace temperatures were measured by four thermocouples symmetrically located in the furnace chamber as shown on Illustration 8. The unexposed surface temperatures of the floor, penetration seals and cables were measured with thermocouples as shown on Illustrations 9 and 10. Each thermocouple was covered with a dry, insulating 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 8.

Observations of the Exposed Surface - At 5 minutes of fire exposure, the ends of the electrical cables were charred. At 7 minutes, the cables were flaming and the flames were about 1 ft. (304.8 mm) long. At 24 minutes, the cables continued to flame and there was a slight amount of smoke in the furnace chamber.

At 30 minutes, the cables continued to flame and there was reduced visibility within the furnace due to a moderate amount of smoke. At 50 minutes, there was poor visibility of the fire stops due to the increased smoke in the furnace. The condition of the fire stops could not be observed for the remainder of the test.

See Illustration 11 for a view of the exposed surface after the fire endurance test.

Observations of the Unexposed Surface - At 30 minutes of exposure, there were slight water marks on the concrete surface. At 50 minutes, there was water on the surface of the concrete at several locations. Also at Fire Stops A and D the mastic coating appears not to be secured to the steel sleeve due to the upward expansion of the foam.

At 90 minutes, a slight amount of smoke was noted coming from Fire Stop A at the location of the cables and the steel sleeve. At 110 minutes, there was a slight amount of smoke coming from Fire Stops A, B and C. The smoke at D had stopped. At 140 minutes, the smoke described at 110 minutes continued and the water on the concrete was reduced.

At 155 minutes, there was little change. There was still some water on the concrete surface. There was some discoloration of the mastic at Fire Stops A, B, C and D primarily at the location of the steel sleeve. There was no change in Fire Stop E.

At 170 minutes, there was further discoloration of the mastic at Fire Stop A. No further changes were noted on the unexposed surface during the test.

See Illustration 12 for a view of the unexposed surface at 3 hours of exposure.

The pressure in the furnace chamber was 0.02 in. of H_2O (4.98 Pa) below atmospheric pressure throughout the fire test. The pressure was measured at north edge of the furnace.

Temperatures at Unexposed Side of Stops - The temperatures that developed during the test and the thermocouple locations are shown on Illustrations 9 and 10.

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 70°F (21°C).

HOSE STREAM TEST

The same floor 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 11 and 12.

Immediately after fire exposure of 180 minutes, the assembly was subjected to the impact, cooling and eroding action of a hose stream for 37.5 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). The pressure was 30 psi (207 kPa) as measured at the nozzle base and the hose stream was applied uniformly over a 5 ft. (1.52 m) square surface area of the floor 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 Fire Stop D.

Water did not project beyond the unexposed side of Fire Stops A, B, C and E.

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 13 and 14. The conditions at each stop are noted below:

Fire Stop A - On the unexposed side the mastic material was discolored particularly where the seal material met the sleeve and where the seal material met the cables.

A segment of the electrical cables near the stop surface was discolored and slightly charred.

At the exposed side the majority of the jacket and insulation on each cable was gone. A cavity existed in the seal and its depth was about 6 in. (152.4 mm) from the fire exposed end of the steel sleeve.

Fire Stop B - The same observations for Stop A apply to Stop B.

Fire Stop C - On the unexposed side there was a slight discoloration of the mastic coating. On the exposed side there was a large cavity in the seal between the sleeve and the conduit. About 75 percent of the seal material was gone from the fire stop.

Fire Stop D - A through opening existing in the seal with almost all of the seal material gone from the stop.

Fire Stop E - On the unexposed side there was no noticeable change in the fire stop. At the exposed side the surface of the Kaowool was compressed into the stop.

CONCLUSIONS

Fire Stops A, B, C and E 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 Stop D failed the hose stream requirement of the ASTM E814-81, therefore a F nor T rating could not be assigned.

Fire Stops A, B, C and E 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 70°F (21°C). Stop C achieved a 2 hour T rating and Stop E achieved a 3 hour T rating.

Since the different cables in Fire Stops A and B were not segregated into groups, the T rating obtained applies to the entire fire stop and not to the individual cable types in each stop. Therefore, Fire Stop A achieved a 2 hour T rating and Stop B achieved a 3 hour T rating.

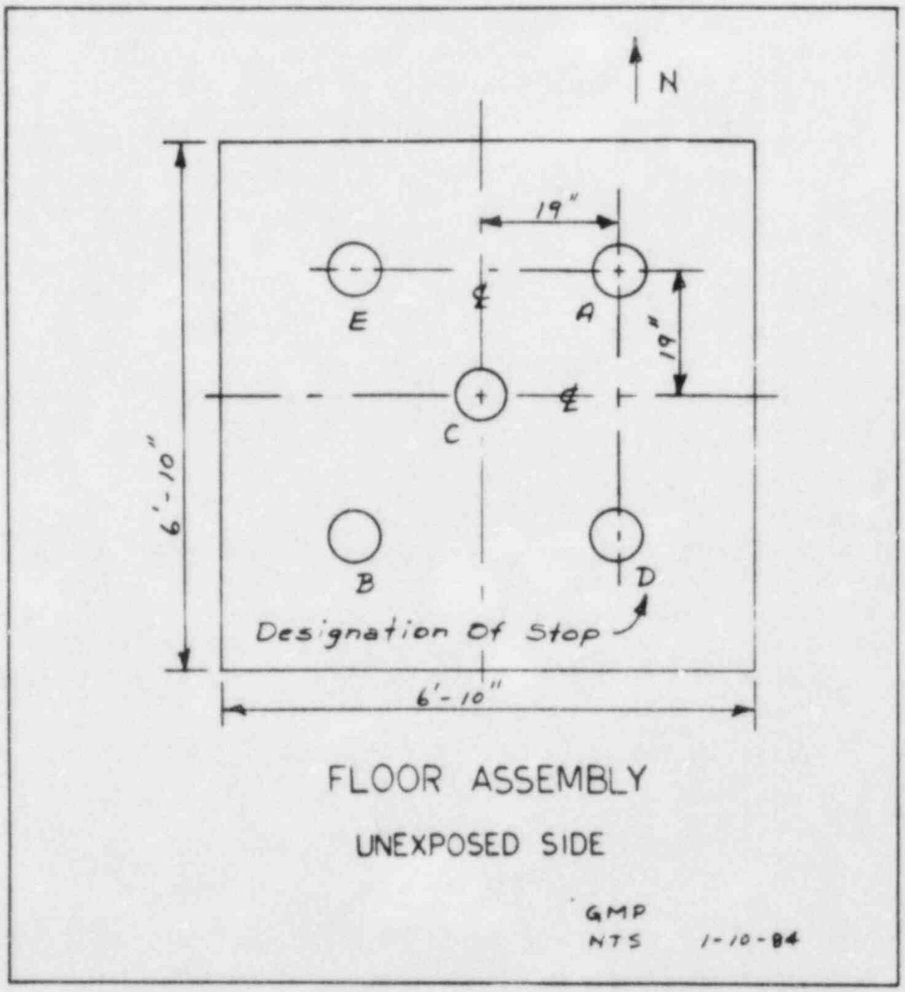
PRACTICABILITY:

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

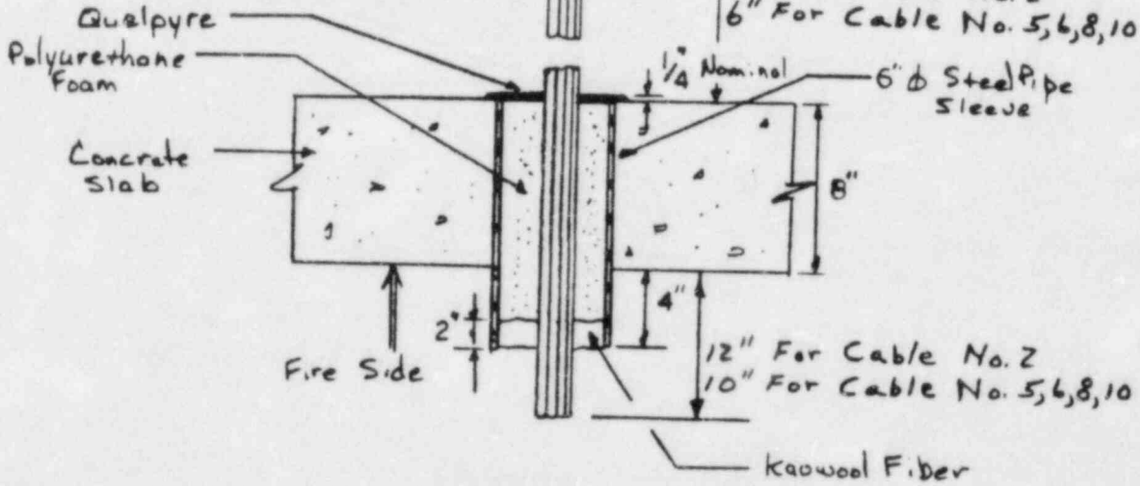


FLOOR ASSEMBLY

UNEXPOSED SIDE

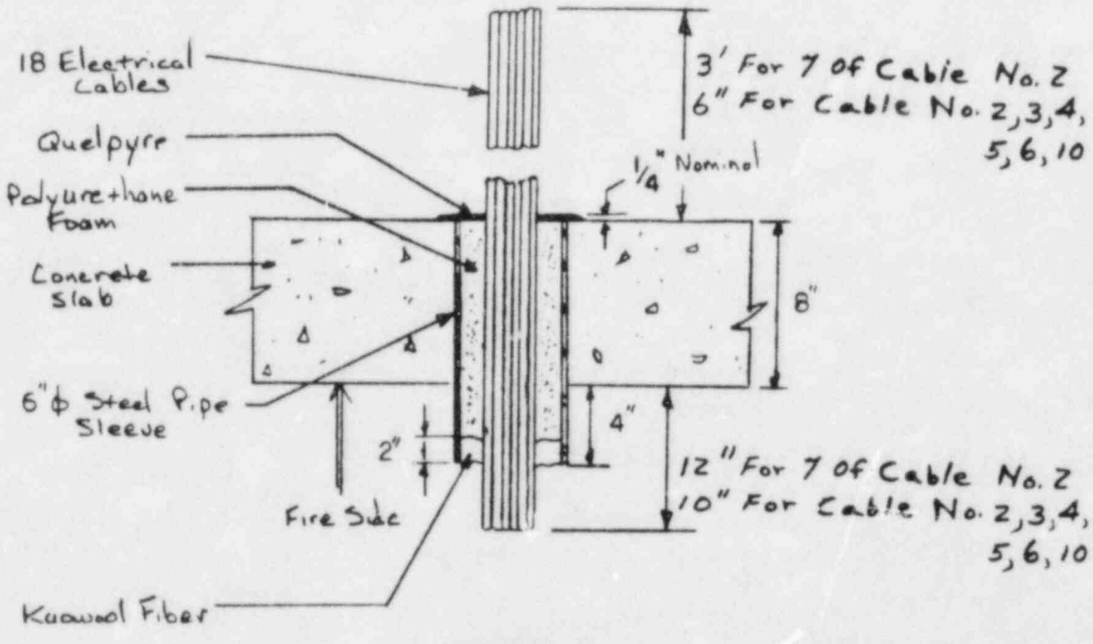
GMP
NTS 1-10-84

ILLUSTRATION 2



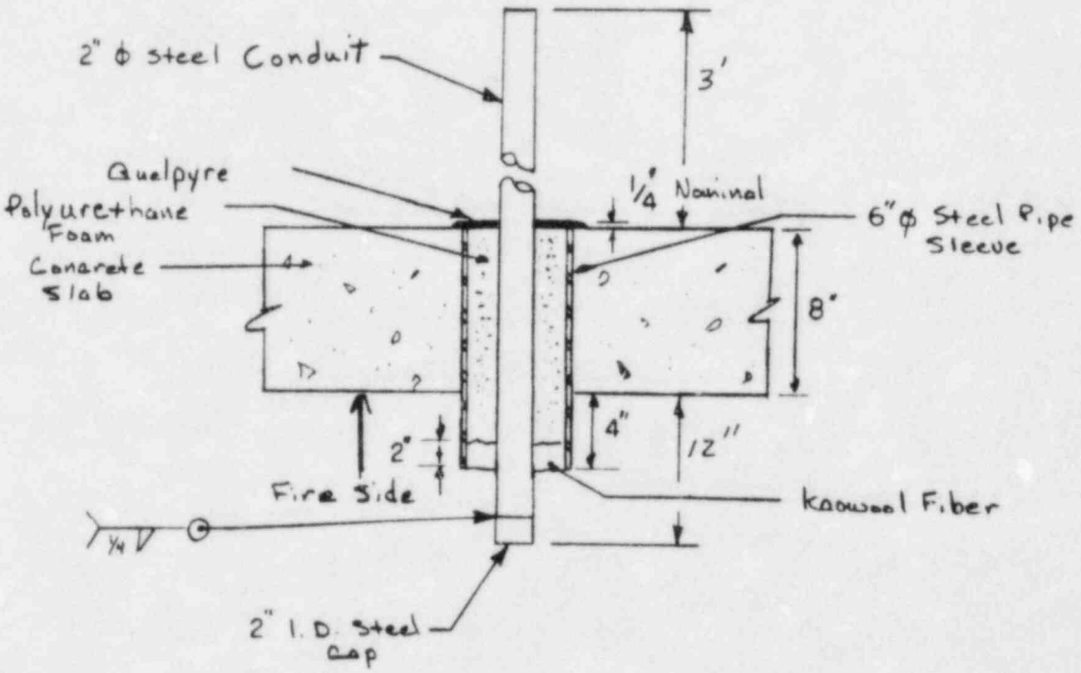
STOP A

ILLUSTRATION 3



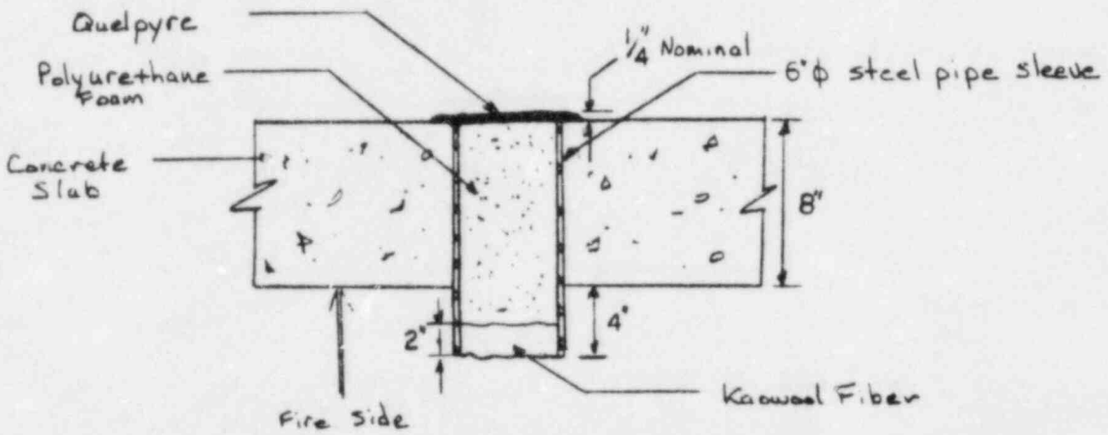
