A TEST REPORT FOR
IOWA ELECTRIC LIGHT AND POWER COMPANY

FIRE ENDURANCE AND HOSE STREAM TESTS ON ELECTRICAL CABLE PENETRATION FIRE STOP DESIGNS USED AT THE DUANE ARNOLD ENERGY CENTER

By: R.H. Hollenbacher
R. H. Hollenbacher
EDS Nuclear, Inc.

Reviewed by: Terry A. Gucciardo
Terry Gucciardo
Technical Group Leader - Electrical Design
Iowa Electric Light and Power Company

Reviewed by: R F Salmon
R. F. Salmon, Nuclear Design Engineer
Iowa Electric Light and Power Company

Approved by: Philip D Ward
P. D. Ward
Manager, Design Engineering
Nuclear, Generation, IEL&P
Iowa Electric Light and Power Company

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I. SYNOPSIS

This fire test report describes the testing program undertaken by the Iowa Electric Light and Power Company to determine the fire endurance ratings of the electrical cable and cable tray penetration fire stop designs installed at the Duane Arnold Energy Center (DAEC). The purpose of this testing program was to verify that the electrical cable and cable tray penetration designs installed at the DAEC have a minimum fire endurance rating of three hours and afford adequate fire barrier protection to the plant.

The test program consisted of identifying the penetration fire stop designs and repair procedures used at the DAEC, developing conservative test configurations representative of the installed designs, and conducting fire tests on these designs in accordance with the ASTM E-119 time-temperature curve. This test report provides the test procedure and acceptance criteria used for evaluating the electrical cable penetration fire stops; describes the fabrication details and materials used for all test assemblies; includes actual test data substantiating the three-hour endurance ratings for these designs; and discusses the test results relative to fire hazards which exist at the plant.

II. INTRODUCTION

As part of an extensive review of the adequacy of the fire protection system and fire stop designs at the Duane Arnold Energy Center (DAEC), the Iowa Electric Light and Power Company initiated an electrical cable penetration fire barrier testing program. The objectives of this program were:

- To rate the electrical cable penetration fire stop designs installed at DAEC and determine their adequacy.
- To verify that procedures currently used for repairing electrical cable penetrations do not degrade the fire stop design.
- To qualify additional electrical cable penetration fire stop designs to supplement those currently used in plant modifications.

The Construction Technology Laboratories division of the Portland Cement Association, a nationally recognized fire test laboratory, was contracted to provide assistance in this program by constructing all test assemblies and conducting all fire tests.

The basis for the testing program, the installed electrical cable penetration fire stop design and repair procedures used at DAEC, was determined through a review of design documents and interviews with electrical maintenance personnel at the DAEC. From these, it was determined that there are six basic 6-inch diameter wall cable penetration designs with two repair procedures, one 4-inch diameter wall/floor cable penetration design, one 8-inch diameter floor penetration design with three repair procedures, four 1-inch diameter cable penetration fire stop designs, and four basic electrical cable tray penetration fire stop designs. To ensure that the fire stop designs and the repair procedures tested were representative of those installed at the DAEC, engineers from the DAEC, who were instructed by the DAEC electrical maintenance personnel on electrical cable penetration construction and repair procedures, personally supervised the construction of all electrical cable penetration fire stops in the test laboratory. The testing materials, including the electrical cable used, were also representative of those installed at the DAEC. To qualify the fire stop designs for the entire range of cable loadings encountered in the plant, maximum cable fills, judged appropriate for each particular design, were used. The new fire stop designs qualified in this report were developed through the consideration of several factors including the results from previous tests, the ease with which the materials could be installed, and the degradation or shelf life of the materials.

The fire test procedure, Section III, and more importantly, the test acceptance criteria for the testing program are in accordance with IEEE 634-78, Standard Cable Penetration Fire Stop Qualification Test. The salient aspects of this criteria are:

- No visible flaming on the unexposed side of the fire stop.
- The cable jacketing material does not exceed 700°F.
- The fire stop will withstand the specified hose stream test without the hose stream causing an opening through the test specimen.

Although both the American Nuclear Insurers (ANI) and IEEE criteria are applicable, the IEEE criteria was selected because it was deemed more relevant to the fire hazards existing at DAEC, i.e., cable insulation, and more applicable to the tests conducted on the cable penetrations. The ANI acceptance criteria differs from the IEEE 634-78 acceptance criteria in two areas: it limits the temperature of the unexposed surface to 325°F above ambient, and it requires a hose stream test, specified in ASTM E-119. Although the ANI acceptance criteria has not been used, the fire tests were conducted so that data would be available to evaluate fire stop performance against these criteria.

To insure the validity of test results, all testing was performed in accordance with the Quality Assurance Program of the Construction Technology Laboratories. This program, which was approved by the Iowa Electric Light and Power Company, covered all aspects of the tests including construction of test slabs, procurement of test materials, and calibration of testing equipment.

III. TEST PROCEDURE FOR ELECTRICAL CABLE PENETRATION FIRE STOPS

EDS NUCLEAR INC.

Test Procedure
for
Electrical Cable Penetration Fire Stops

DUANE ARNOLD ENERGY CENTER
IOWA ELECTRIC LIGHT AND POWER COMPANY

Job Number 0460-023
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Submitted: Ralph H. Hollenbacher — 12/1/79
Project Engineer — Date

Reviewed: James V. Conway — 12/1/79
Fire Protection Engineer — Date

Approved: Daniel F. Brosnan — 12/1/79
Section Manager — Date

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I. Introduction

Several different designs of electrical cable penetration fire stops have been installed at the Iowa Electric Light and Power Company's Duane Arnold Energy Center. In conjunction with the DAEC Fire Hazards Analysis Report and in response to an SER question, Iowa Electric is undertaking an electrical cable penetration testing program to establish fire resistance ratings for typical electrical cable penetration fire stop designs located throughout the plant. The resultant fire resistance test data will be used to demonstrate the adequacy of the existing cable penetration fire stops in relation to the fire loadings of areas immediately adjacent to each side of the fire stop as described in the DAEC Fire Hazards Analysis Report.

II. Purpose

This test procedure describes the methods that will be used to evaluate the duration for which different electrical cable penetration fire stop designs will contain a fire and retain their structural integrity during a standard fire test exposure. The performance of the test procedure described herein is intended to constitute a standard fire test as defined in NFPA-251 (ASTM E119-78) and IEEE 634-78 and to provide fire resistance ratings for the electrical cable penetration fire stops tested.

III. Fire Test

1.0 Temperature Control

The fire tests shall be controlled by the standard time-temperature curve shown in Figure 1.

1.1 Temperature of Exposed Surface

The temperature fixed by the standard time-temperature curve shall be deemed to be the average temperature obtained from the readings of not less than three thermocouples disposed and distributed to show the representative temperature near all parts of the test samples. The 1/8 inch thermocouples shall be enclosed in sealed porcelain tubes 3/4 inch (19 mm) in outside diameter or enclosed in sealed, standard-weight, 1/2 inch (13 mm), black wrought steel or black wrought iron pipe. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 inches (305 mm). For floors, the junction of the thermocouples shall be placed 12 inches away from the exposed face of the sample.

The temperatures shall be read and recorded at intervals not exceeding 5 minutes during the first 2 hours and thereafter the intervals may be increased to not more than 10 minutes.

The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results of the pyrometer readings, is within 10 percent of the corresponding area under the standard time-temperature curve shown in Figure 1 for fire tests of 1 hour or less duration, within 7.5 percent for those over 1 hour and not more than 2 hours, and within 5 percent for tests exceeding 2 hours in duration.

1.2 Temperature of Unexposed Surface

Temperatures of unexposed surfaces may be measured by thermocouples. Temperature readings shall be taken at several points, as appropriate, on the surface of the test fixture. These points shall be on the exterior surface material, near the cable jacket/cable penetration fire stop interface and near the interface between the fire stop and through metallic components other than the insulated cable jacket for each fire stop design under test.

Temperature readings shall be taken at intervals not exceeding 15 minutes until a reading exceeding 212°F has been obtained at any one point. Thereafter, the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 minutes.

The temperature end point of the fire endurance period shall be determined by the average of the measurements taken at the individual points on each respective fire stop design; however, if a burn through occurs, the remainder of the test for that particular specimen shall be ignored and the fire endurance period judged as ended. Failure of one test specimen in the test slab shall not affect the results of other test specimens being tested concurrently.

2.0 Test Samples

The samples selected for testing shall be representative of the installed configuration of cable loading and penetration fire stop size and design. The electrical cables used in the tests shall be comprised of cable sizes and the insulation materials used at the facility. All cables penetrating the fire stop should extend at least three feet on the unexposed side and at least one foot on the exposed side of the fire stop.

3.0 Conduct of Fire Tests

Both wall and floor test fixtures will be available for conducting fire tests. Test samples of penetration fire stop designs installed in floors shall be tested in a floor test configuration. Test samples of penetration fire stop designs installed in walls shall be qualified by testing in floor test configuration and shall thereby qualify for either a wall or floor penetration fire stop design.

Test samples shall be subjected to a hose stream test in all cases where the resistance period of the test sample is equal to or greater than one hour. The hose stream test shall be made on the specimen subjected to the fire endurance test immediately following the expiration of the fire endurance test as defined for nuclear generating stations in IEEE 634-78.

When several test samples are concurrently tested in the same test fixture and individual test samples fail prior to the expiration of the fire test, the openings created by the failed test samples shall be plugged and the test continued until all test samples have failed or the test is completed. Records of time of failure for each test sample shall be measured to the nearest 5 minutes and recorded.

4.0 Conditions of Acceptance

The fire test shall be considered successful if it meets the criteria of IEEE 634-78 and NFPA-803 as follows:

a. Cable penetration fire stops do not allow fire to propagate to the unexposed side of the test assembly or any visible flaming on the unexposed side within the specified fire rating time.

b. Temperature readings on the unexposed side of the cable penetration fire stop shall not exceed the self-ignition temperature of the outer cable covering, the fire stop materials, or materials in contact with the cable penetration fire stop, whichever has the lower self-ignition temperature. For purposes of these tests, a temperature limit of 700°F shall be used.

c. The cable penetration fire stops shall withstand the hose stream test specified in IEEE 634-78 without the hose stream causing an opening through the test specimen.

IV. Format of the Fire Test Report

1.0 Title Page

2.0 Table of Contents

3.0 Description of Fire Test Facility and Tests Conducted

3.1 Description of Test Furnace

3.2 Description of All Materials

Type, size, class, strength, densities, trade name, and any additional data necessary to define materials. The testing laboratory should indicate whether materials meet ASTM Standards by markings, as applicable; by statement of sponsor; by physical or chemical test by the testing laboratory.

3.3 Description of Test Assembly

3.3.1 Give details of structural design.

3.3.2 Include plan, elevation, principal cross section, plus other sections as needed for clarity.

3.3.3 Give location of thermocouples and other items for test.

3.3.4 Describe general ambient conditions

a. During the time of construction

b. During curing (time from construction to test)

c. During time of Test.

3.4 Description of Test

3.4.1 Report temperature at the beginning and every 5 minutes thereafter. If charts are included in the report, clearly indicate time and temperature

a. In furnace space

b. On unexposed surface.

3.4.2 Report appearance of unexposed face

a. Every 15 minutes

b. At any noticeable development including cracking, smoking, and buckling and report time and details

c. At the end of the test.

3.4.3 Report time of failure

a. By temperature rise

b. By passage of flame or temperature rise, where applicable.

3.4.4 If a hose stream test is required, describe the test apparatus and procedure. If failure occurs in the hose stream test, describe the nature of the failure.

3.4.5 Provide a statement to the effect that the test construction represents facility construction. If the construction does not represent typical facility construction, note the deviations.

3.4.6 If construction is unsymmetrical (has different details on each face), indicate the face exposed to fire.

4.0 Summary of Results

4.1 Endurance time

4.2 Nature of failure

4.3 Hose stream test results (if required)

5.0 List Official Observers - Signatures of Responsible Persons

6.0 Drawings and Photographs

6.1 Detailed drawings of the test assembly are required for the test report

6.2 Photographs required for the test report

a. Assembly in construction

b. Unexposed face at the end of the fire endurance test

c. Exposed face after the hose stream test

d. Unexposed face after the hose stream test.

6.3 Photographs taken to show what cannot be covered in the report or to add clarification

a. Exposed face prior to fire test

b. Unexposed face at the start of the endurance test; include recording equipment when possible

c. Exposed face at the end of the fire endurance test

d. Unexposed face at the end of the fire exposure before the hose test

e. Exposed face at the end of the fire exposure before the hose test.

7.0 Appendix

Include all data not specifically required by the test standard but useful to a better understanding of the test results.

FIGURE 1

STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS

Time (h:min)	Temperature (°F)	Area Above 68° F Base (°F-min)	Area Above 68° F Base (°F-h)	Temperature (°C)	Area Above 20° C Base (°C-min)	Area Above 20° C Base (°C-h)
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	486 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	9 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 090	5 818
6:00	2 150	649 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594

IV. MATERIALS

The materials used in the construction of the electrical cable and cable tray fire stop test assemblies are described in the following paragraphs. These materials are the same materials currently used at DAEC and were procured for the testing program under either the Iowa Electric or the Construction Technology Laboratories Quality Assurance Program.

A. ELECTRICAL CABLE AND CABLE TRAYS

1. Electrical Cable

Instrumentation and 600-volt power and control cables representative of those installed at the DAEC were used in the tests in the varying fills indicated on the sketches in Section V. The cabling used in these tests has a fire resistant neoprene jacket and an ethylene-propylene rubber insulating material. All cables used in the test were manufactured by Okonite.

2. Cable Tray

The cable trays were made of galvanized steel with a ladder back construction, 24 inches wide by 4 inches deep overall, with inward facing one-inch wide channel shaped sides. The ladder rings were hat shaped, 2-1/8 inches wide overall by 5/8-inch deep, of 0.064 inch thick galvanized steel with the top surface 3/4-inch wide and located 9 inches on center. The inside dimensions of the tray were 23-7/8 inches wide by 3-1/4 inches deep.

B. PENETRATION FIRE STOP MATERIALS

1. Marinite I Board

A rigid, thermal insulation board manufactured by the Johns-Manville Company. This insulating board had an average thickness of 1/2 $\pm$ 1/32-inch and density of 46 pounds per cubic foot. Marinite board is sold in 4-foot by 8-foot panels and was cut to fit test assembly requirements.

2. Kaowool (Bulk A)

An alumina silica ceramic fiber insulation manufactured by Babcock and Wilcox Company. The insulation is a loose fiber material.

3. Ductseal

A multipurpose sealing and caulking compound with a heavy putty-like consistency. This compound consists of an asbestos inert fiber and a nondrying synthetic oil base. It adheres to most clean surfaces and is insoluble in water. Ductseal is manufactured by the Johns-Manville Company under the trade name Duxseal.

4. Flamemastic (71-A Mastic, Trowel Grade)

A fire retardant compound comprised of waterbase thermoplastic resins, flame retardant chemicals, and inorganic incombustible fibers. This material was used primarily as an exterior fire stop coating.

5. Cellular Concrete

A controlled density concrete made by mixing cement (ASTM Type III), water, and a light density foam manufactured by the Elastizell Corporation of America. The wet density of the mixture used in the test specimens was approximately 39.6 pounds per cubic foot which yielded a dry density of approximately 34.5 pounds per cubic foot.

6. RTV Silicone (RTV-102)

A thixotropic, spreadable silicone caulk manufactured by the General Electric Company.

7. Insta Foam (Froth Pak Kit)

A rigid urethane foam which when installed has an approximate density of 2 pounds per cubic foot.

C. TEST ASSEMBLY CONSTRUCTION MATERIALS

1. Conduit (1-, 4- and 6-inch nominal diameter round stock)

   Standard electrical rigid steel conduit was used in all test assemblies.

2. Transite Pipe

   Standard 8-inch diameter sewer pipe manufactured by the Johns-Manville Company.

3. Cinch Anchors

   Concrete anchor bolt assemblies manufactured by the Hilti Corporation.

4. Concrete

   Laboratory mixed concrete consisting of ASTM C150, Type 1 cement, sand, pea gravel, vinsol resin, and water. The concrete mixture had a wet density of approximately 146 pounds per cubic foot. The average compressive strength measured at 28 days was approximately 4500 psi.

V. FIRE TESTS

A. WALL CABLE PENETRATION TESTS

1. Penetration Designs

The six basic 6-inch diameter electrical cable wall penetration designs used at the DAEC are shown in drawings WPD-1 through WPD-6. Each of these designs is a symmetrical design wherein the penetration has been sealed from both sides of the fire barrier wall. Sheet Number 2 of designs WPD-3, -4,-5, and-6 illustrates the actual seal design as it would be installed in a one foot thick fire barrier. It should be noted that at the DAEC most fire barriers are greater than one-foot thick and, therefore, the intervening air gap between the two sides of the fire stop is conservatively shown as a minimum distance in these test configurations.

The one basic 4-inch diameter electrical cable wall penetration design used at DAEC is shown in drawing WPD-7. This design is also a symmetrical design wherein sketch WPD-7 represents only one-half of the installed penetration.

Penetration fire stop designs WPD-8 and WPD-9 are not currently installed at DAEC. Both of these designs have been developed as unsymmetrical designs to supplement current plant electrical cable penetration wall designs.

Drawings WPD-RP-1 and WPD-RP-2 illustrate the two repair procedures which are used at DAEC. These repair procedures have been used with all basic designs with the exception of penetration designs WPD-4 and WPD-6. Repairs to these penetrations will be made by restoring the penetration to its original design condition.

a. General Notes for Cable Penetration Fire Stops

1) The percentage of cable fill in a penetration is determined by dividing the sum of the individual cable cross-sectional areas by the area of the conduit and multiplying by 100%.

2) All cable penetrations shall be exposed to fire tests only on the side coated with flamemastic unless otherwise noted.

b. Penetration Designs

	Drawing Number	Number of Sheets
1)	WPD-1	1
2)	WPD-2	1
3)	WPD-3	2
4)	WPD-4	2
5)	WPD-5	2
6)	WPD-6	2
7)	WPD-7	1
8)	WPD-8	2
9)	WPD-9	2

c. Wall Penetration Repair Procedures

	Drawing Number	Number of Sheets
1)	WPD-RP-1	4
2)	WPD-RP-2	4

2. Test Fixture

a. The Test Slab

The electrical cable wall penetration fire stop designs were tested on a small floor test furnace capable of supporting a concrete slab 48 inches square with an effective test area 32 inches square. The test slabs were 12 inches thick and contained nine equally spaced 6-inch diameter penetrations, with the exception of one test slab that contained seven 6-inch diameter penetrations, one 4-inch diameter penetration, and one 8-inch diameter transite sleeve. To simulate plant conditions, the rigid steel conduit penetration sleeves protruded approximately two inch from each side of the test slab providing an effective penetration length of 16 inches.

b. Placement of Thermocouples

Three thermocouples were used for monitoring the temperature of each test of each penetration design. These thermocouples were located at the center of the cable bundle in plane with the unexposed surface of the penetration fire stop, on the surface of the cable bundle at the interface with the unexposed surface of the fire stop, and on the penetration sleeve near the unexposed surface of the test slab. For each of the repair procedure tests, a fourth thermocouple was used to monitor the temperature on the repair cable at its interface with the unexposed surface of the fire stop. An additional thermocouple was located on the unexposed surface of the test slab away from the penetrations.

c. Test Configurations

Initial tests on all basic 4- and 6-inch wall penetration designs, WPD-1 through WPD-7, sheet 1, were made using only one side or effectively one-half of the penetration. These tests were run to simulate the actual installation conditions in the plant. In this manner, the use of damming materials, the compaction of the Kaowool, and the flow of sealing materials could be more closely controlled. Additionally, designs like WPD-1 contained too much material to be effectively tested as a double ended design in a twelve-inch slab. After testing the basic designs, additional test configurations WPD-3, -4, -5, and -6, sheet 2, were conducted to test the effect of the additional fire stop materials in the complete penetration design.

The tests on all repair procedures were conducted on only one side of the penetration design due to the space requirements for the double ended test and because this was a more conservative test in terms of proving the structural integrity of the repair and in proving the insulating ability of the repair materials.

Penetration fire stop designs WPD-8 and WPD-9 are unsymmetrical designs developed for sealing a penetration from only one end. To qualify these designs, two tests were run exposing each surface to the furnace temperature.

d. Hose Stream Tests

To provide additional test data on the structural integrity of the cable penetrations, fire stops, and penetration fire stop repair procedures, an additional hose stream test, as specified in ASTM E-119-73 was performed subsequent to the IEEE 634 hose stream test specified in this test procedure.