STOP B

ILLUSTRATION 4

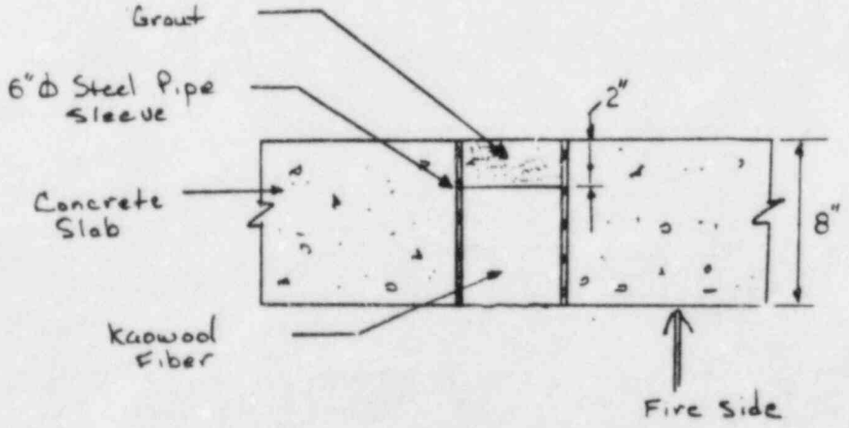


STOP C

ILLUSTRATION 5



STOP D



STOP E

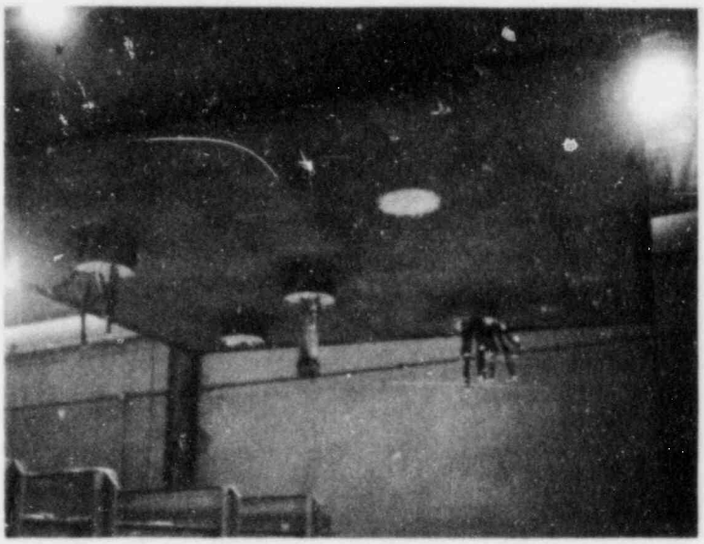


ILLUSTRATION 6

Exposed Surface Before
Fire Endurance Test

(3925-1)

ILLUSTRATION 7

Unexposed Surface Before
Fire Endurance Test

(3925-2)