3.0 Summary of Results

(SEE TABLE)

WALL CABLE PENETRATION TESTS
SUMMARY OF RESULTS

Penetration Design Number	Test Sketch Number	Interior Cable Bundle Jacket Temp at 3 Hrs (^{o}F)	Cable Bundle Surface Temp - Unexposed Side at 3 Hrs (^{o}F)	Hose Stream Test IEEE	Hose Stream Test ASTM
WPD-1, SH1	C-1	430	270	PASS	PASS
WPD-2, SH1	C-4	420	390	PASS	PASS
WPD-3, SH1,	C-7	740	700	PASS	PASS
SH2	C-7X	470	365	PASS	PASS
WPD-4, SH1,	C-16	825	640	PASS	PASS
SH2	C-16X	325	200	PASS	PASS
WPD-5, SH1,	C-10	620	720	PASS	PASS
SH2	C-10X	350	225	PASS	PASS
WPD-6, SH1,	C-13	925	940	PASS	PASS
SH2	C-13X	185	165	PASS	PASS
WPD-7, SH1	C-18	555	520	PASS	PASS
WPD-8, SH1	C-27, 28	205	170	PASS	PASS
WPD-9, SH1	C-25, 26	240	185	PASS	PASS

Notes:
1. Penetration designs WPD-1 through-7 sheet #1 indicate the test results where only one-half of the penetration fire stop was tested. Penetration designs WPD-3 through-6 sheet #2 indicate the test results from tests on the entire, symmetrical penetration fire stop design.
2. Penetration designs WPD-8 and-9 list the more conservative temperatures from tests of each side of an unsymmetrical design.

WALL CABLE PENETRATION TESTS
REPAIR PROCEDURES
SUMMARY OF RESULTS

Penetration Design Number		Test Sketch Number	Interior Cable Bundle Jacket Temp at 3 Hrs (°F)	Cable Bundle Surface Temp - Unexposed Side at 3 Hrs (°F)	Hose Stream Test	
					IEEE	ASTM
WPD-RP-1	SH1	C-2	560	395	PASS	PASS
	SH2	C-5	640	335	PASS	PASS
	SH3	C-8	720	685	PASS	PASS
	SH4	C-11	575	480	PASS	PASS
WPD-RP-2	SH1	C-3	410	445	PASS	PASS
	SH2	C-6	750	465	PASS	PASS
	SH3	C-9	620	475	PASS	PASS
	SH4	C-12	665	640	PASS	PASS

4.0 Conclusions

The summary of Results for the wall cable penetration fire stop designs is divided into six columns. The wall penetration design numbers correspond with the design drawings provided in this section. Sheet # 1 of designs WPD-1 through 7 indicates the design configuration and corresponding test results for <u>one-half</u> of a symmetrical penetration design. Sheet # 2 of drawings WPD-3 through WPD-6 indicates the test configuration and the corresponding test results for a symmetrical fire stop designs typical of those installed at the DAEC. For the unsymmetrical designs WPD-8 and 9 which were tested with each end exposed to the fire test, only the higher temperatures are listed.

The test sketch numbers in the second column were used during the testing phases of the program to identify fire stop designs.

The interior cable bundle jacket temperature at three hours, column three, represents the highest cable jacketing temperatures encountered during the tests. The stated test acceptance criteria limits this temperature to 700°F. From a review of the symmetrical design test configurations, WPD-3 through WPD-6 sheet 2 and a review of the test results on one-half of a symmetrical design configurations, WPD-1, -2, and -7, it can concluded that all of these fire stop designs will maintain cable jacketing insulation temperatures well below the specified 700°F limit. Unsymmetrical wall penetration fire stop designs WPD-8 and 9 are also well below the specified cable jacketing insulation temperature limit.

The cable bundle surface temperature, column four, provides temperature indication at the cable bundle exterior penetration fire stop unexposed surface interface. Although space limitations did not permit accurate thermocouple placement on the unexposed surface of the fire stop in accordance with ANI test criteria, the thermocouple data taken on the surface of the cable bundle at the interface with the unexposed surface of the fire stop does provide a conservative indication of these temperatures. The ANI acceptance criteria states that the unexposed surface temperature should not exceed 325°F above ambient (approximately 70°F). The symmetrical design configurations of WPD-1 through WPD-7 and WPD-8 and -9 all are below the ANI surface temperature limit, 395°F.

Columns five and six indicate the results of both the IEEE and ASTM hose stream tests. Since all designs passed both hose stream tests and maintained cable jacketing insulation temperatures below 700°F, the symmetrical designs of WPD-1 through WPD-7 and the unsymmetrical designs WPD-8 and -9 are qualified to a 3 hours fire endurance rating under the stated test criteria, IEEE 637-78.

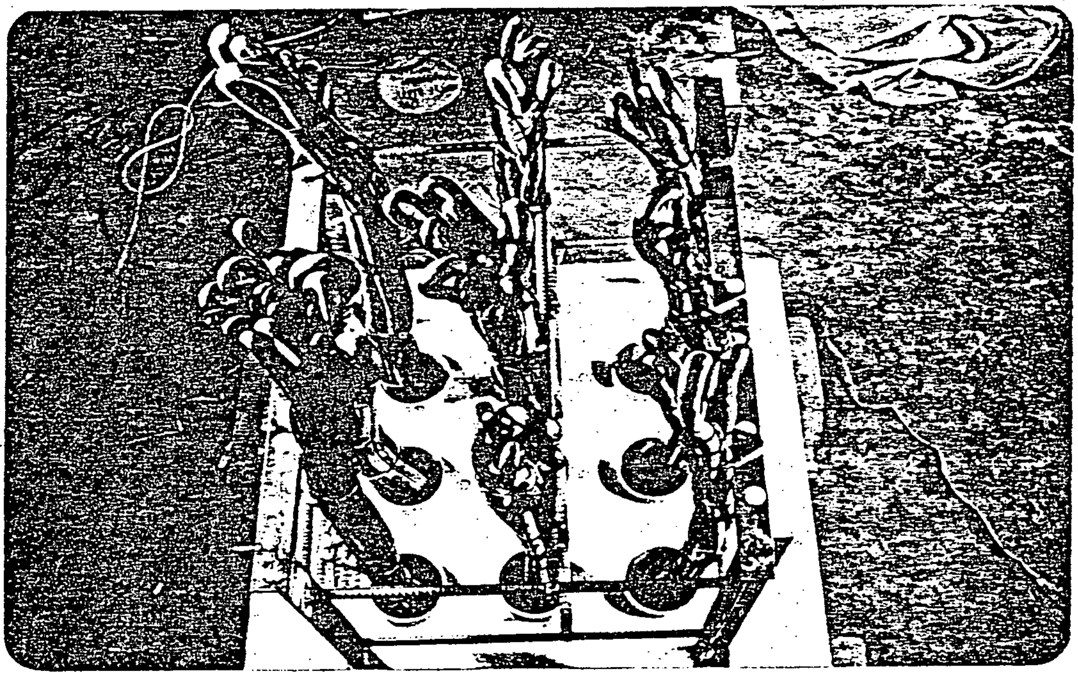
The Summary of Results table for the repair procedures is arranged similar to that for the wall penetration designs. These test results indicate the repairs to the penetration do not affect the structural integrity of the penetration. Additionally, although these repairs may possibly reduce the insulating properties of the original fire stop design, the maximum cable jacketing temperatures obtainable from a repaired symmetrical penetration fire stop design will be well within the temperature limits specified in this test.

While the test results indicate that all fire stop designs are then qualified to a three hour endurance rating, the conservatism in these test results should be noted. The fire tests were performed in a floor test configuration which is a more severe test. Additionally, by observing the initial test results from WPD-4 and WPD-6 and the unrealistic results obtained on an initial test of WPD-2 (see data for test slab # 4) where the cable jacketing material exceed 700° but did not ignite, it can be concluded that the specified temperature limit of 700°F is a conservative temperature limit for the self-ignition temperature of the electrical cable used at the DAEC.

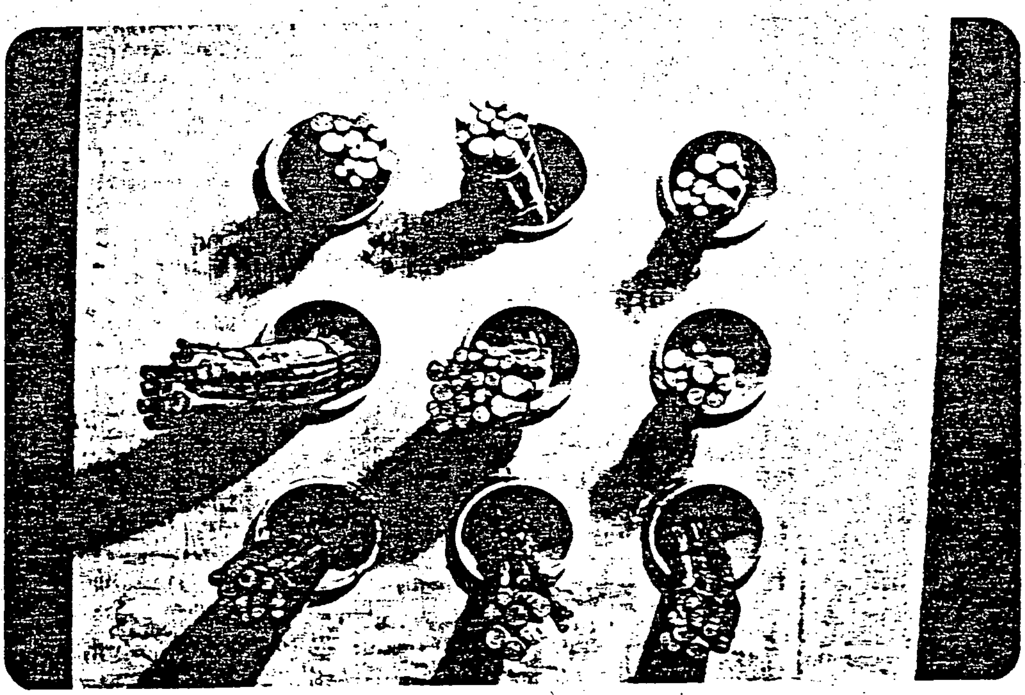
5.0 Photographs

PHOTOGRAPHS

WALL PENETRATION FIRE STOP TESTS

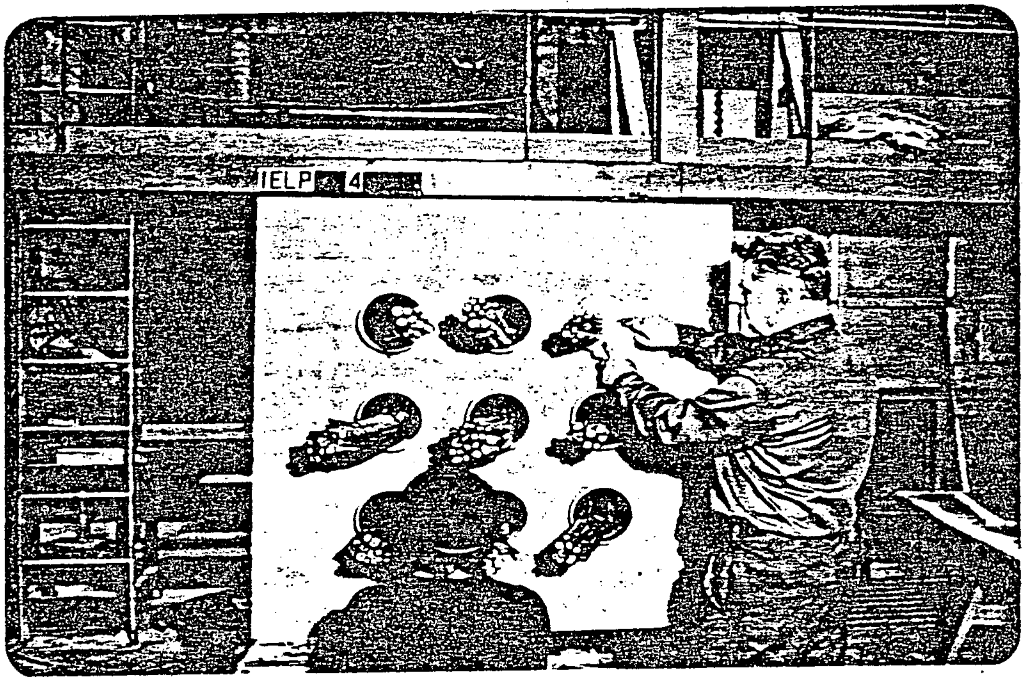


Test Slab After Cable Installation



Cable Installation

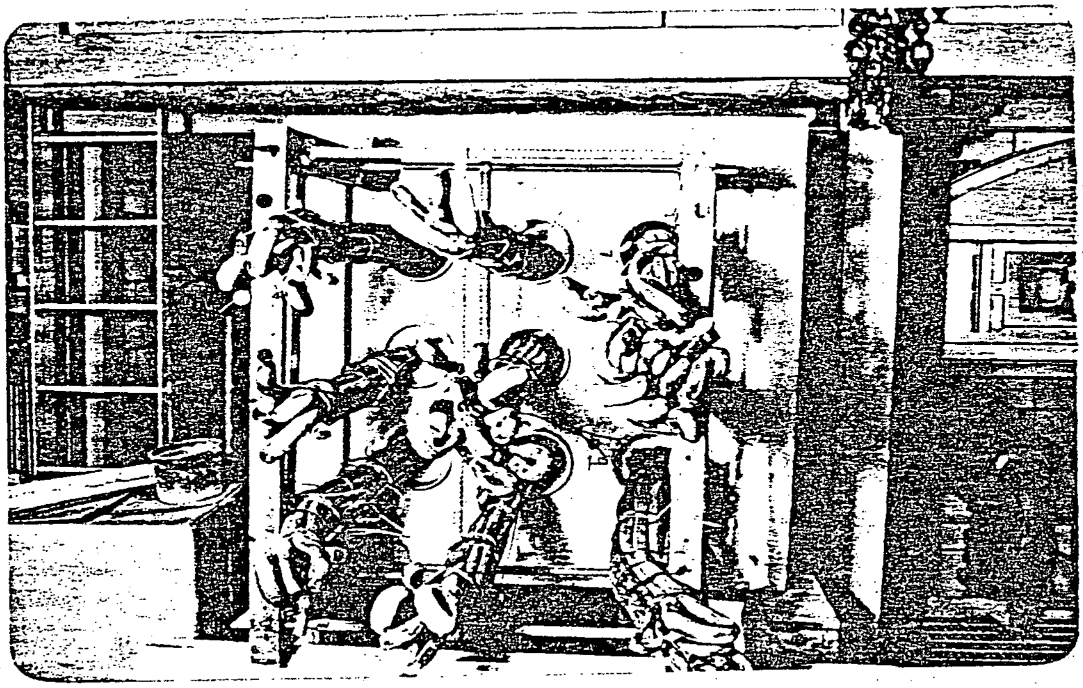
WALL PENETRATION FIRE STOP TESTS



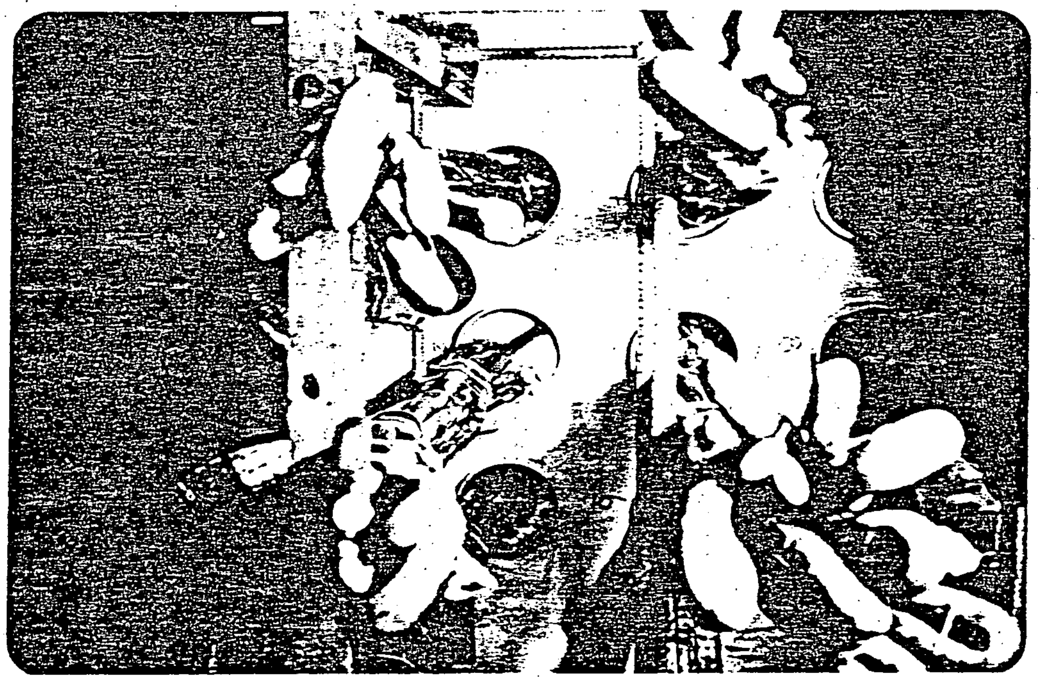
Installation of Fire Stop Materials

Fire Stop Installation in Progress

WALL PENETRATION FIRE STOP TESTS

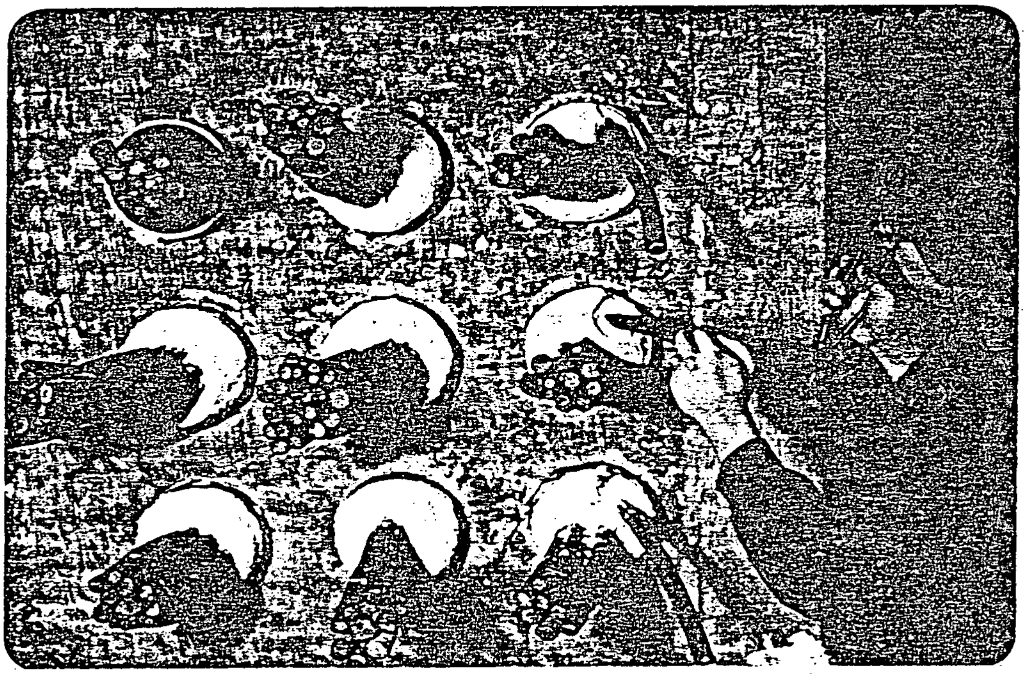


Test Slab During Installation
of Penetration Fire Stops

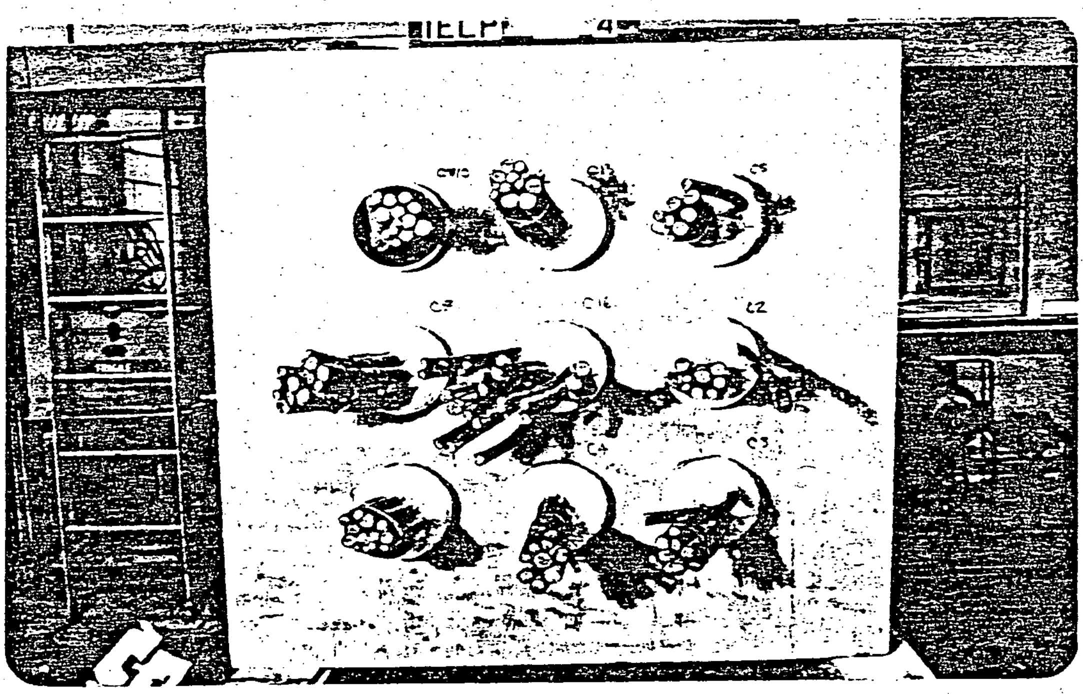


Installation of Fire Stop Materials

WALL PENETRATION FIRE STOP TESTS

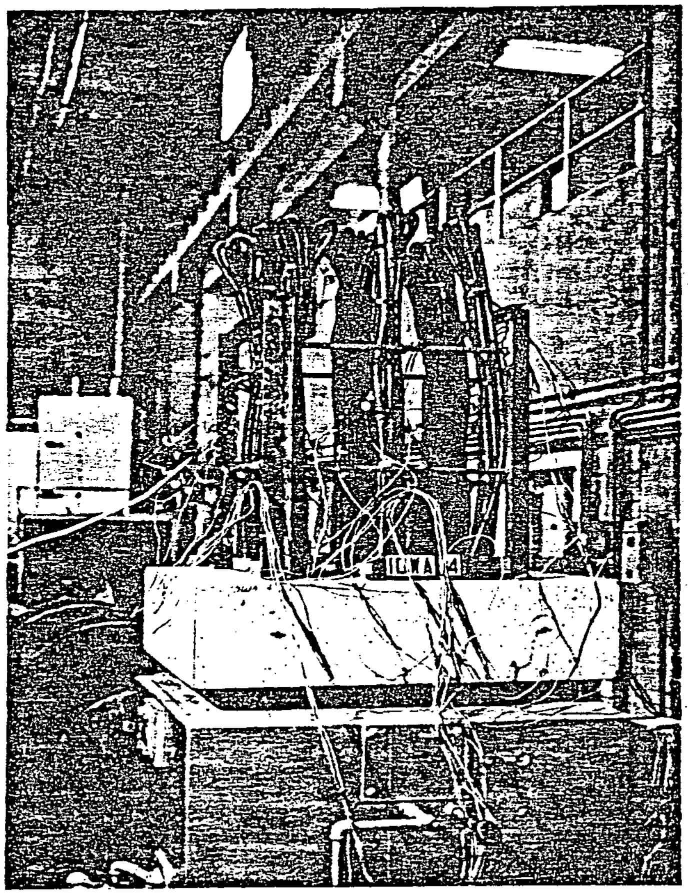


Repairing a Penetration After
Installation Of a New Cable

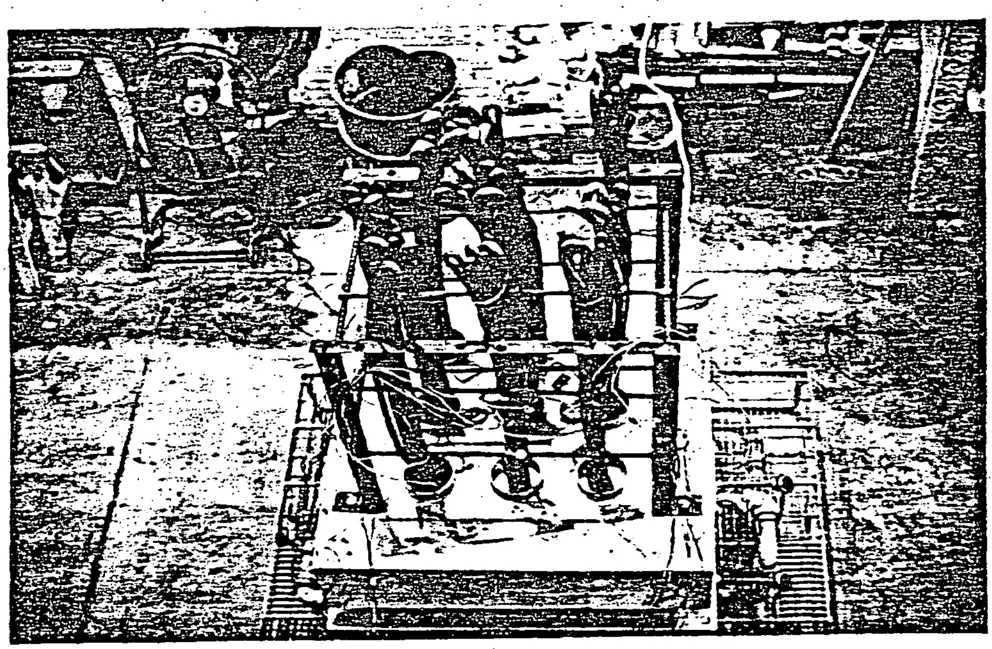


Slab Following Completion Of Repairs

WALL PENETRATION FIRE STOP TESTS

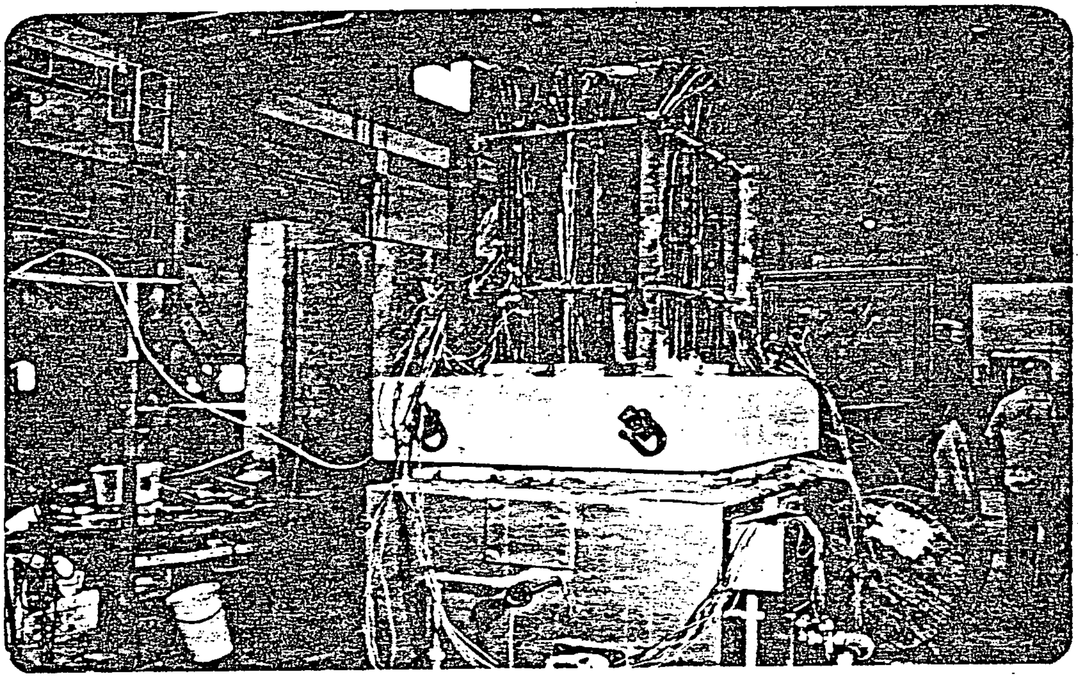


Test Slab on Furnace

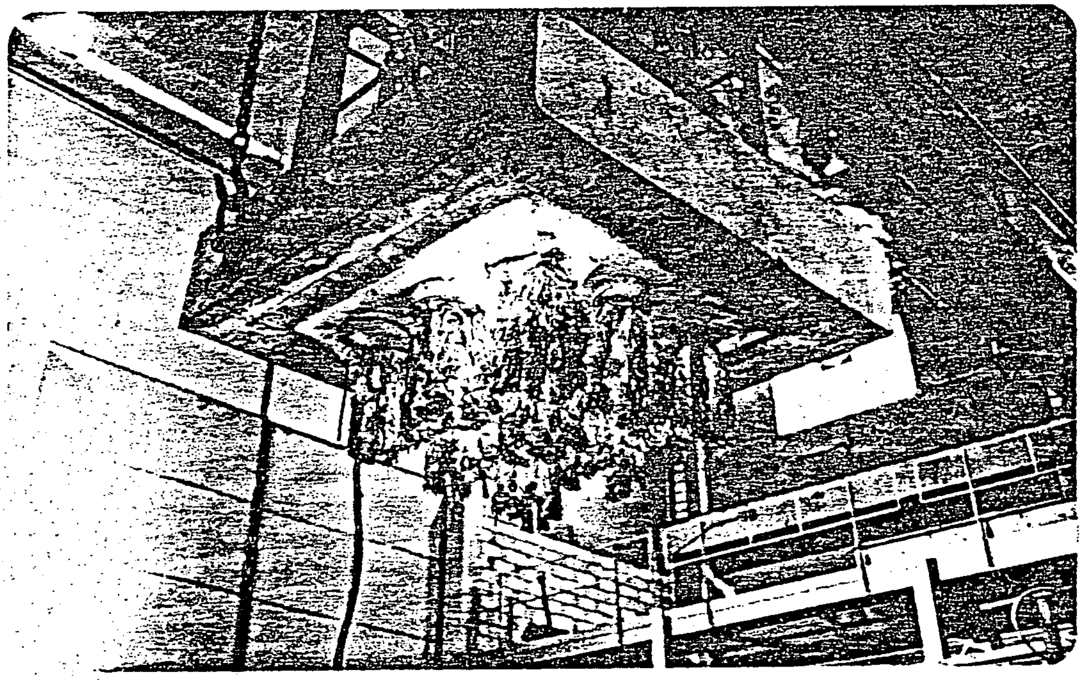


Looking Down at Test Slab on Furnace

WALL PENETRATION FIRE STOP TESTS

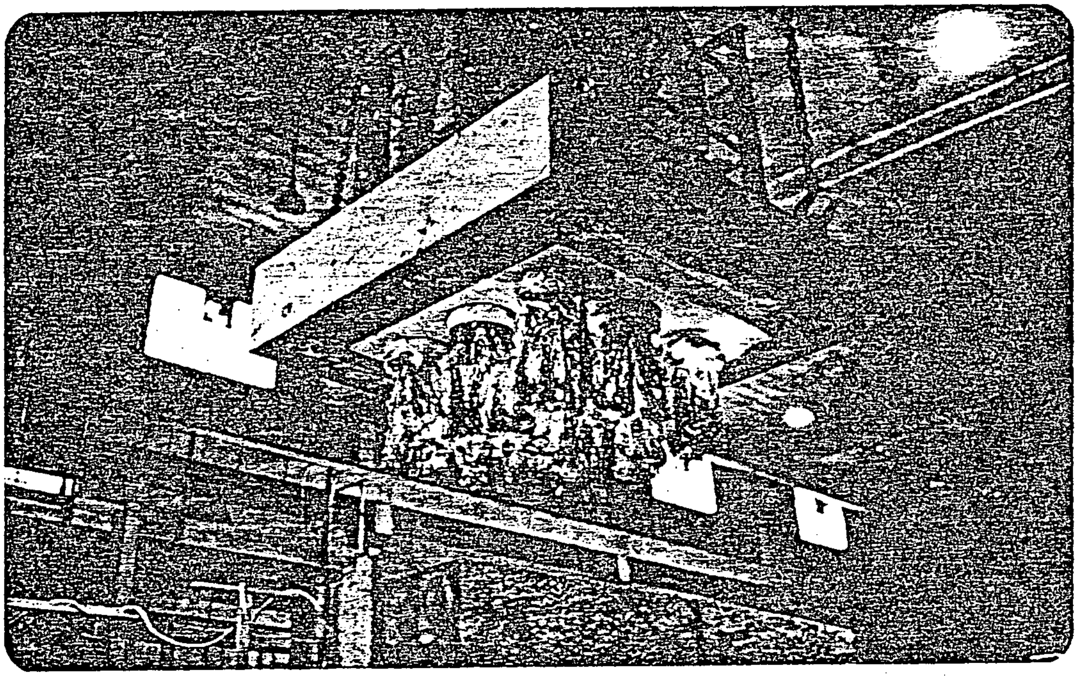


During Test

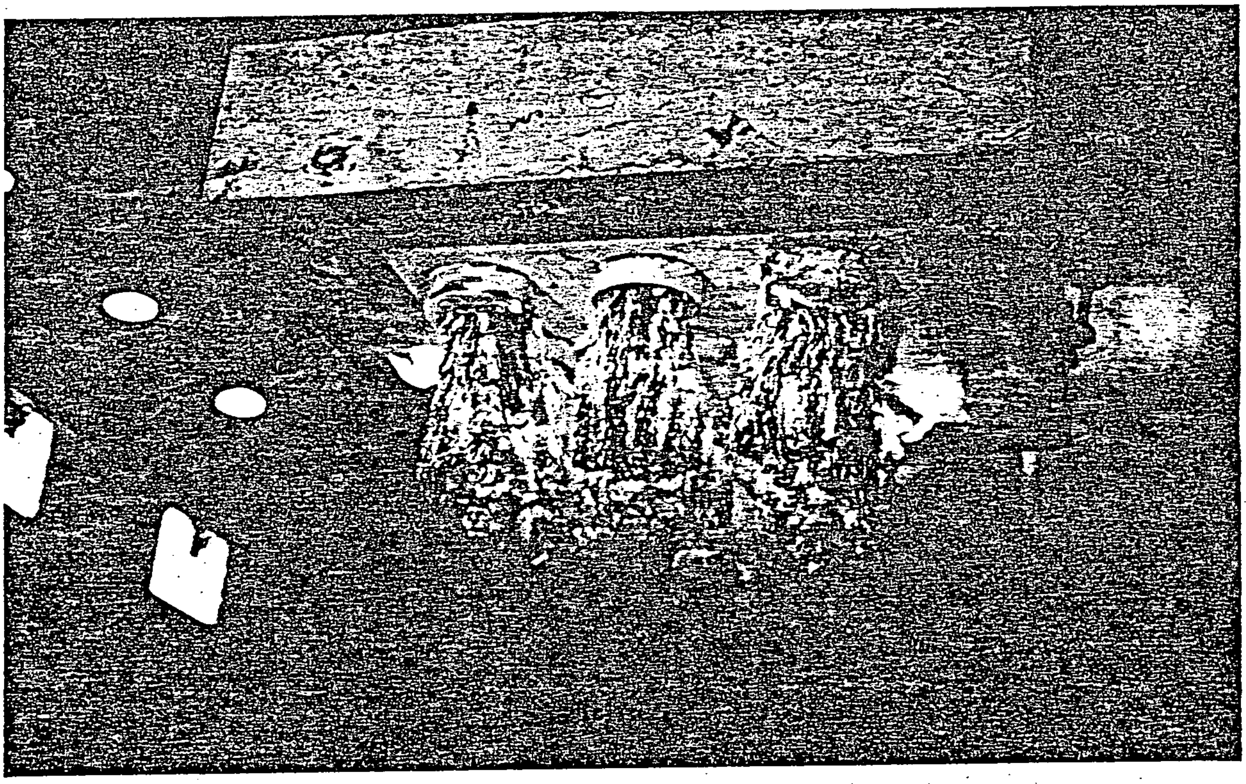


Removing Test Slab From Furnace

WALL PENETRATION FIRE STOP TESTS

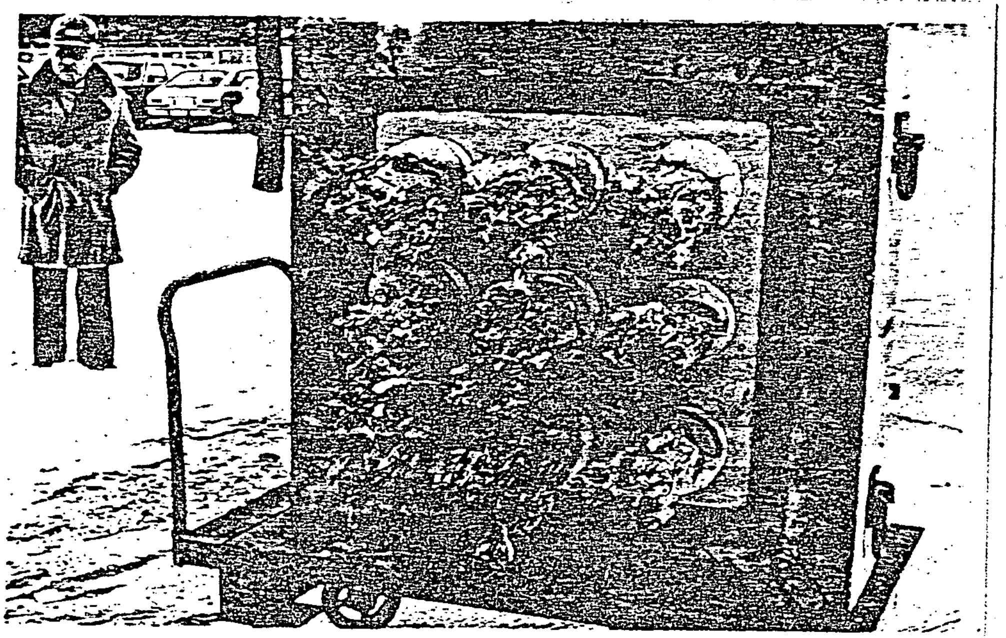


Removing Test Slab From Furnace



Exposed Surface Directly
After Fire Test

— WALL PENETRATION FIRE STOP TESTS

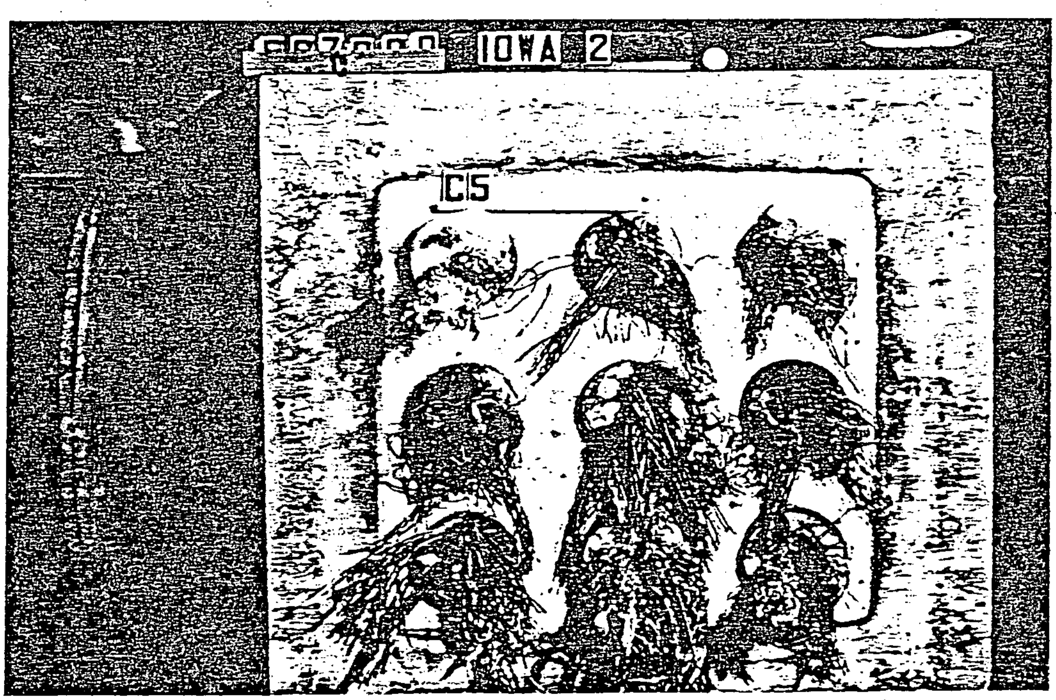


Witnessing Hose Stream Tests

After Hose Stream Tests

WALL PENETRATION FIRE STOP TESTS

Test Slab After Tests



Test Slab After Tests

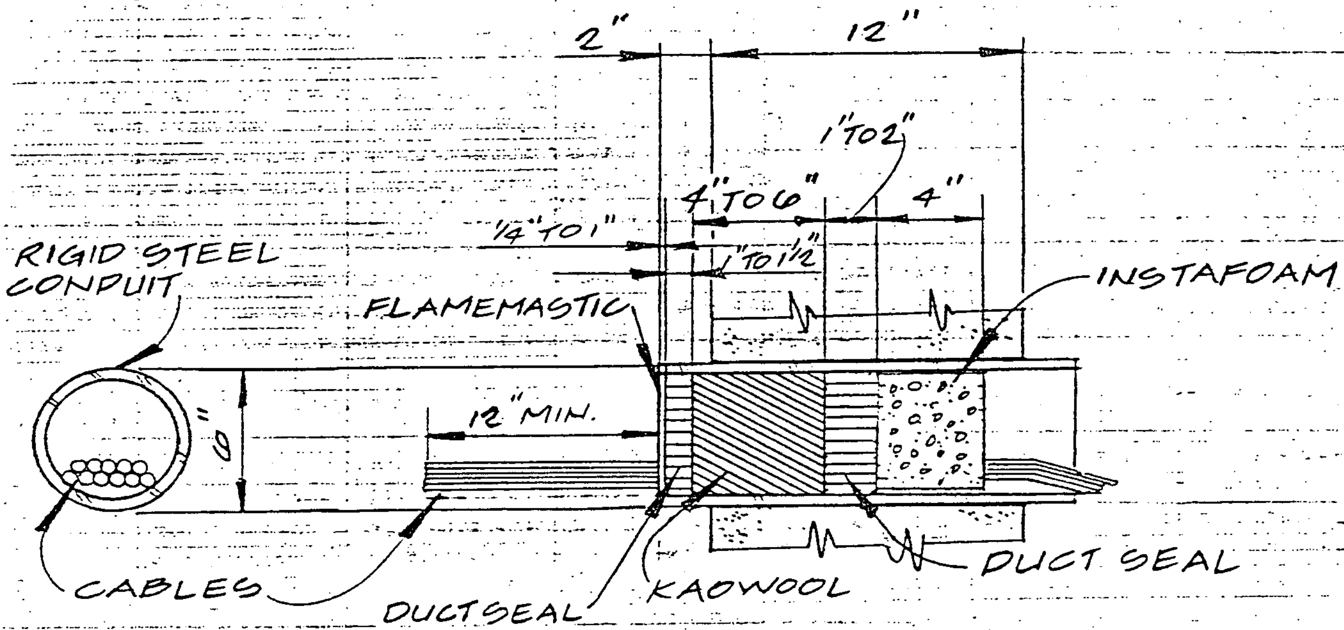
WALL PENETRATION FIRE STOP TESTS

Test Slab #2 After Test

Test Slab #7 After Tests

Wall Penetration Designs

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #1

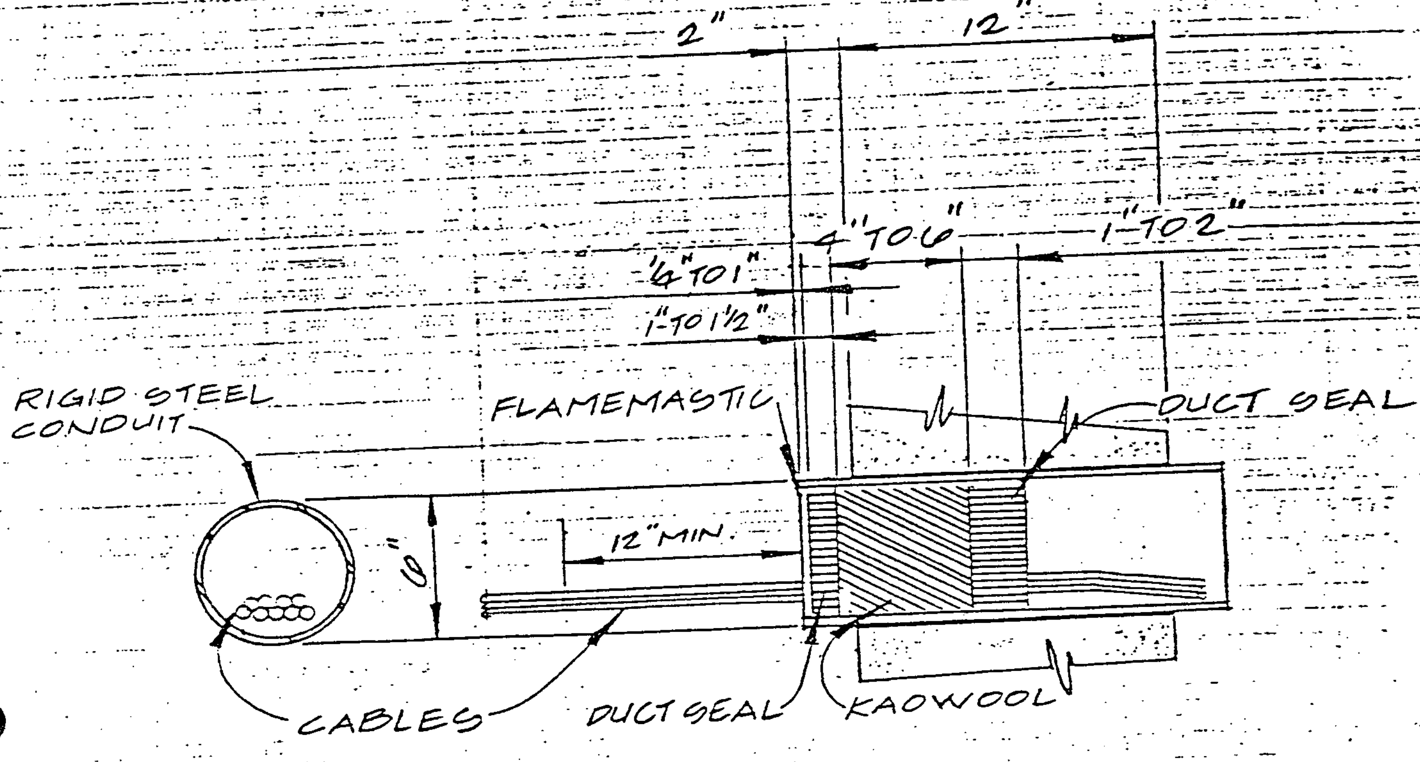


ACTUAL CABLE FILL TESTED - 37%
AREA OF CABLE IN TEST PENETRATION - 10.53 SQ. IN.
TEST CONSTRUCTION SKETCH # C-1
ACTUAL CABLES TESTED - 4-710, 4-2MS, 1-250, 4-V12 & 4-495