FACTORY MUTUAL RESEA

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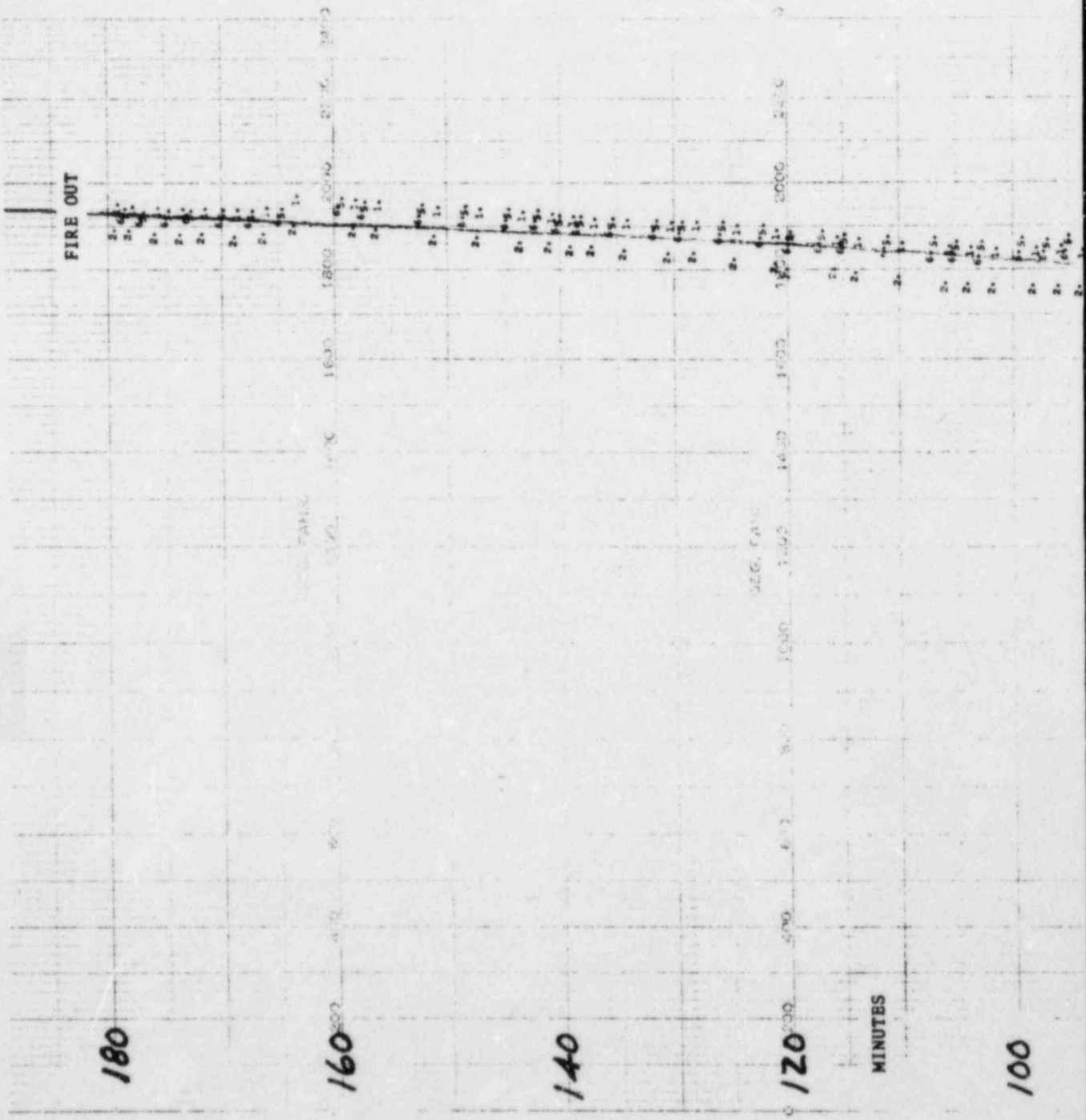