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-1					1 OF 1

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #2

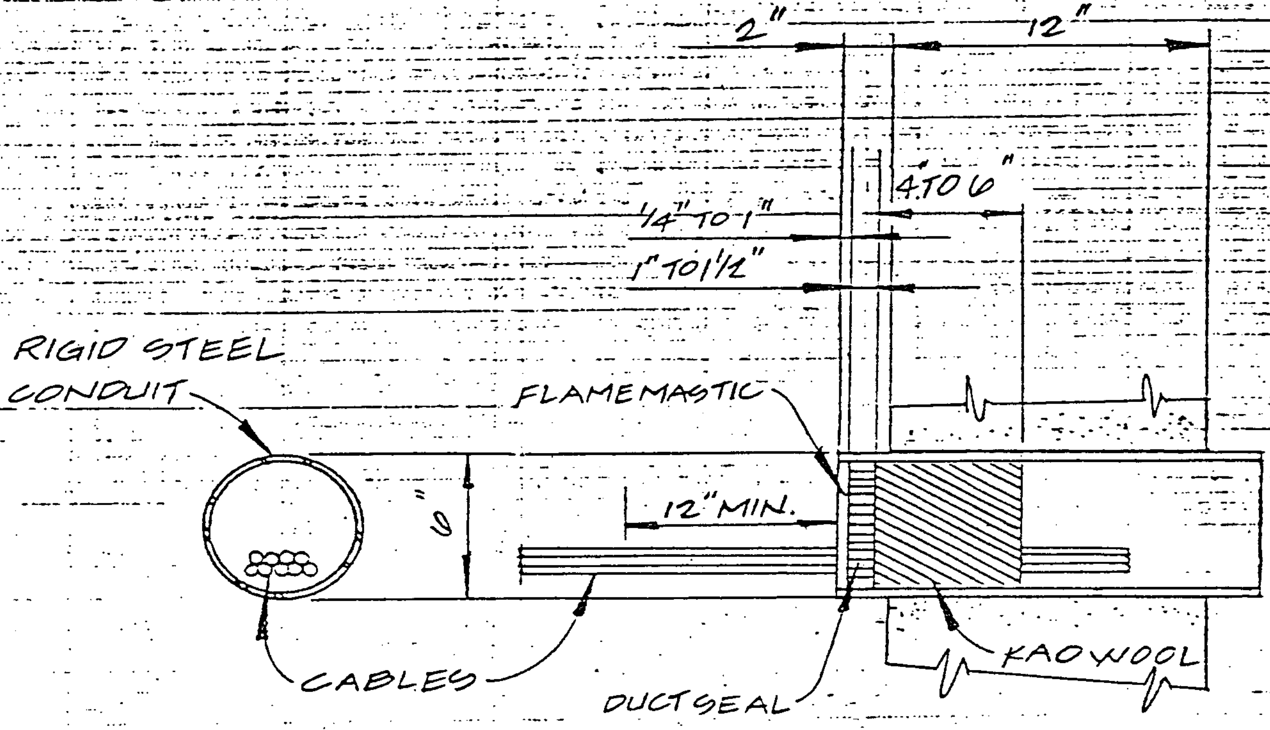


ACTUAL CABLE FILL TESTED - 37%
AREA OF CABLE IN TEST PENETRATION - 10.53 SQ. IN.
TEST CONSTRUCTION SKETCH #C-4
ACTUAL CABLES TESTED - 4-710, 4-2MS, 1-250, 4-495 &
4-V12

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. WPD-2					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #3

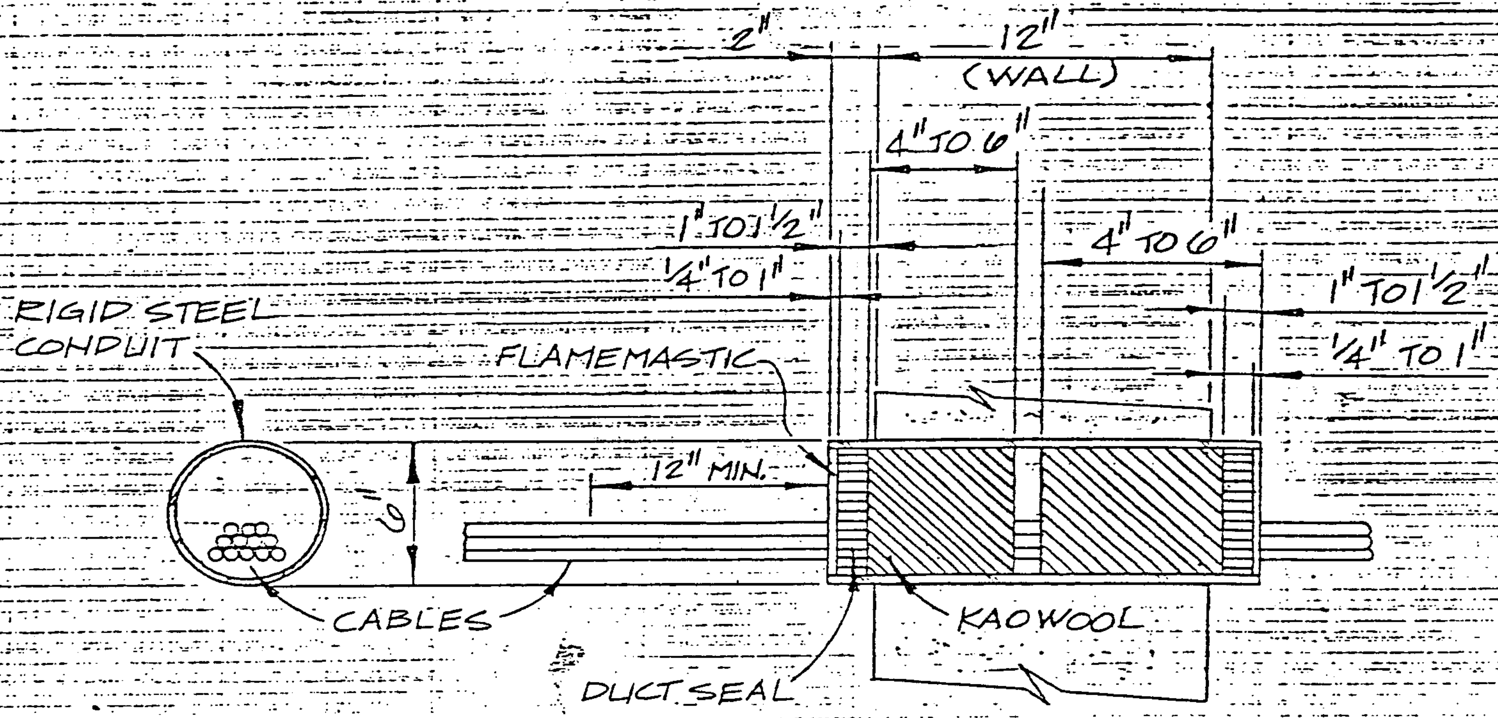


ACTUAL CABLE FILL TESTED - 47%
AREA OF CABLE IN TEST PENENETRATION - 13.53 SQ. IN.
TEST CONSTRUCTION SKETCH # C-7
ACTUAL CABLES TESTED - 10-710, 4-495, 1-250, 4-2MS &
4-V12

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 2
		MARK & DWG. NO. WPD-3					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 3



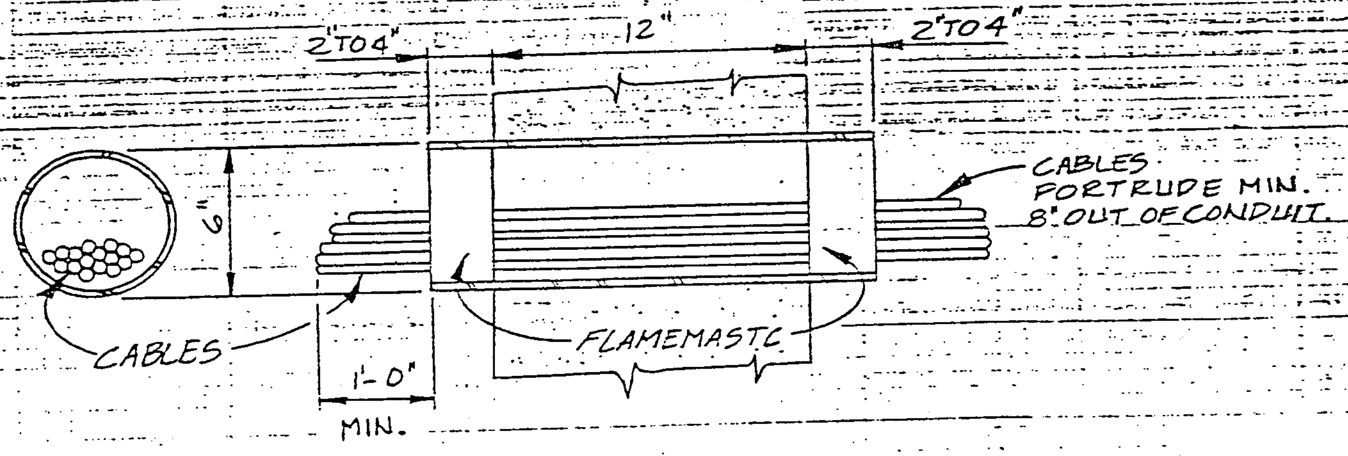
DESIGN CONFIGURATION AS INSTALLED IN THE PLANT

ACTUAL CABLE FILL TESTED - 49%
AREA OF CABLE IN TEST PENETRATION - 13.71 SQ.IN.
TEST CONSTRUCTION SKETCH # C-7X
ACTUAL CABLES TESTED - 1-250, 2-125, 2-M14, 7-V12, 2-19R, 1-2MS & 2-495

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRICITY DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 2
		MARK & DWG. NO. WPD-3					

ELECTRICAL CABLES PENETRATION FIRE STOP
WALL PENETRATION DESIGN #4

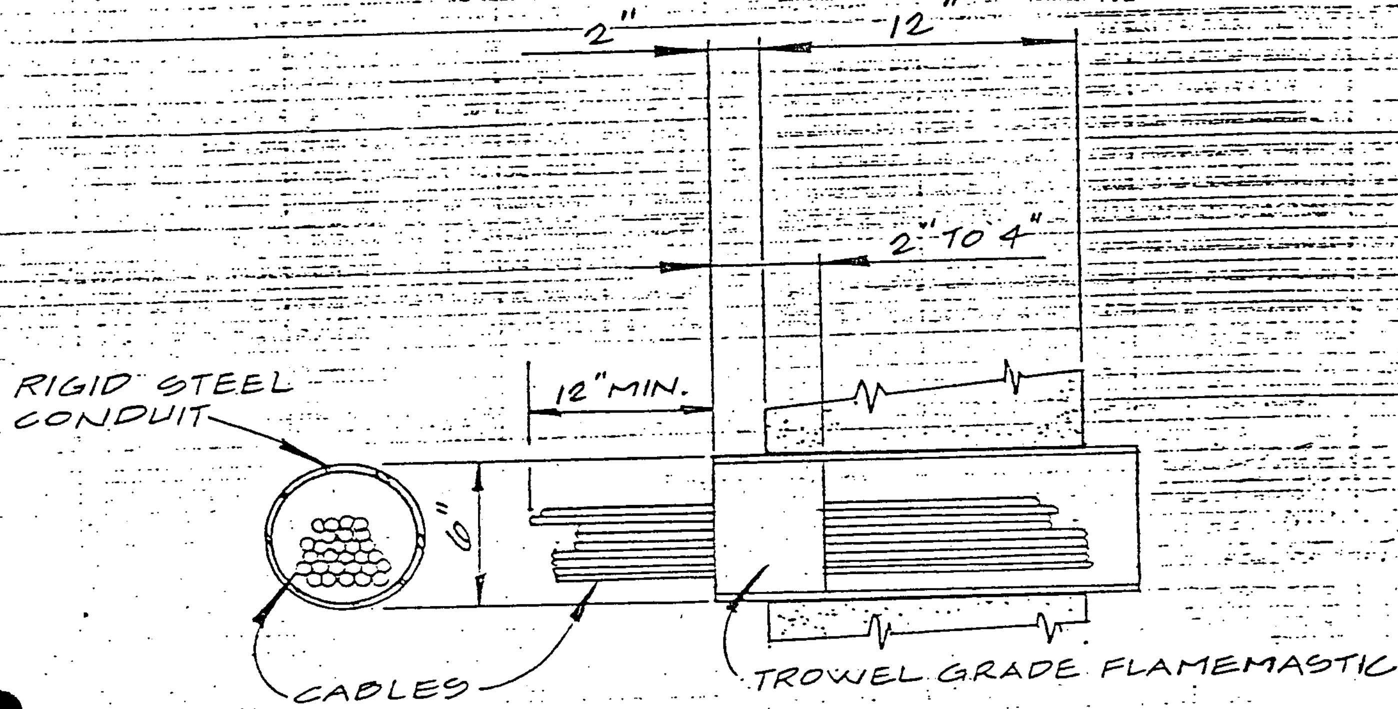


ACTUAL CABLES FILL TESTED - 51%
AREA OF CABLES IN TEST PENETRATION - 14.45 SQ. IN.
TEST CONSTRUCTION SKETCH # 16 X
ACTUAL CABLE TESTED - 1-250, 2-495, 2-2M, 2-MMS, 2-125, 4-M14
6-V12 AND 2-19R

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN-FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 2
		MARK & DWG. NO. WPD-4					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #4

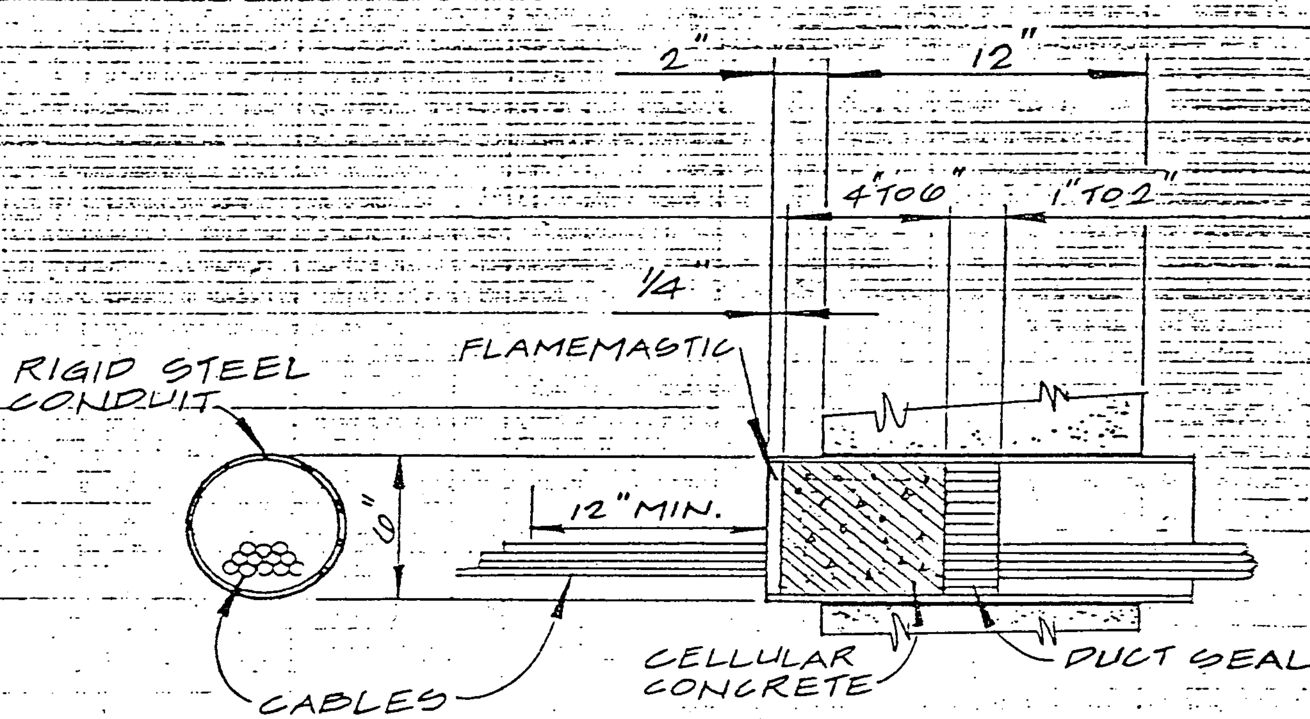


ACTUAL CABLE FILL TESTED - 51%
AREA OF CABLE IN TEST PENETRATION - 14.53 SQ. IN.
TEST CONSTRUCTION SKETCH #C-16
ACTUAL CABLES TESTED - 12-710, 1-250, 4-2MS, 4-V12 &
4-495

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-392					SHEET 2 OF 2
		MARK & DWG. NO. WPD-4					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 5

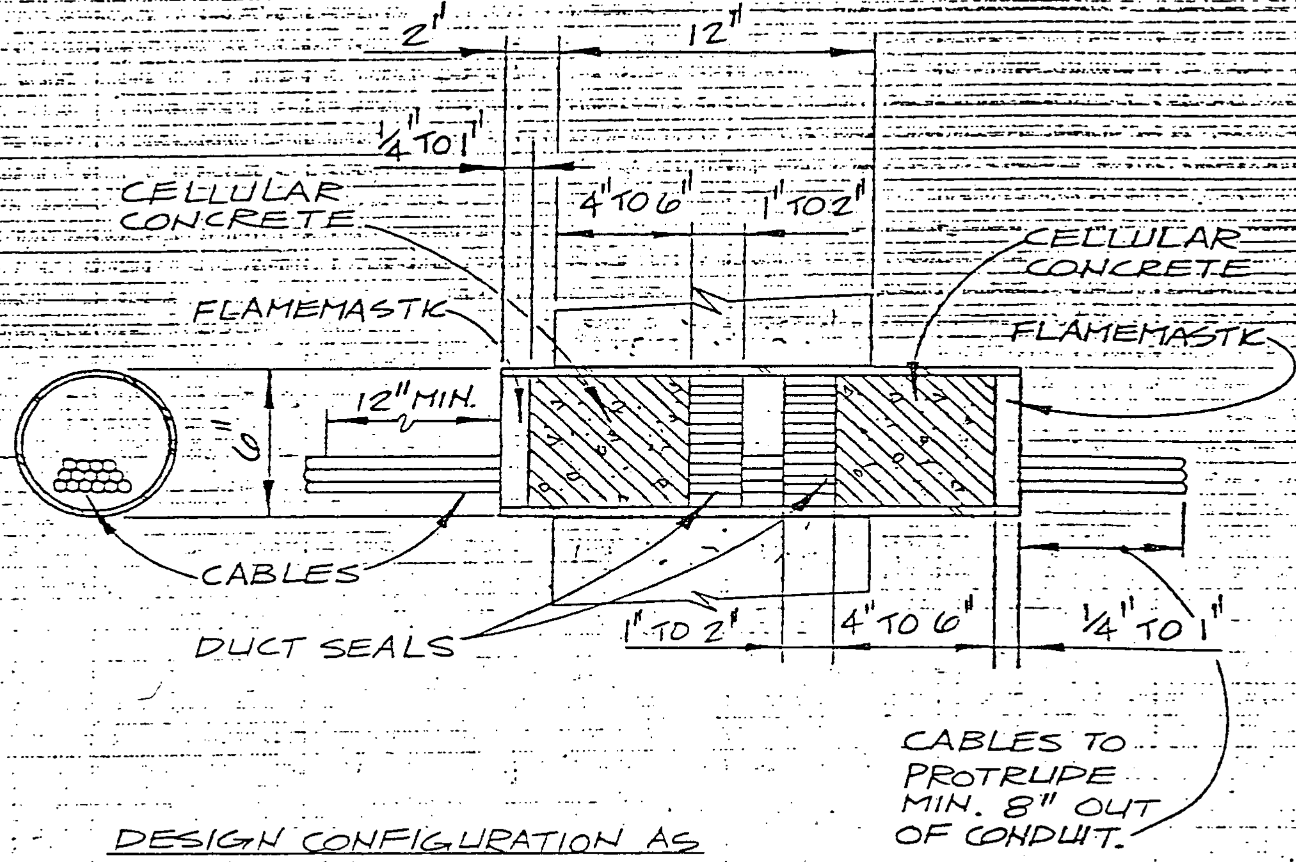


ACTUAL CABLE FILL TESTED - 37%
AREA OF CABLE IN TEST PENETRATION - 10.53 SQ. IN.
TEST CONSTRUCTION SKETCH # C-10
ACTUAL CABLES TESTED - 4-710, 4-2MS, 1-250, 4-V12 &
4-495

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 2
		MARK & DWG. NO. WPD-5					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 5



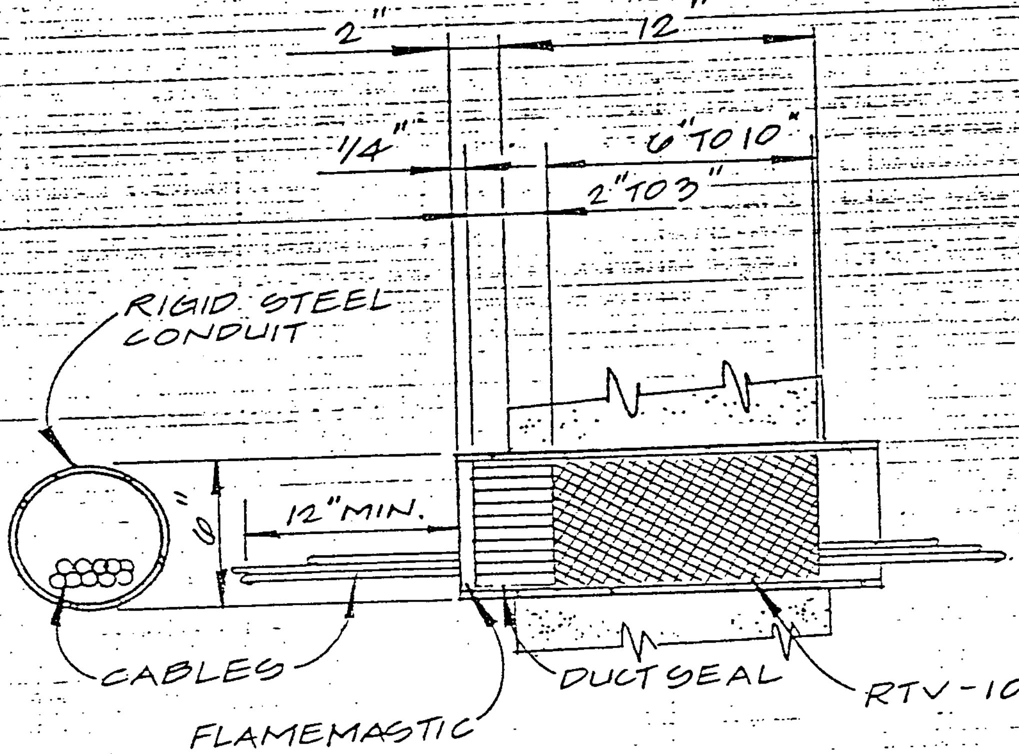
DESIGN CONFIGURATION AS INSTALLED IN THE PLANT

ACTUAL CABLE FILL TESTED - 37%
AREA OF CABLE IN TEST PENETRATION - 10.47 SQ. IN.
TEST CONSTRUCTION SHEET # C-10X
ACTUAL CABLES TESTED - 1-250, 2-125, 2-MMS, 4-V12, 2-19R & 2-M14

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 2
		MARK & DWG. NO. WPD-5					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 6

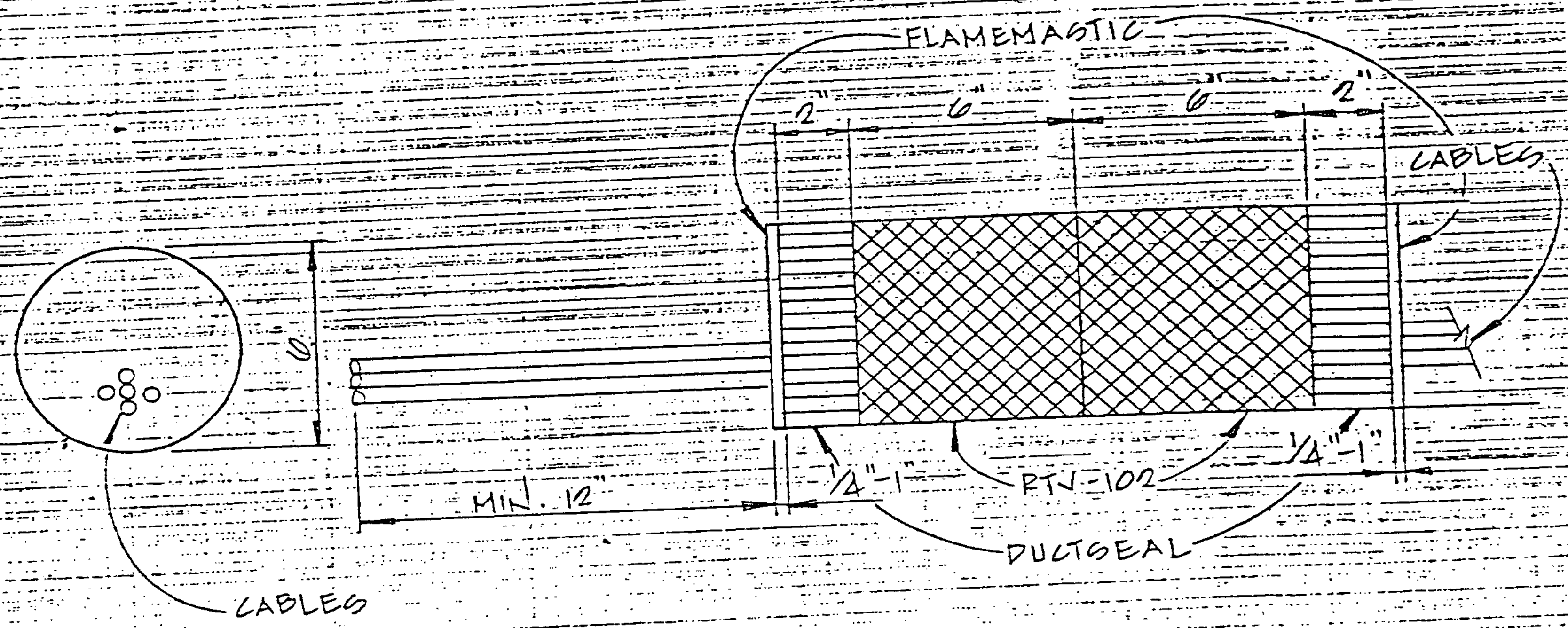


ACTUAL CABLE FILL TESTED - 37%
AREA OF CABLE IN TEST PENETRATION - 10.53 SQ. IN.
TEST CONSTRUCTION SKETCH # C-13
ACTUAL CABLES TESTED - 4-710, 4-2MS, 1-250, 4-V12 AND 4-495

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 2
		MARK & DWG NO. WPD-6					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 6



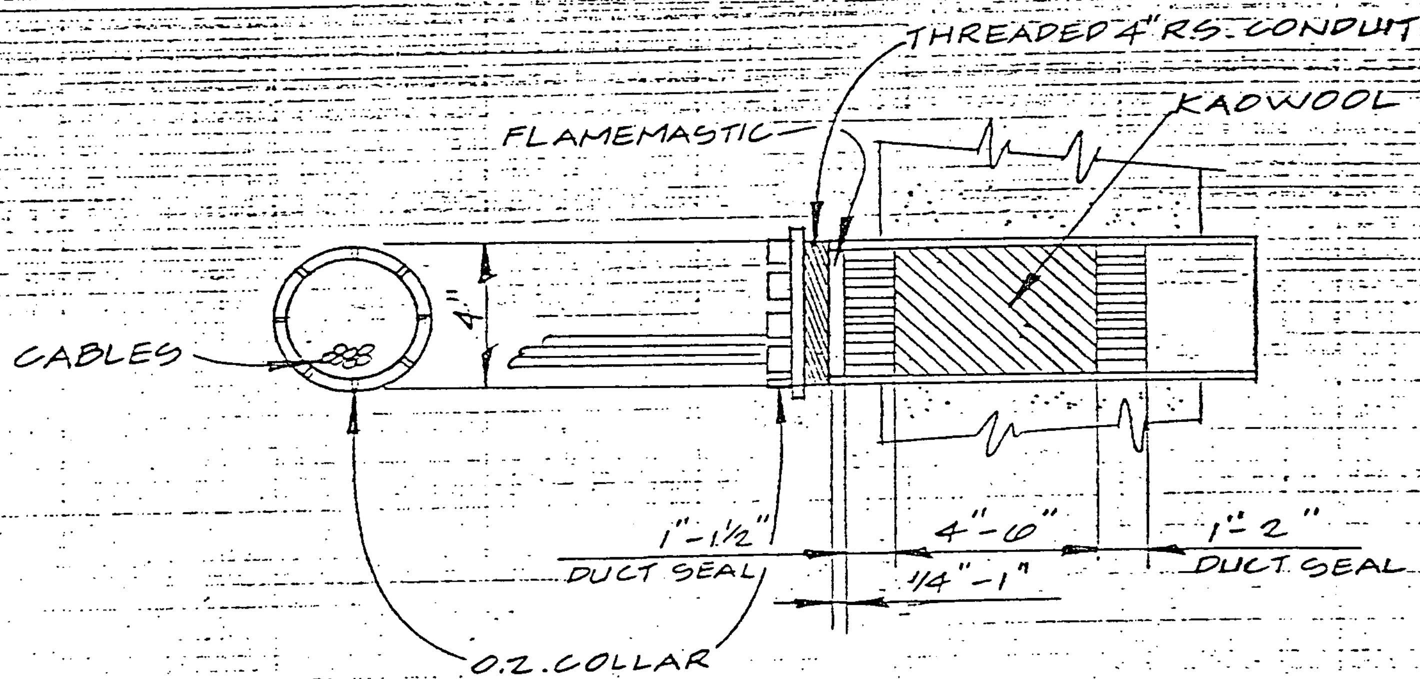
DESIGN CONFIGURATION AS INSTALLED IN THE PLANT

ACTUAL CABLE FILL TESTED - 30%
AREA OF CABLE IN TEST PENETRATION - 8.47 SQ. IN.
TEST CONSTRUCTION SKETCH # C-13X
ACTUAL CABLES TESTED -1-250, 1-514, AND 7-7P

NOTES:

		DRN	DES	CHK	APP	DATE	REV
eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.						0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 2
		MARK & DWG. NO. WPD-6					

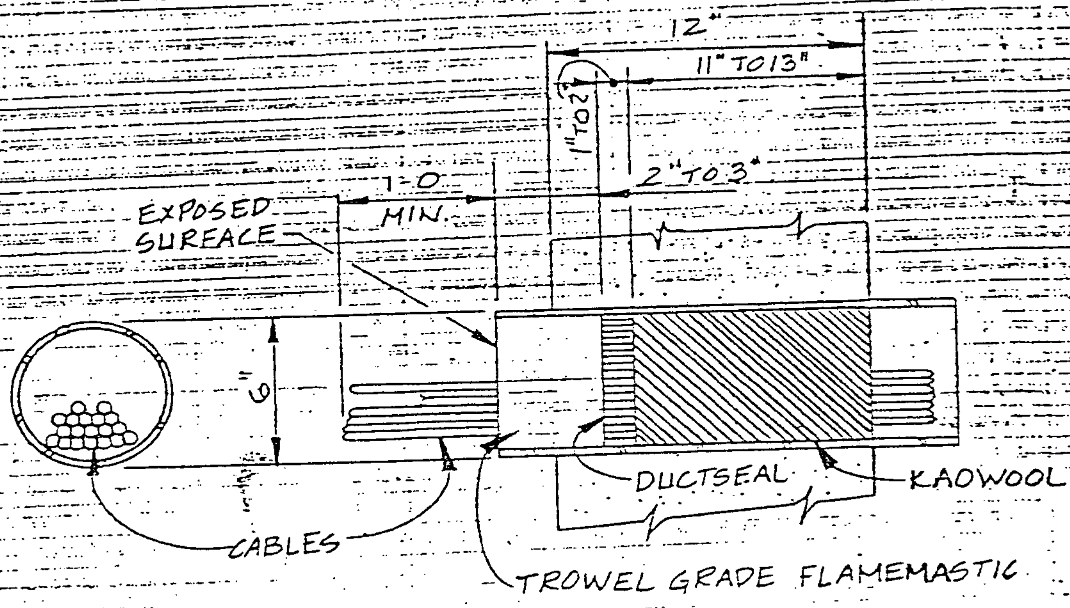
ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #7.



ACTUAL CABLE FILL TESTED - 43%
AREA OF CABLE IN TEST PENETRATION - 5.38 SQ. IN.
TEST CONSTRUCTION SKETCH - C18
ACTUAL CABLES TESTED - 1-250, 1-514, AND 6-19R
NOTES:
O.Z. COLLAR IS THREADED ON THE RIGID STEEL CONDUIT

		DRN	DES	CHK	APP	DATE	REV
eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.						0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-7					1 OF 1

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #8



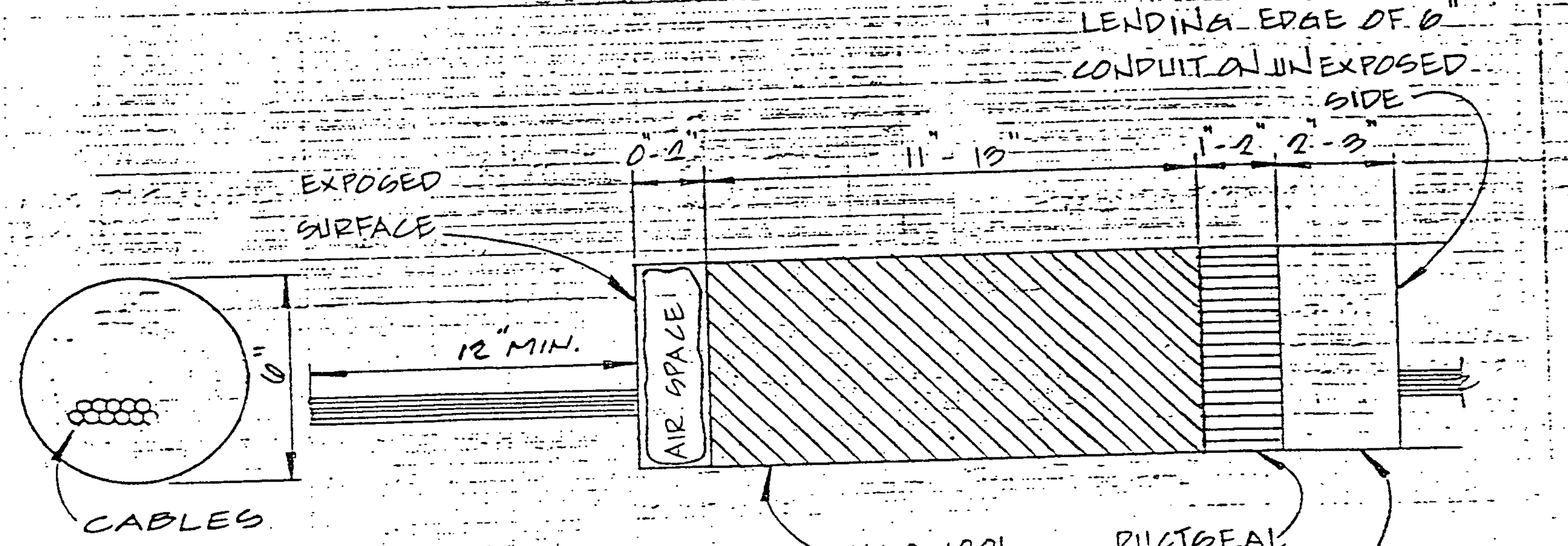
ACTUAL CABLE FILL TESTED - 42%
AREA OF CABLE IN TEST PENETRATION - 5.33 SQ. IN.
TEST CONSTRUCTION SKETCH #C-27
ACTUAL CABLES TESTED - 1-250, 1-5/4 & 10-7P

NOTES:

1) QUALIFICATION OF NEW FIRE STOP DESIGN. TEST CONFIGURATION FOR QUALIFYING UNEXPOSED SURFACE SHOWN ON SHEET 2. COMBINED TEST RESULTS CONSTITUTE QUALIFICATION OF AN UNSYMMETRICAL DESIGN.

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 2
		MARK & DWG. NO. WPD-8					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #8



ACTUAL CABLE FILL TESTED -42%

AREA OF CABLE IN TEST PENETRATION - 11.75 SQ. IN.