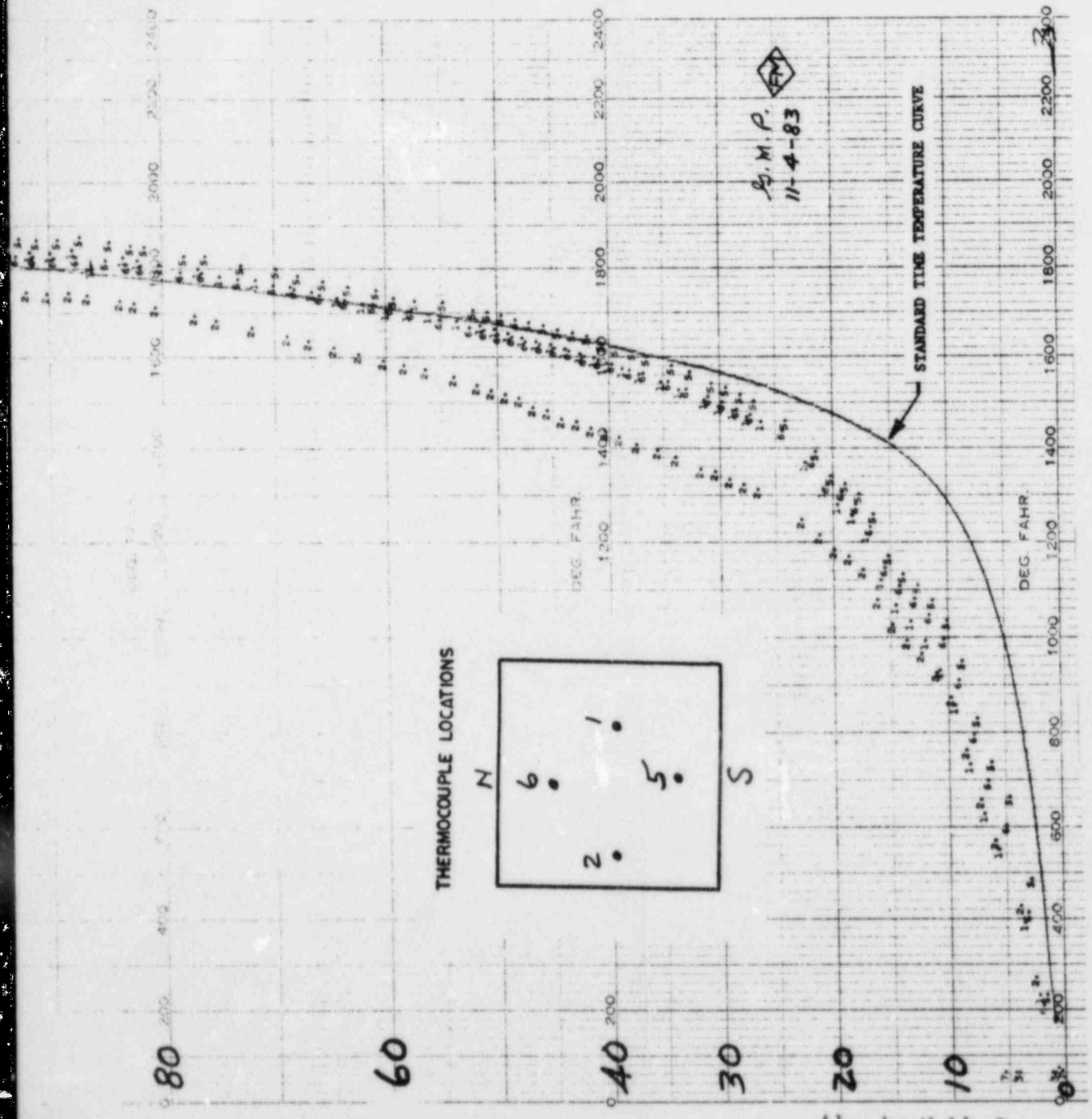
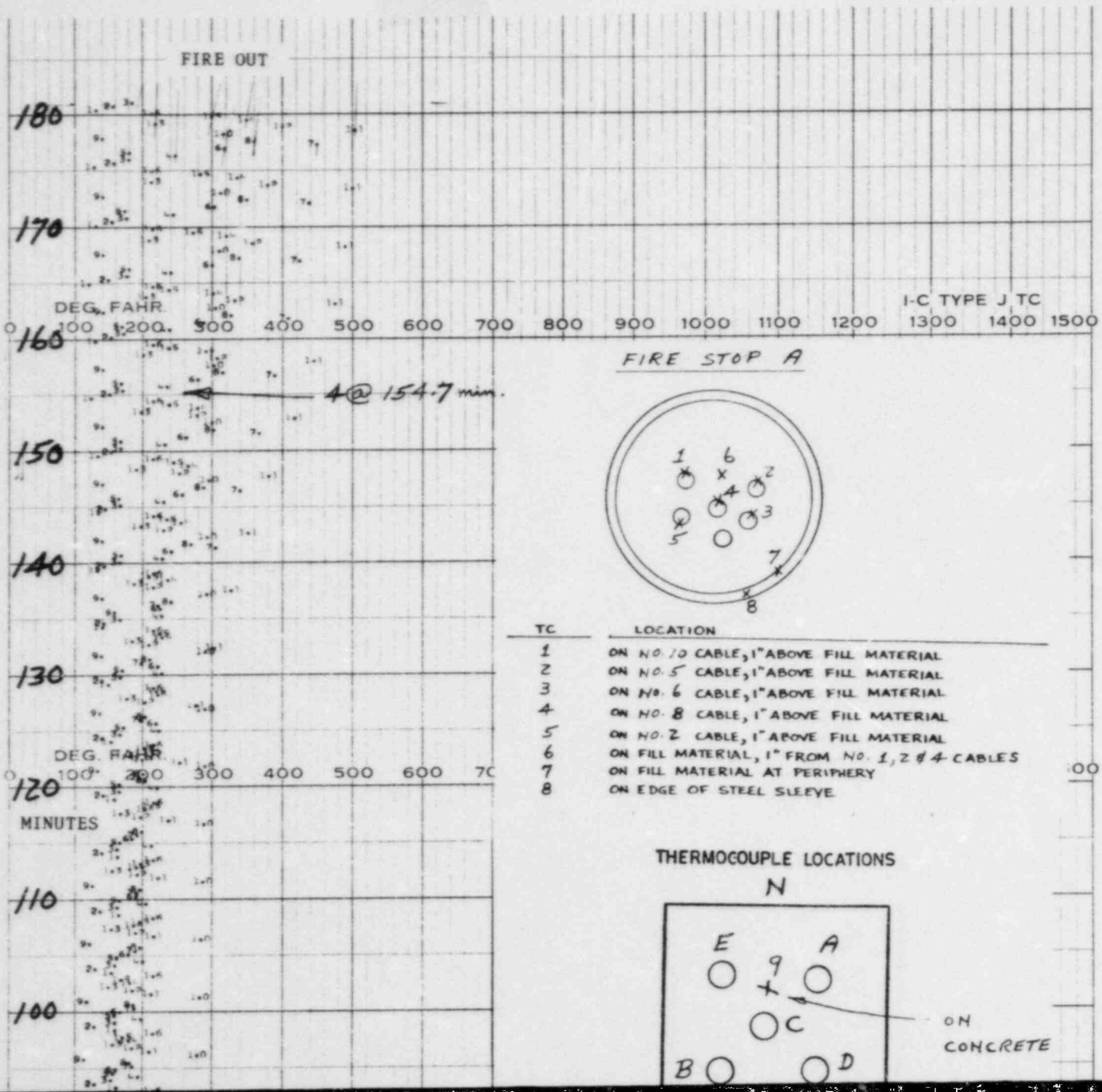