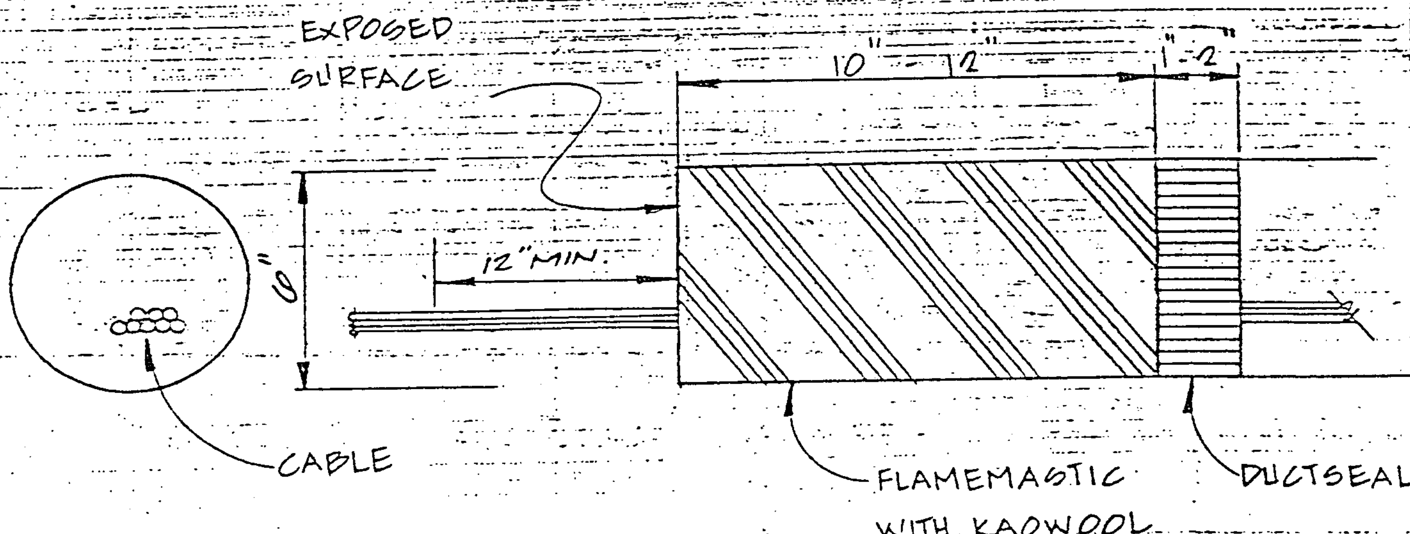
TEST CONSTRUCTION SKETCH #C28

ACTUAL CABLES TESTED -1-250, 1-314 AND 10-7P

NOTES: QUALIFICATION OF NEW FIRE STOP DESIGN, TEST CONFIGURATION FOR QUALIFYING UNEXPOSED SURFACE IS SHOWN ON SHEET 1. COMBINED TEST RESULTS CONSTITUTE QUALIFICATION OF AN UNSYMMETRICAL DESIGN.

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD CENTER CENTER	JOB. NO.	0460-023-332				SHEET 2 OF 2
		MARK & DWG. NO.	WPD-8				

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #9



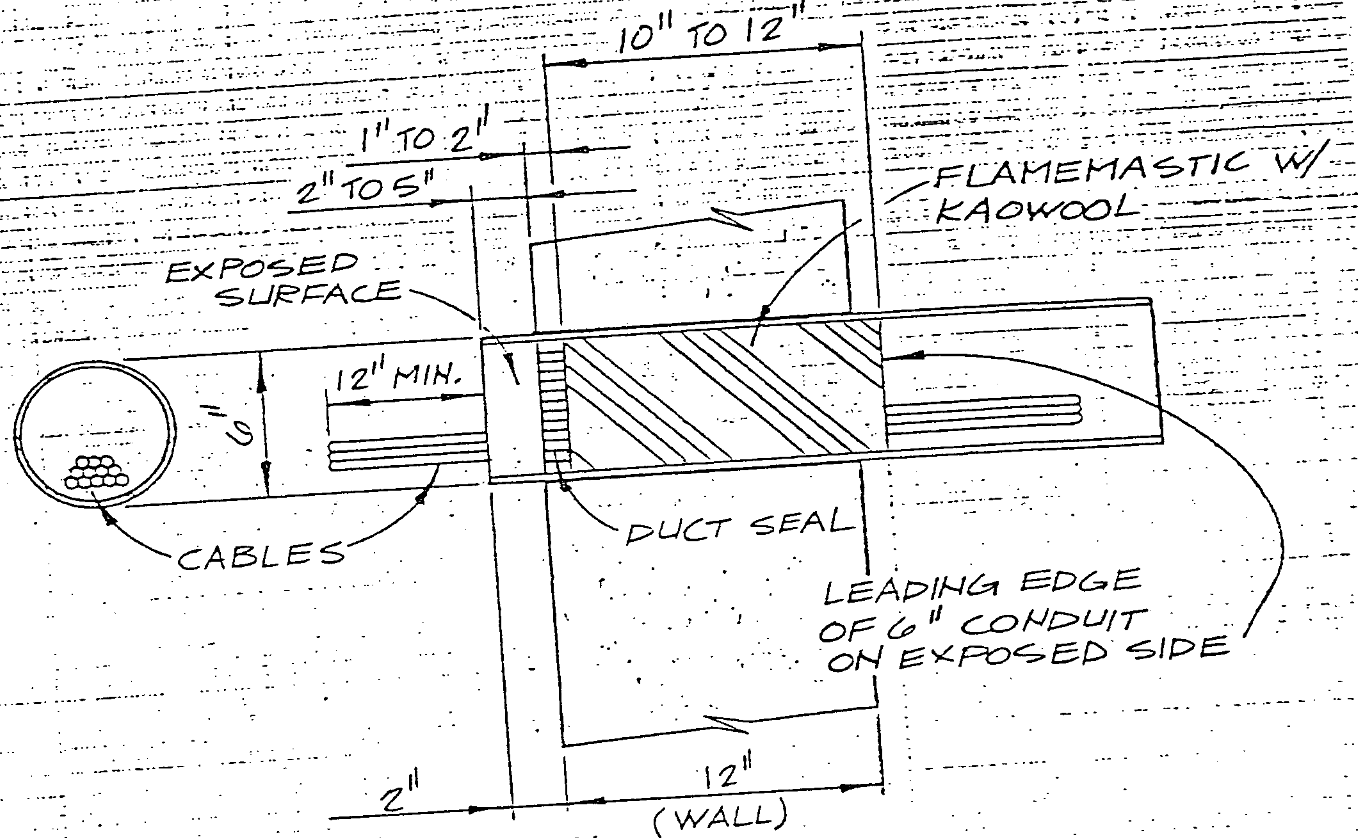
ACTUAL CABLE FILL TESTED - 42%
AREA OF CABLE IN TEST PENETRATION - 11.75 SQ.IN.
TEST CONSTRUCTION SKETCH # C-25
ACTUAL CABLES TESTED - 1-250, 1-5/4, 10-7P

NOTES:

1. MIX APPROXIMATELY EQUAL PORTION, BY VOLUME, OF KAOWOOL WITH TROWEL GRADE FLAMEMASTIC TO FORM A UNIFORM CONSISTENCY PRIOR TO APPLICATION.
2. QUALIFICATION OF A NEW FIRE STOP DESIGN. TEST CONFIGURATION FOR QUALIFYING UNEXPOSED SURFACE IS SHOWN ON SHEET 2. COMBINED TEST RESULTS CONSTITUTE QUALIFICATION OF AN UNSYMMETRICAL DESIGN.

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO.	0460-023-332				SHEET
		MARK & DWG. NO.	WPD-9				1 OF 2

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #9



ACTUAL CABLE FILL TESTED - 42%
AREA OF CABLE IN TEST PENETRATION - 11.75 SQ. IN.
TEST CONSTRUCTION SKETCH # C-26
ACTUAL CABLES TESTED - 1-250, 1-514 & 107P

NOTES:

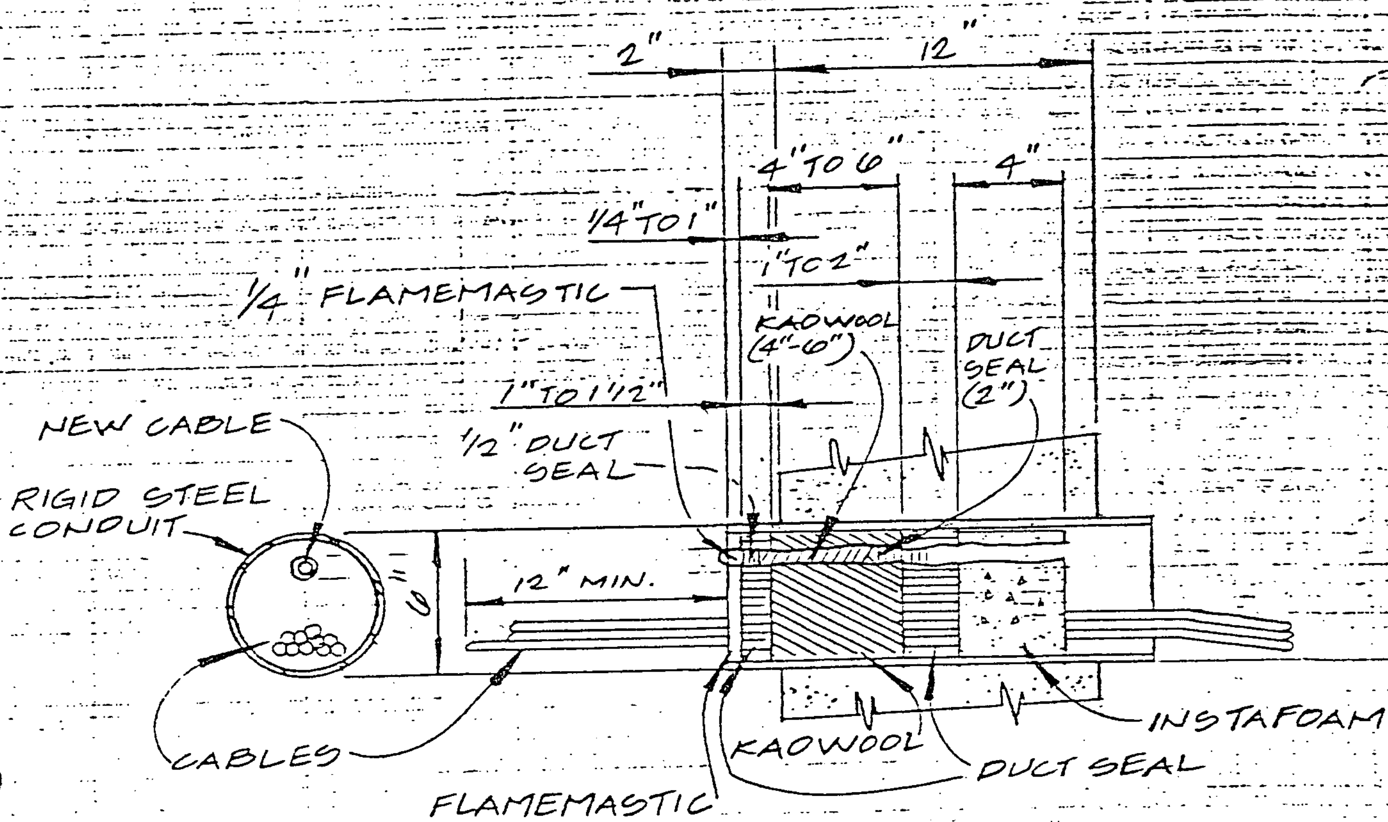
1) MIX APPROXIMATELY EQUAL PORTIONS, BY VOLUME, OF KAOWOOL WITH TROWEL GRADE FLAMEMASTIC TO FORM A UNIFORM CONSISTENY PRIOR TO APPLICATION.

2) QUALIFICATION OF A NEW FIRE STOP DESIGN. TEST CONFIGURATION FOR QUALIFYING UNEXPOSED SURFACE IS SHOWN ON SHEET 1. COMBINE RESULTS CONSTITUTE QUALIFICATION OF AN UNSYMETRICAL DESIGN.

		DRN	DES	CHK	APP	DATE	REV
e.d.s nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.						0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 2
		MARK & DWG. NO. WPD-9					

Wall Penetration Repair Procedures

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #1
REPAIR PROCEDURE #1

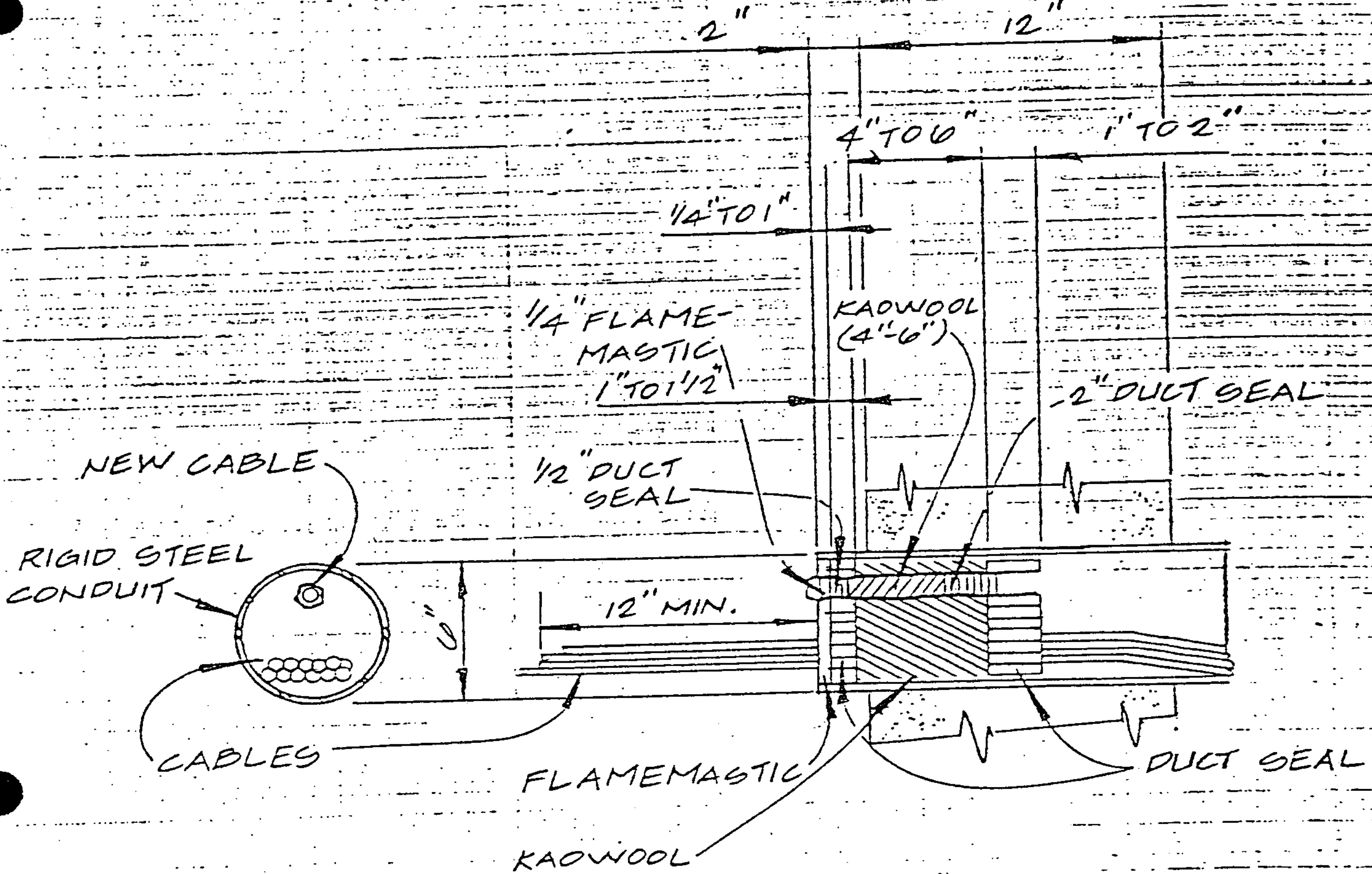


ACTUAL CABLE FILL TESTED - 20%
AREA OF CABLE IN TEST PENETRATION - 5.55 SQ. IN
TEST CONSTRUCTION SKETCH # C-2
ACTUAL CABLE TESTED - 2-710, 2-2MS, 1-250, 2-495 AND 2-V12

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 4
		MARK & DWG. NO. WPD-RP-1					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #2
REPAIR PROCEDURE #1

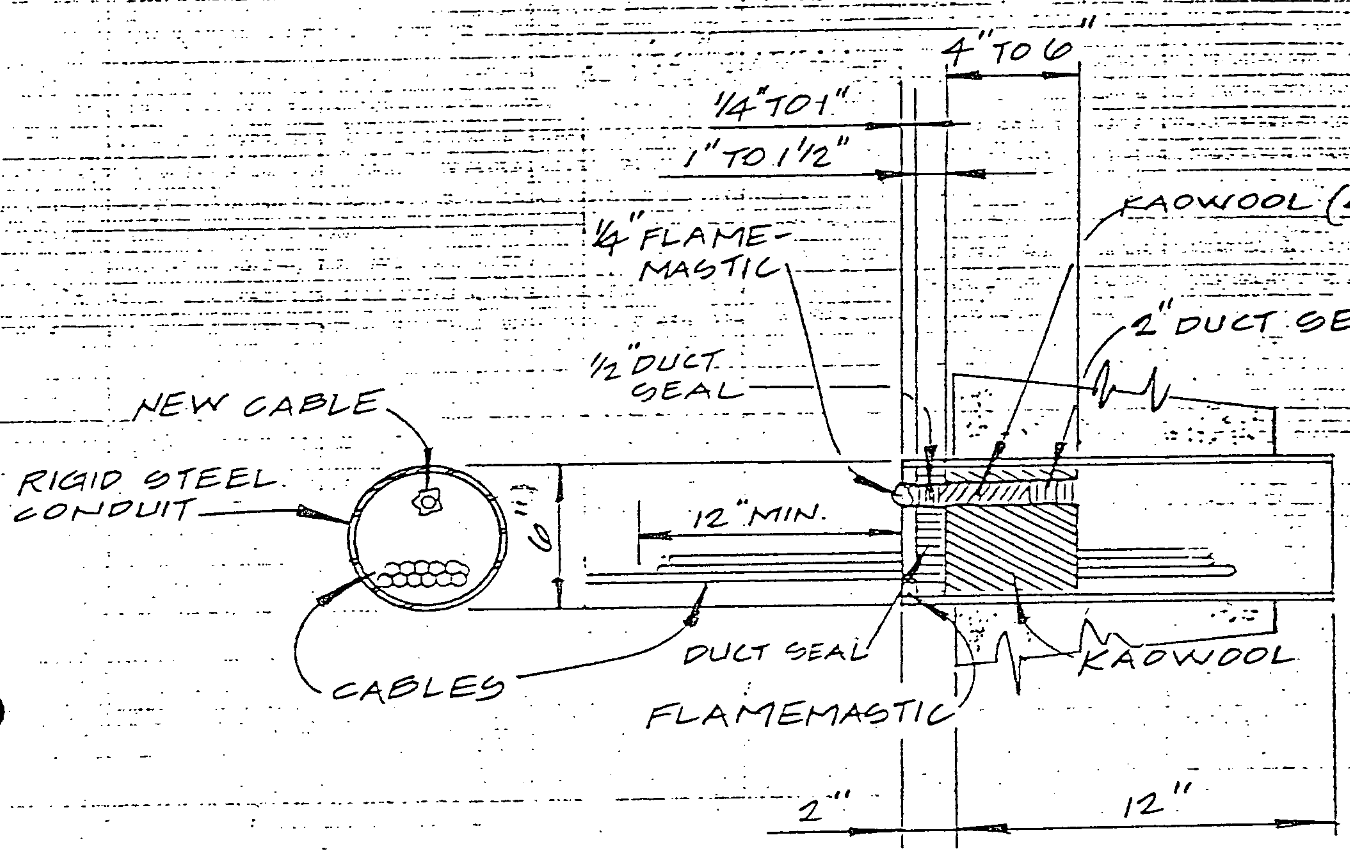


ACTUAL CABLE FILL TESTED - 20%
AREA OF CABLE IN TEST PENETRATION - 5.55 SQ IN.
TEST CONSTRUCTION SKETCH #C-5
ACTUAL CABLE TESTED - 2-710, 2-2MS, 1-250, 2-495 AND 2-V12

NOTES:

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 4
		MARK & DWG NO. WPD-RP-1					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 3
REPAIR PROCEDURE # 1



ACTUAL CABLE FILL TESTED - 27.4%
AREA OF CABLE IN TEST PENETRATION - 7.60 SQ IN.
TEST CONSTRUCTION SKETCH # C-8
ACTUAL CABLE TESTED - 1-250, 2-M14, 2-914, 2-195, 2-2MS, AND 4-MMS

NOTES:

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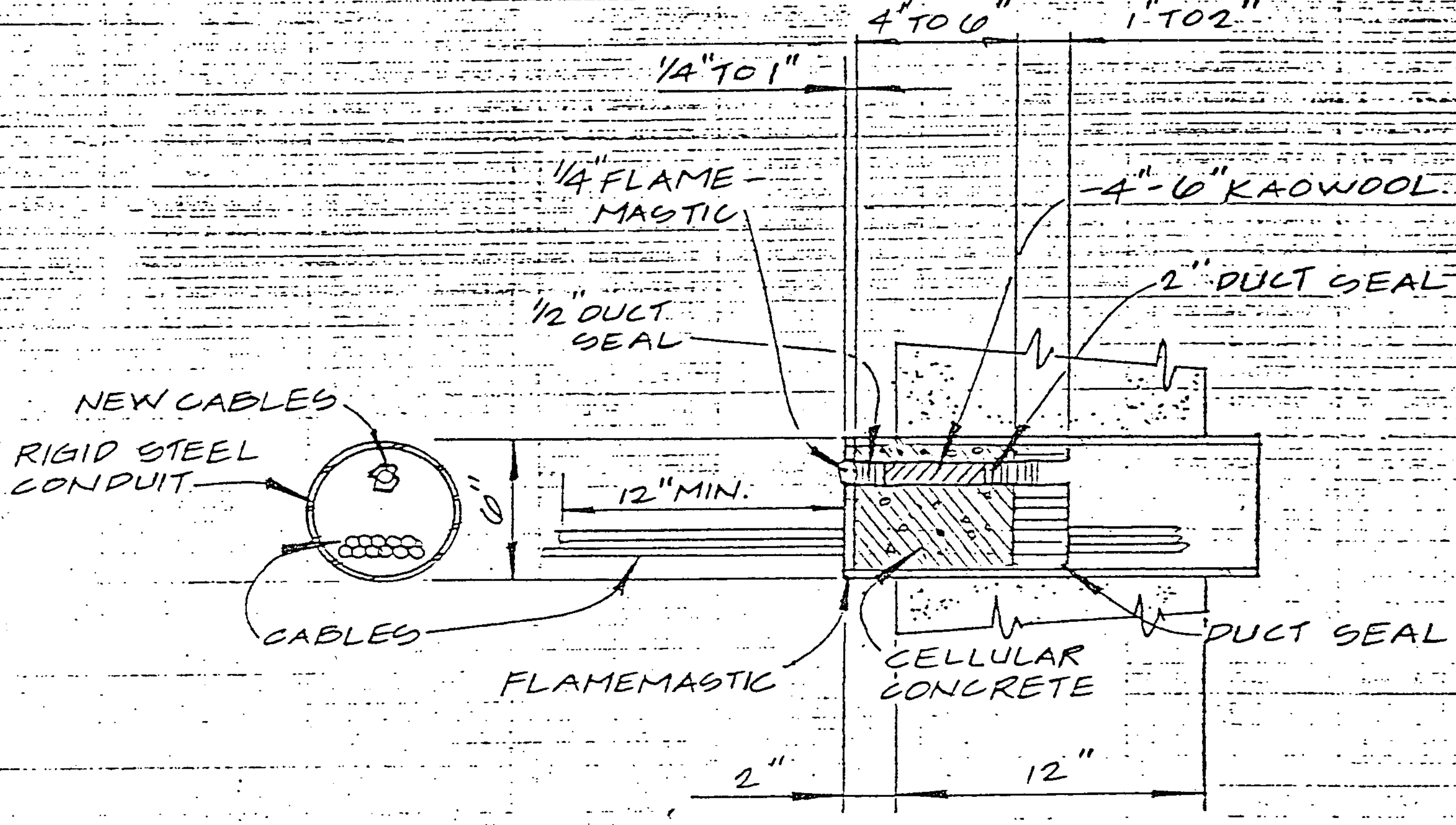
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-RP-1					3 OF 4

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 5
REPAIR PROCEDURE #1



ACTUAL CABLE FILL TESTED - 20.5%
AREA OF CABLE IN TEST PENETRATION - 5.7 SQ IN.
TEST CONSTRUCTION SKETCH # C-11
ACTUAL CABLES TESTED - 1-250, 2-19R, 2-MMS, 2-914 AND 2-19S

NOTES:

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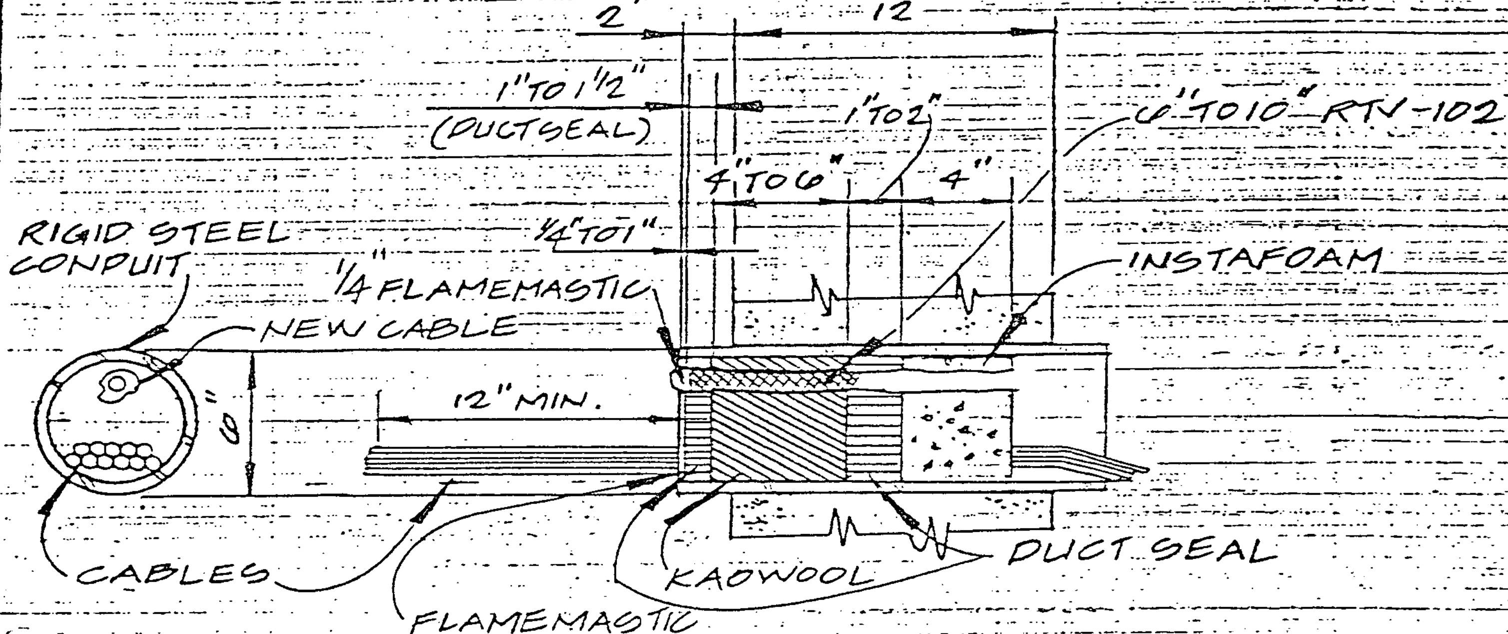
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-RP-1					4 OF 4

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #1
REPAIR PROCEDURE #3



ACTUAL CABLE FILL TESTED - 20%
AREA OF CABLE IN TEST PENETRATION - 5.55 SQ IN.
TEST CONSTRUCTION SKETCH # C-3
ACTUAL CABLES TESTED - 2-710, 2-2MS, 1-250, 2-495, AND 2-V12

NOTES:

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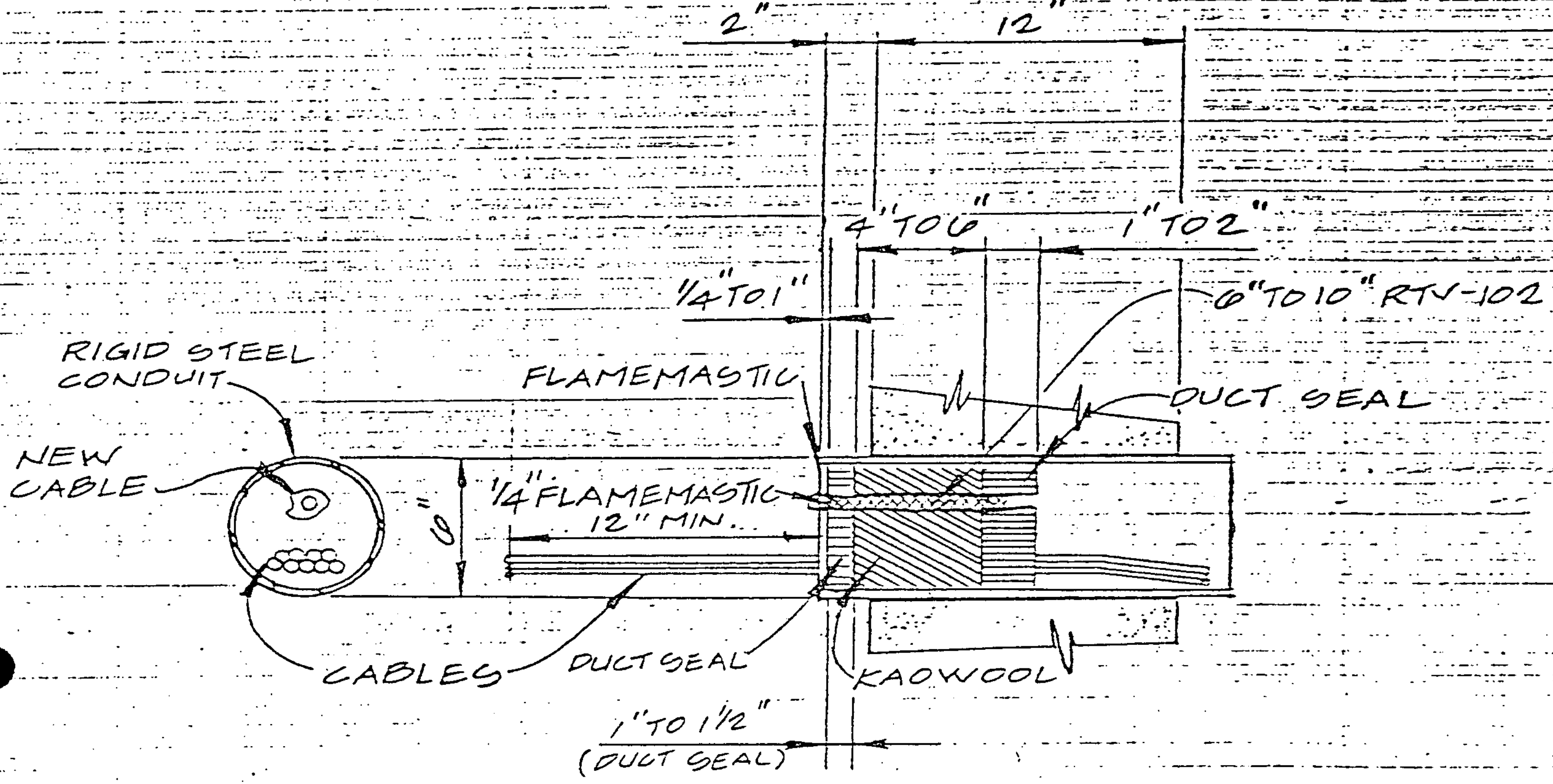
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER						0
		JOB. NO. 0460-023-332					SHEET 1 OF 4
		MARK & DWG. NO. WPD-RP-3					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #2
REPAIR PROCEDURE #3



ACTUAL CABLE FILL TESTED - 21%

AREA OF CABLE IN TEST PENETRATION - 5.77 SQ.IN.

TEST CONSTRUCTION SKETCH # C-6

ACTUAL CABLES TESTED - 2-2MS, 2-914, 1-250, 2-195, 2-495 AND 2-19R

NOTES:

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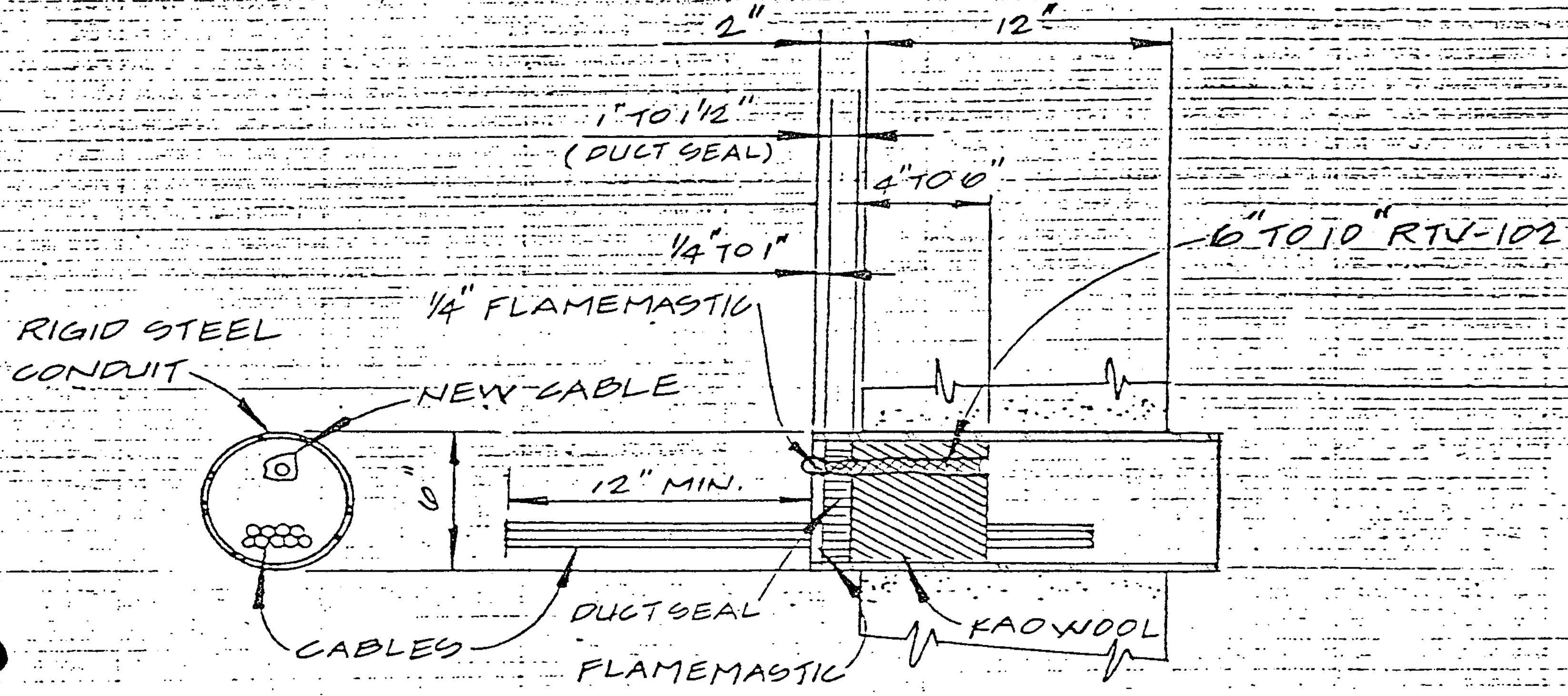
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 2 OF 4
		MARK & DWG. NO. WPD-RP-2					

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN #3
REPAIR PROCEDURE #3



ACTUAL CABLE FILL TESTED - 32%
AREA OF CABLE IN TEST PENETRATION - 8.85 SQ.IN.
TEST CONSTRUCTION SKETCH # C-9
ACTUAL CABLES TESTED - 1-250, 2-195, 4-MMS, 2-914, 2-125, AND 2-M14

NOTES:

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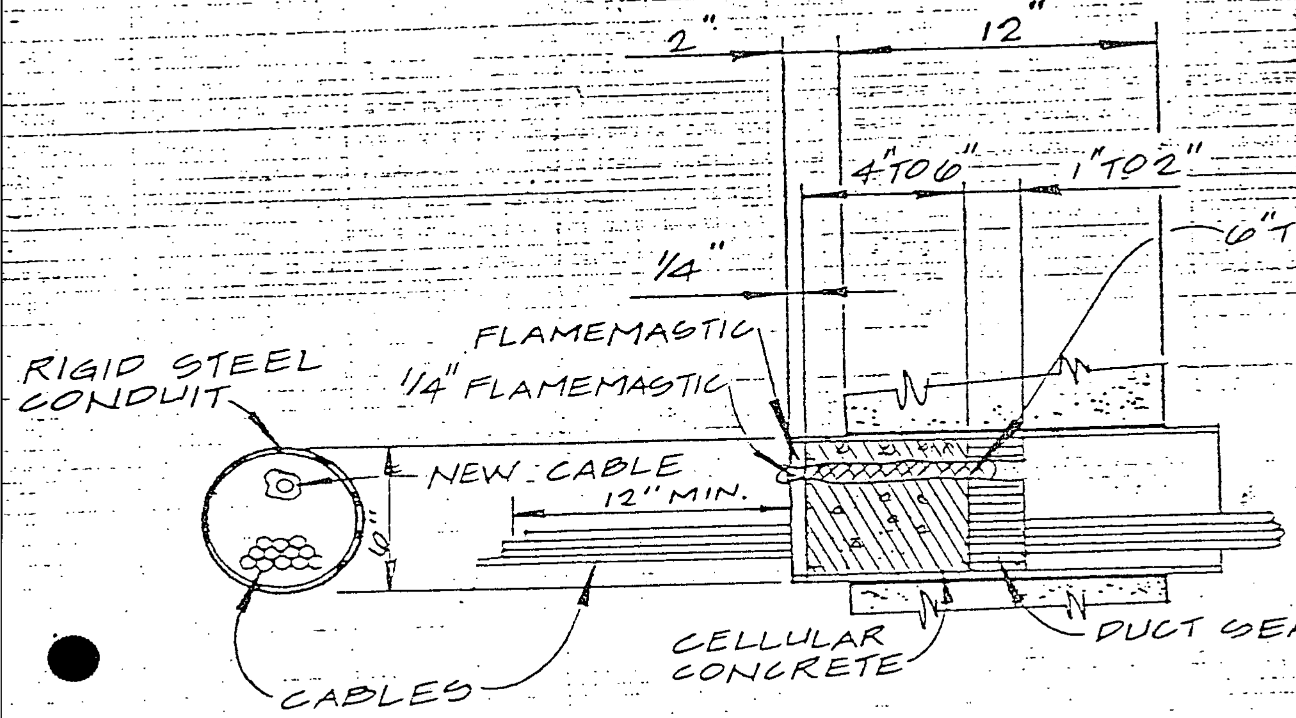
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-RP-2					3 OF 4

ELECTRICAL CABLE PENETRATION FIRE STOP
WALL PENETRATION DESIGN # 5
REPAIR PROCEDURE #3



ACTUAL CABLE FILL TESTED - 20.8%
AREA OF CABLE IN TEST PENETRATION - 5.77 SQ. IN.
TEST CONSTRUCTION SKETCH # C-12
ACTUAL CABLES TESTED - 2-2MS, 2-914, 1-250, 2-195, 2-495 AND 2-19R

NOTES:

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							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WPD-RP-2					4 OF 4

B. FLOOR CABLE PENETRATION TESTS

1. Penetration Designs

The basic 8-inch diameter electric cable floor penetration design used at DAEC is shown in drawing FPD-1. This is a symmetrical design which occupies the entire free volume of the cable penetration.

Drawings FPD-RP-1 through FPD-RP-4 illustrate the repair procedures used for adding additional cables to the penetration and, additionally, test the fire integrity of floor penetrations in which 1-inch diameter electrical conduit is installed.

a. General Notes for Floor Penetration Designs

1) Percentage of cable fill in a penetration is determined by dividing the sum of the individual cable cross-sectional areas by the area of the conduit and multiplying by 100%.

b. Floor Penetration Designs

Drawing Number	Number of Sheets
FPD-1	1

c. Floor Penetration Repair Procedures

Drawing Number	Number of Sheets
1) FPD-RP-1	1
2) FPD-RP-2	1
3) FPD-RP-3	1
4) FPD-RP-4	1

2. Test Fixture

a. Test Slab

The electrical cable floor penetration fire stop designs were tested on a small floor test furnace capable of supporting a concrete slab 48 inches square with an effective test area of 32 inches square. There were two 12-inch thick test slabs; one which contained four 8-inch diameter penetrations and one which contained one 8-inch diameter penetration, one 4-inch diameter penetration and seven 6-inch diameter penetrations. To simulate in plant conditions, all 8-inch diameter transite sleeves were cut flush with the test slab.

b. Placement of Thermocouples

Three thermocouples were used for monitoring the basic floor penetration fire stop design (FPD-1). These thermocouples were located at the center of the cable bundle in plane with the unexposed penetration fire stop surface, on the surface of the cable bundle at the interface with the unexposed surface of the fire stop, and on the unexposed penetration surface.

For each repair cable and each 1-inch diameter conduit, an additional thermocouple was used. The unexposed surface of the test slab was also monitored.

c. Test Configurations

The test configurations were representative of installed plant designs.

d. Hose Stream Tests

To provide additional test data on the structural integrity of the cable floor penetration fire stop and floor penetration fire stop repair procedures, an additional hose stream test, as specified in ASTM E-119-78 was performed subsequent to the IEEE 634 hose stream test specified in the test procedure.