MPERATURES
RANCE TEST
4, 1983
ECTRIC COMPANY ILLUSTRATION 8





FIRE STOP A

TC	LOCATION
1	ON NO. 10 CABLE, 1" ABOVE FILL MATERIAL
2	ON NO. 5 CABLE, 1" ABOVE FILL MATERIAL
3	ON NO. 6 CABLE, 1" ABOVE FILL MATERIAL
4	ON NO. 8 CABLE, 1" ABOVE FILL MATERIAL
5	ON NO. 2 CABLE, 1" ABOVE FILL MATERIAL
6	ON FILL MATERIAL, 1" FROM NO. 1, 2 & 4 CABLES
7	ON FILL MATERIAL AT PERIPHERY
8	ON EDGE OF STEEL SLEEVE

THERMOCOUPLE LOCATIONS

FACTORY MUTUAL RESEAR

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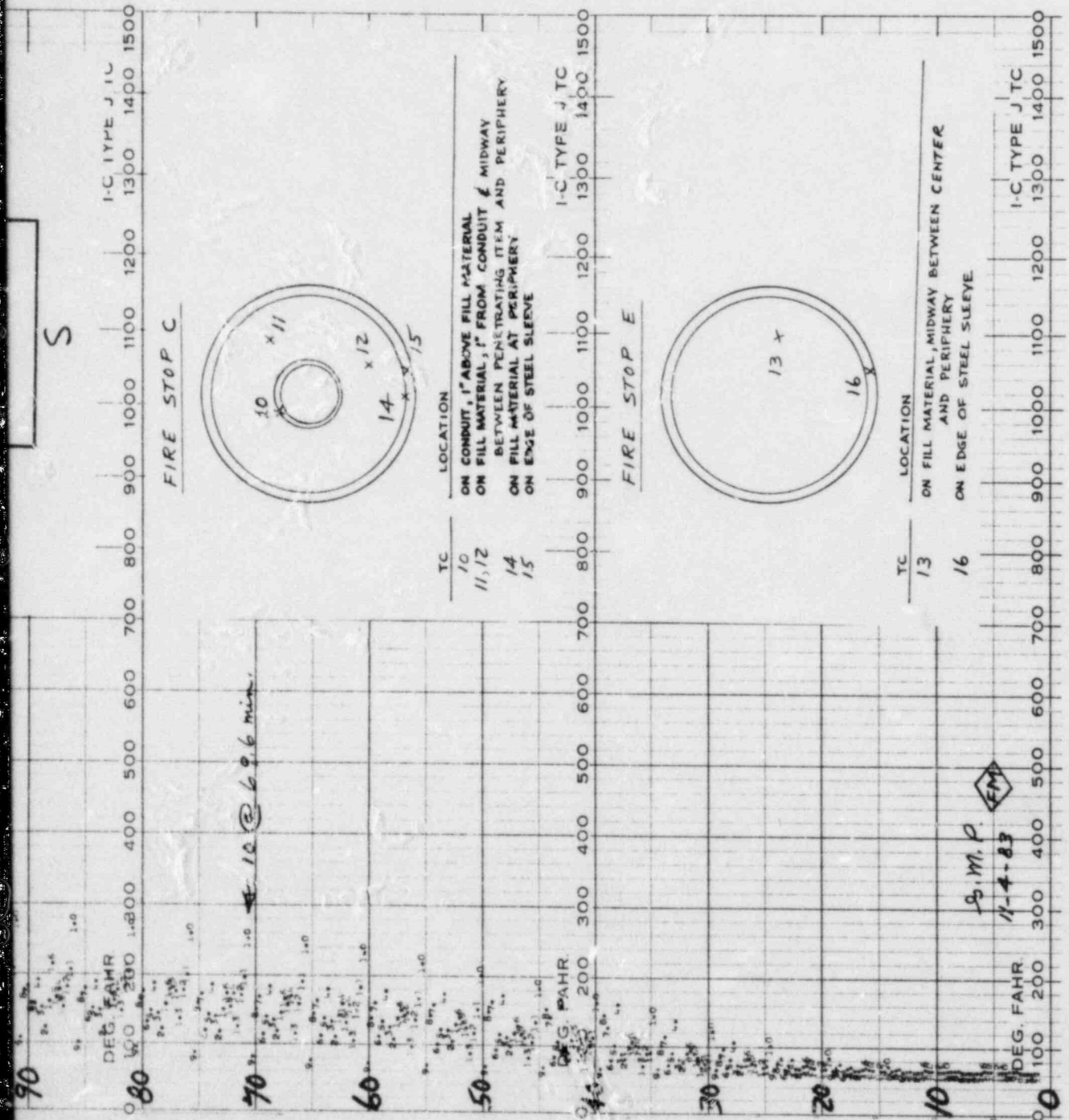
UNEXPOSED SURFAC

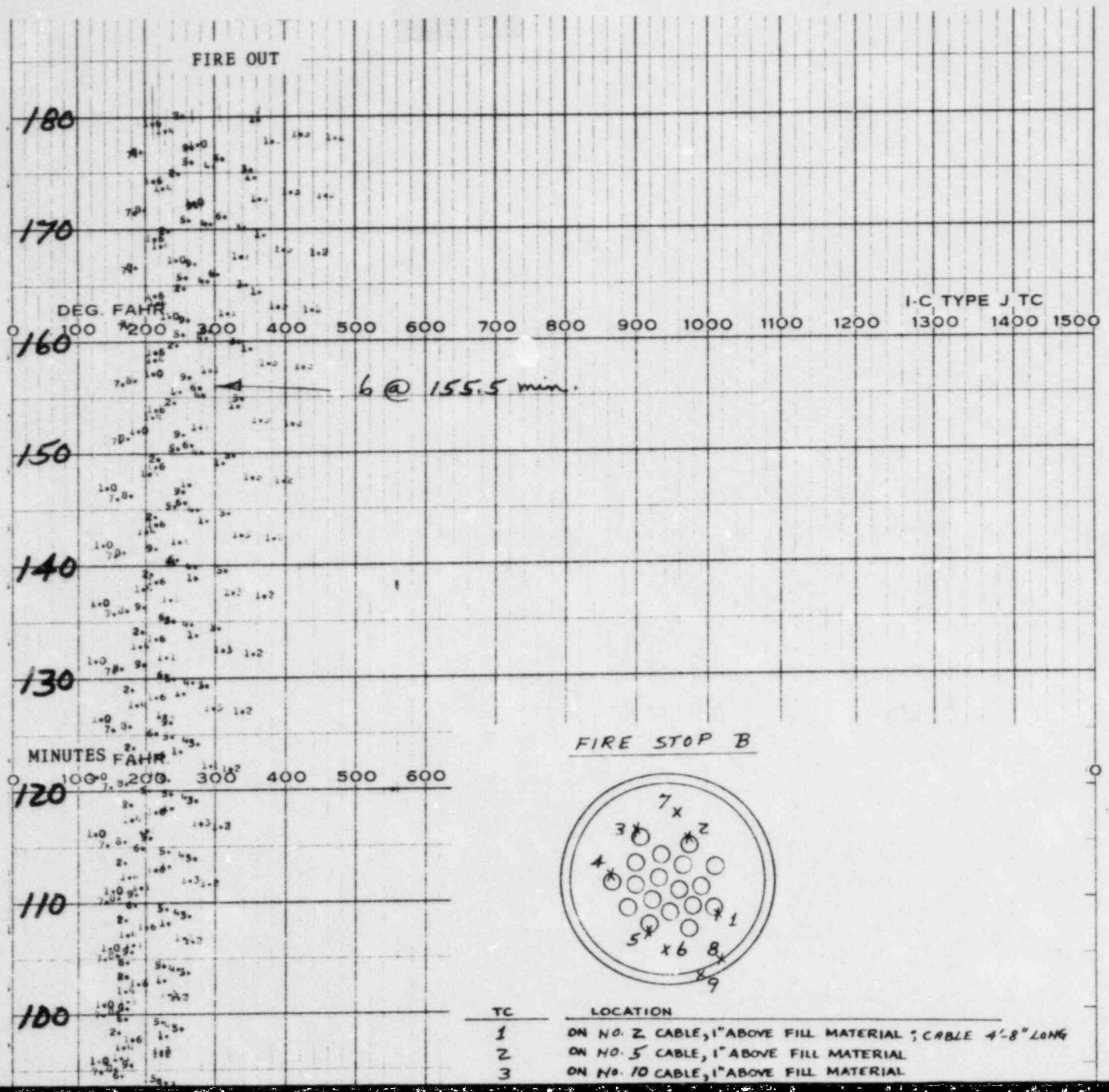
FIRE ENDUR

NOVEMBER

PHILADELPHIA EL

TEMPERATURES
NCE TEST
, 1983
TRIC COMPANY ILLUSTRATION 9





FIRE STOP B

TC	LOCATION
1	ON NO. 2 CABLE, 1" ABOVE FILL MATERIAL ; CABLE 4'-8" LONG
2	ON NO. 5 CABLE, 1" ABOVE FILL MATERIAL
3	ON No. 10 CABLE, 1" ABOVE FILL MATERIAL

FACTORY MUTUAL RESEAR

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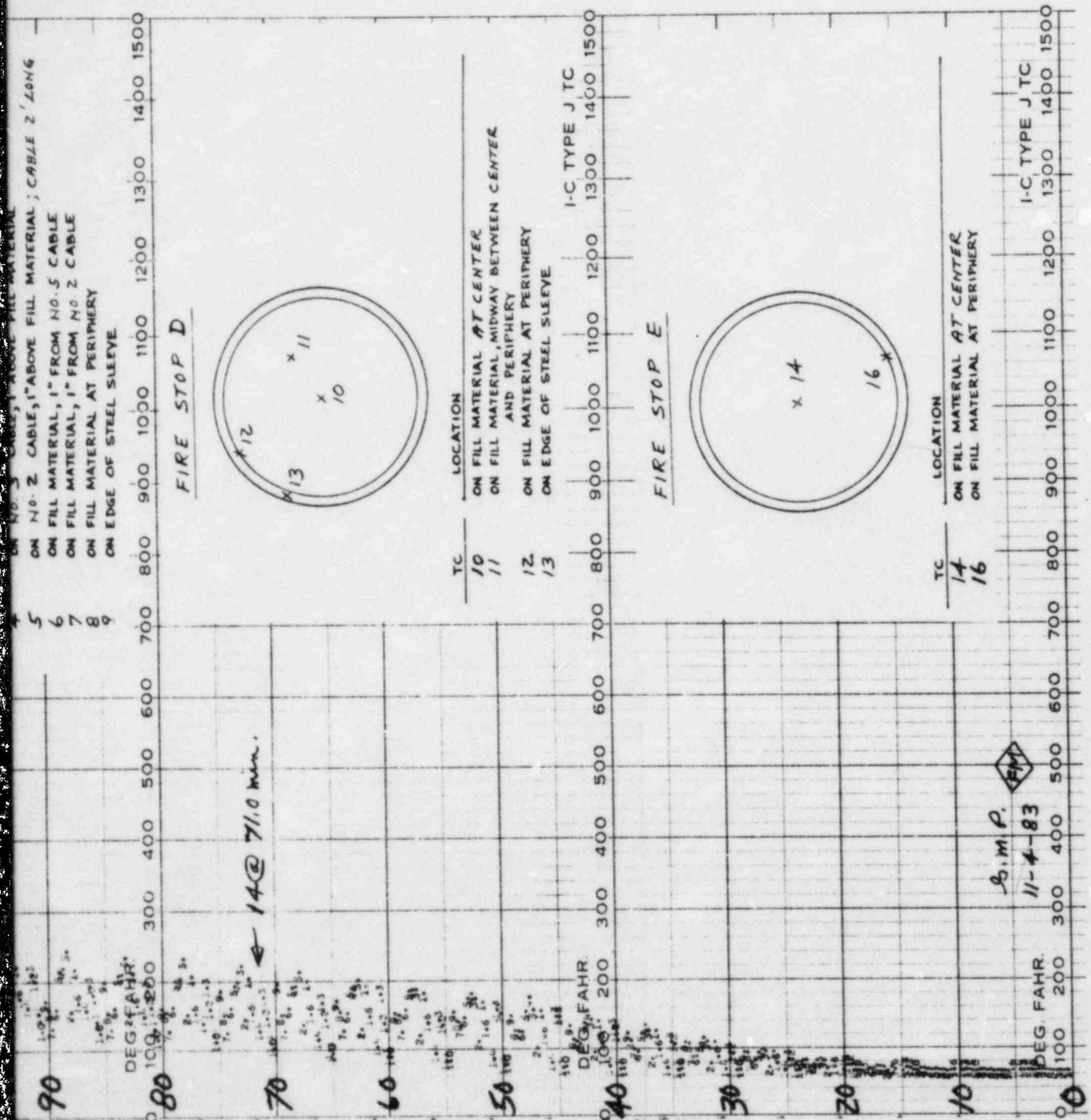
UNEXPOSED SURFAC
FIRE ENDUR
NOVEMBER
PHILADELPHIA ELE

TEMPERATURES
NCE TEST
4, 1983
CTRIC COMPANY ILLUSTRATION 10



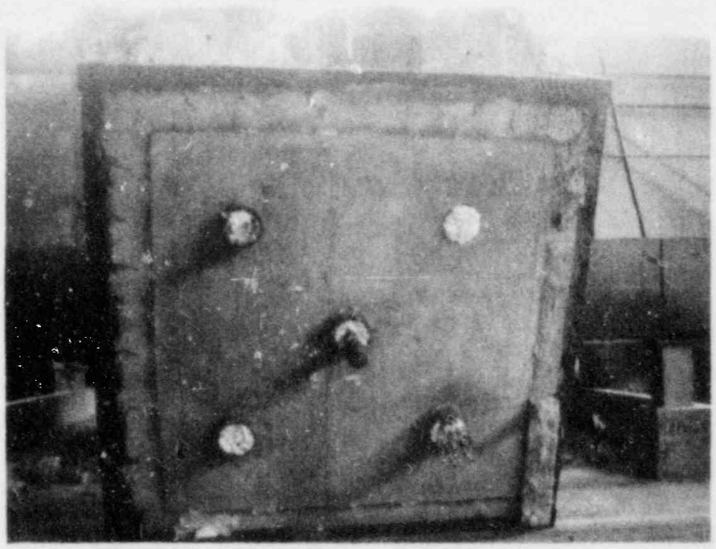


ILLUSTRATION 11

Exposed Surface After
Fire Endurance and
Before Hose Stream Test

(3925-3)

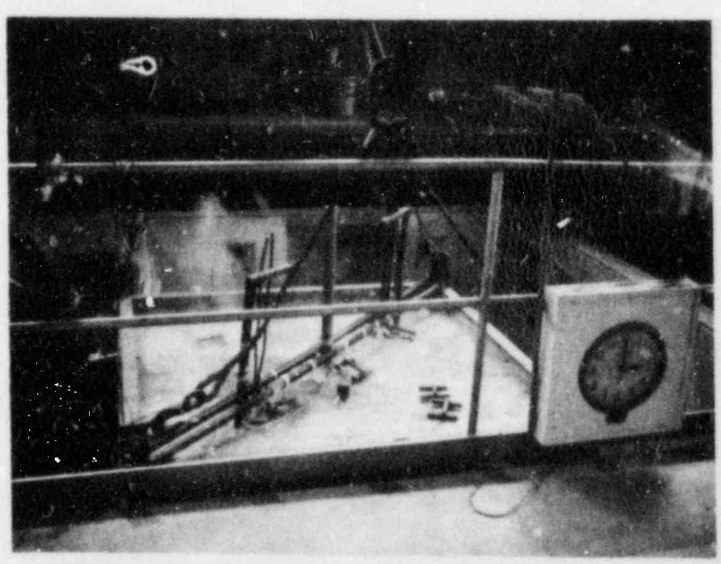


ILLUSTRATION 12

Unexposed Surface at
Three Hours of
Fire Exposure

(3925-4)

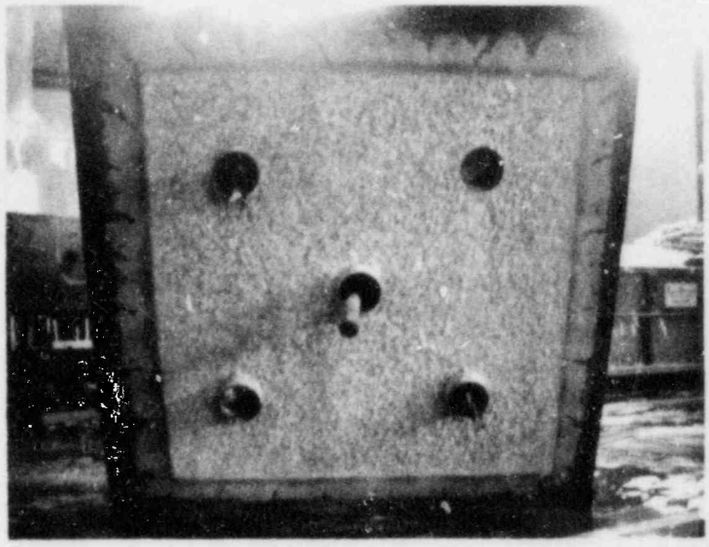


ILLUSTRATION 13

Exposed Surface After
Fire Exposure and
Hose Stream Test

(3925-5)

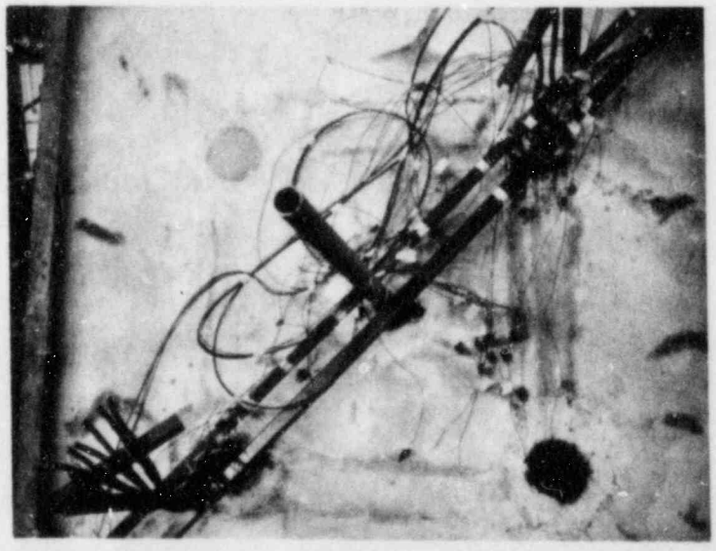


ILLUSTRATION 14

Unexposed Surface After
Fire Exposure and
Hose Stream Test

(3925-6)

TEST BY:

Fire Technology Group
National Gypsum Co., Gold Bond Building Products Division
Design FC 350

REPORT, TECHNICAL SUPERVISION OF
CONSTRUCTION AND FIRE TEST BY:

G. M. Price
Engineer

REPORT APPROVED BY:

W. F. Shield
Asst. Manager, Materials Section
Codes/Ratings