3. Summary of Results

(TABLE)

FLOOR CABLE PENETRATION TESTS
SUMMARY OF RESULTS

Penetration Design Number	Test Sketch Number	Interior Cable Bundle Jacket Temp at 3 Hrs (^{o}F)	Cable Bundle Surface Temp - Unexposed Side at 3 Hrs (^{o}F)	Unexposed Surface Temperature 3 Hrs.	Hose Stream Test IEEE	Hose Stream Test ASTM
FPD-1	S-1	510	295	200	PASS	PASS
FPD-RP-1	S-2	330	195	170	PASS	PASS
FPD-RP-2	S-3	200	180	190	PASS	PASS
FPD-RP-3	S-4	445	250	140	PASS	PASS
FPD-RP-4	S-5	185	185	185	PASS	PASS

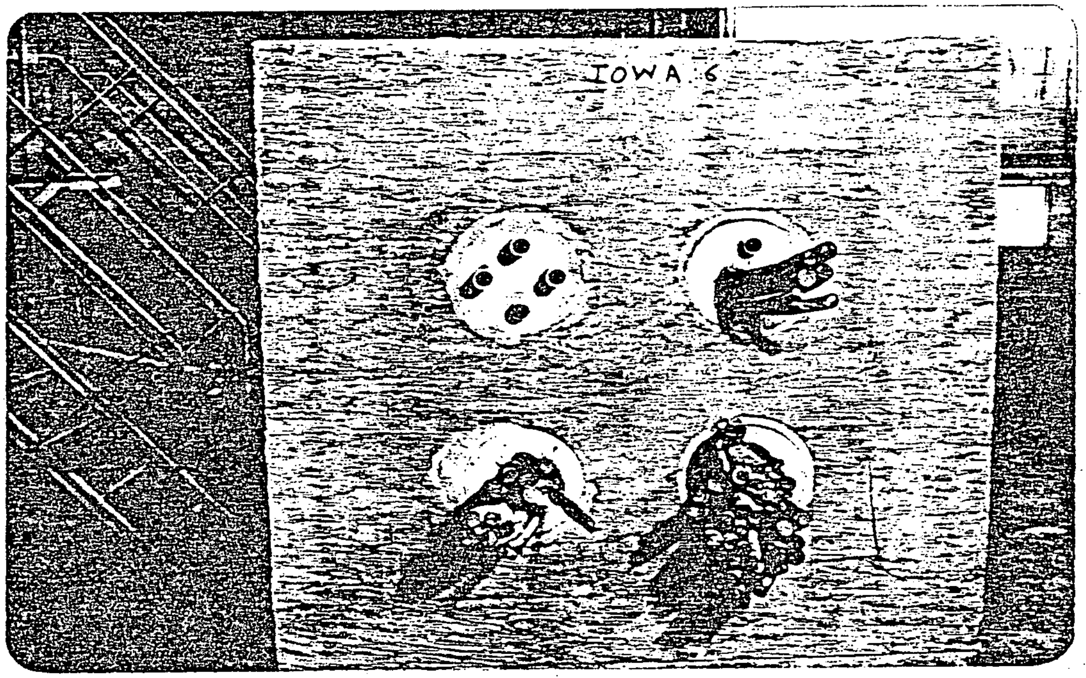
4. Conclusions

The Summary of Results for the floor penetration electrical cable fire stop tests is similar to that described for the wall penetration fire stop tests with notable exception of an additional column entitled Unexposed Surface Temperature at 3 Hours. Due to the space available on the unexposed surface of the floor penetrations, accurate data to evaluate the ANI acceptance criteria relating to an unexposed surface temperature limit of 325^{o}F above the ambient temperature, 70^{o}F, was provided in the column. From the data provided in the Summary of Results, it can be concluded that the floor penetration fire stop design FPD-1 and repair procedures FPD-1 through FPD-4 are all qualified to a 3-hour fire endurance rating under the stated test criteria and are able to maintain cable jacketing insulation temperatures well below the 700^{o}F limit.

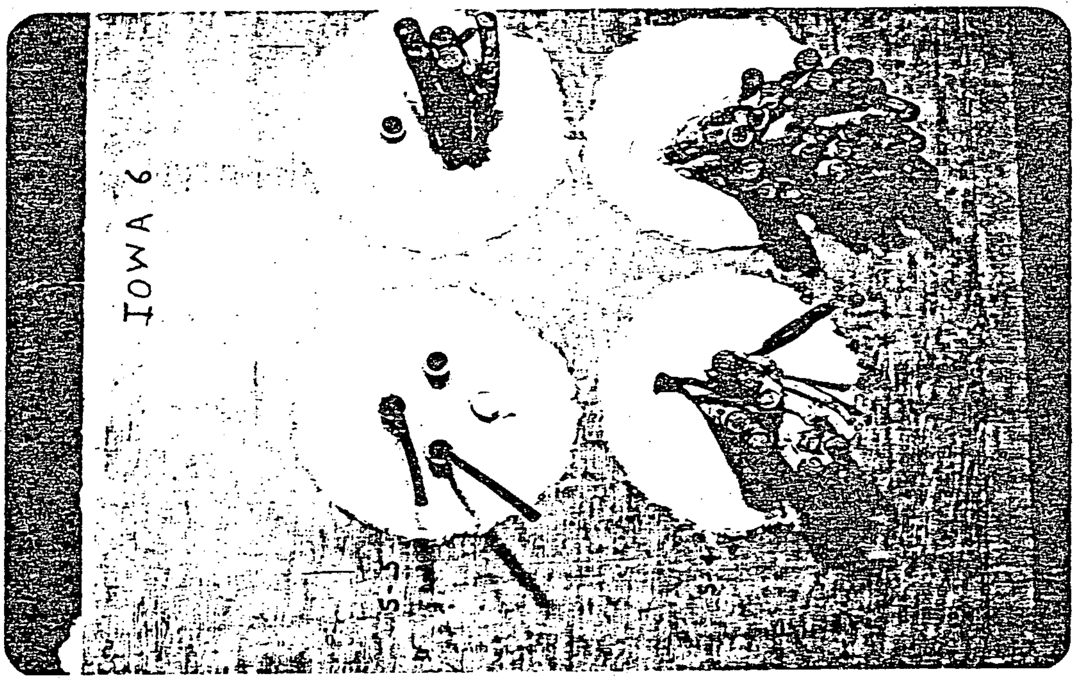
Available test data also confirms that these cable penetrations and repair procedures meet the ANI fire test acceptance criteria for a 3-hour fire endurance rating.

5. Photographs

FLOOR PENETRATION FIRE STOP TESTS

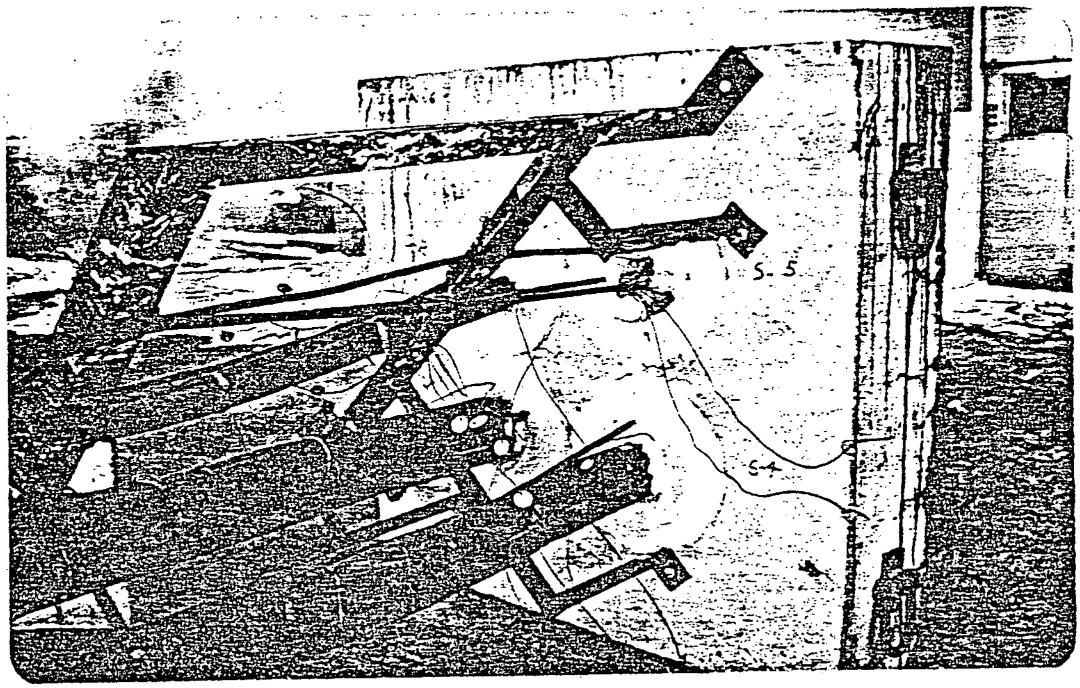


During Construction of Fire Stops



During Construction of Fire Stops

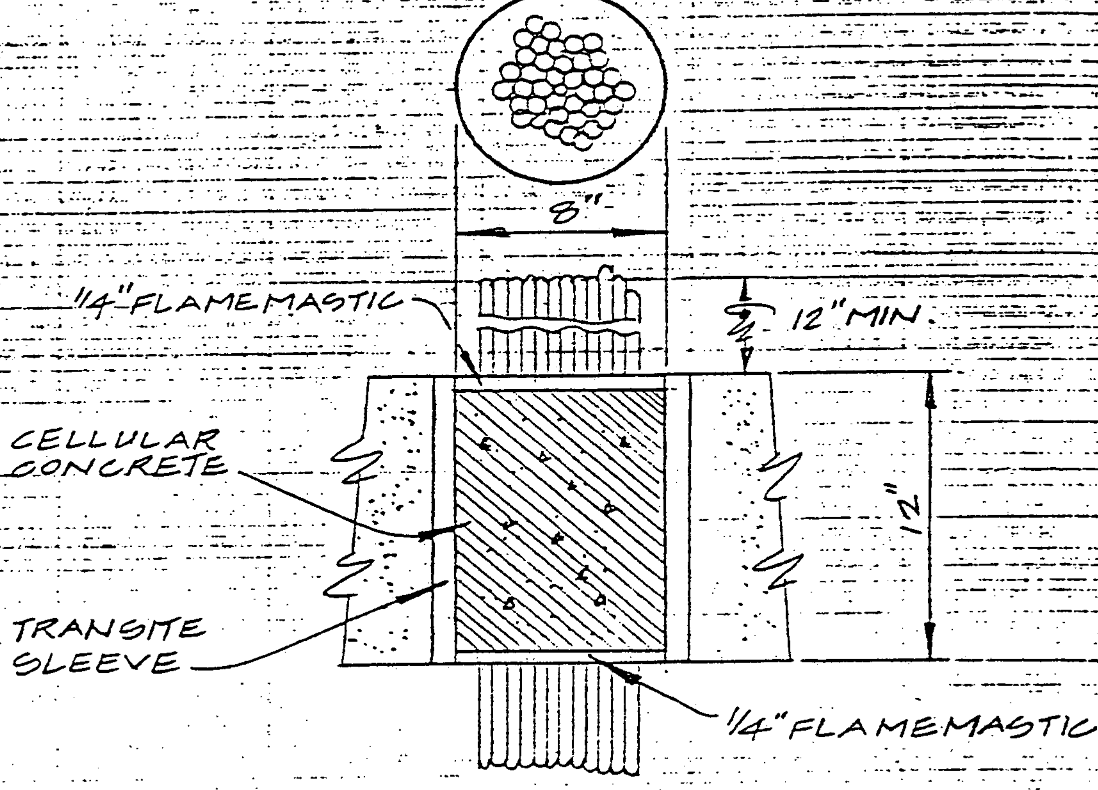
FLOOR PENETRATION FIRE STOP TESTS



After Hose Stream Tests

Floor Penetration Designs

ELECTRICAL CABLE PENETRATION FIRE STOP
FLOOR PENETRATION DESIGN #1



30% CABLE FILL

ACTUAL CABLE FILL TESTED - 43.0%
AREA OF CABLE IN TEST PENETRATION - 22.07 SQ IN.
TEST CONSTRUCTION SKETCH # S-1
ACTUAL CABLES TESTED - 14-495, 6-2MS, 6-19R, 1-250 AND 6-V12

CABLE FILL TO BE AS MUCH AS POSSIBLE BUT TO THE LIMIT THAT THE POURING OF THE CONCRETE WILL NOT BE HINDERED IN FILLING ALL VOIDS (SATURATING THE ENTIRE SLEEVE)

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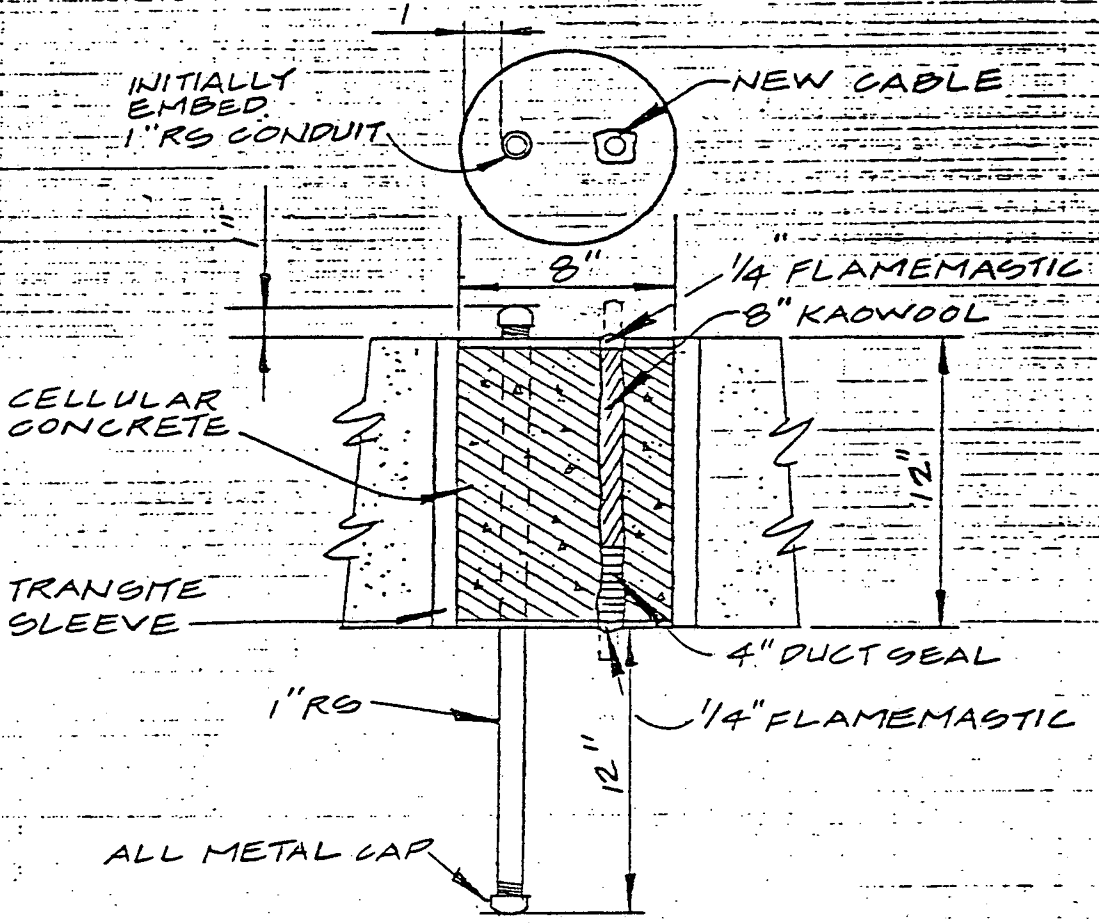
		MARK & DWG. NO. FPD-1					1 OF 1

Floor Penetration Repair Procedures

ELECTRICAL CABLE PENETRATION FIRE STOP
FLOOR PENETRATION DESIGN #1
REPAIR PROCEDURE #1



ACTUAL CABLE FILL TESTED - 10.5% (INITIAL)
AREA OF CABLE IN TEST PENETRATION - 5.28 SQ. IN.
TEST CONSTRUCTION SKETCH # S-2
ACTUAL CABLES TESTED - 1-250, 2-V12, 2-7P AND 2-2M

1" RS CONDUIT TO BE HOLLOW AND CAPPED AT BOTTOM END WITH O.Z. PLASTIC COLLAR W/ METAL DISC. IN CENTER. PAINT OVER CONDUIT PORTRUSIONS WITH 1/4" FLAMEMASTIC

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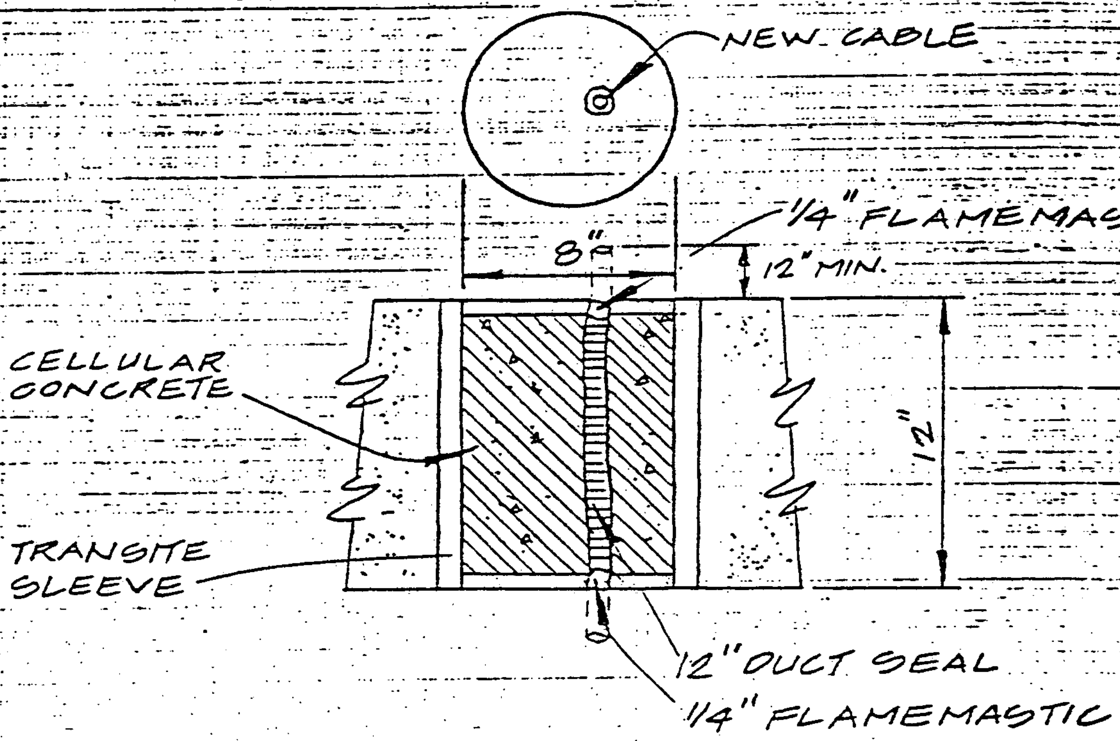
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. FPD-RP-1					

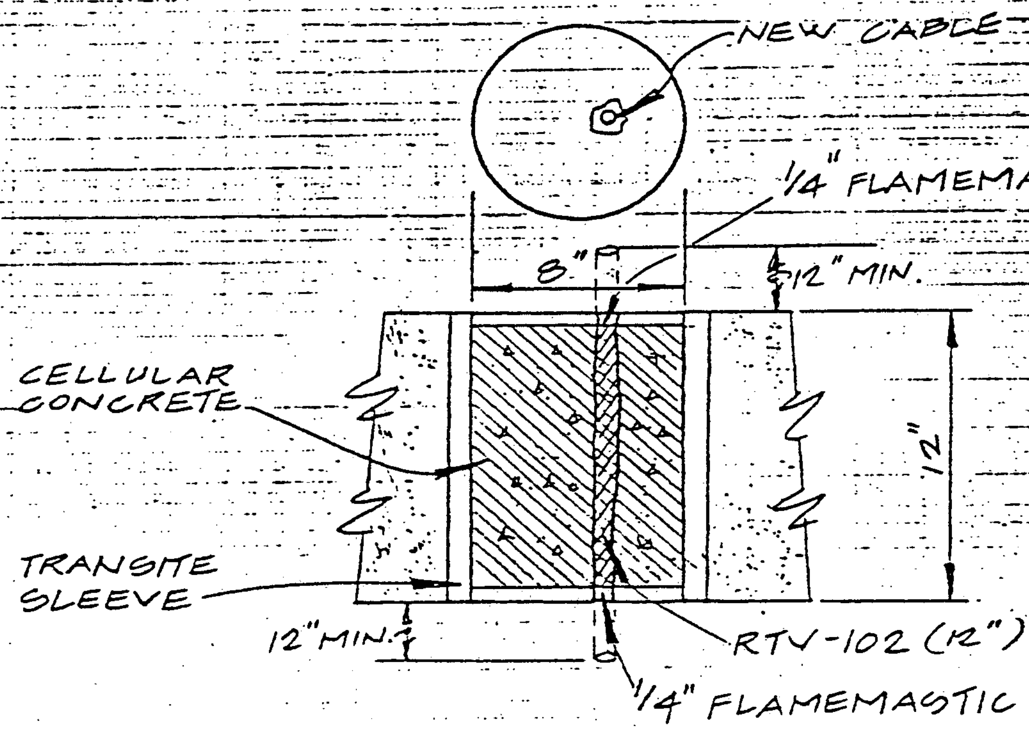
ELECTRICAL CABLE PENETRATION FIRE STOP
FLOOR PENETRATION DESIGN #1
REPAIR PROCEDURE #2



ACTUAL CABLE FILL TESTED - 20%
AREA OF CABLE IN TEST PENETRATION - 10.05 SQ IN.
TEST CONSTRUCTION SKETCH # S-3
ACTUAL CABLES TESTED - 1-250, 10-19R & 2-7P

		DRN	DES	CHK	APP	DATE	REV
eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.						0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-33					SHEET 1 OF 1
		MARK & DWG. NO. FPD-RP-2					

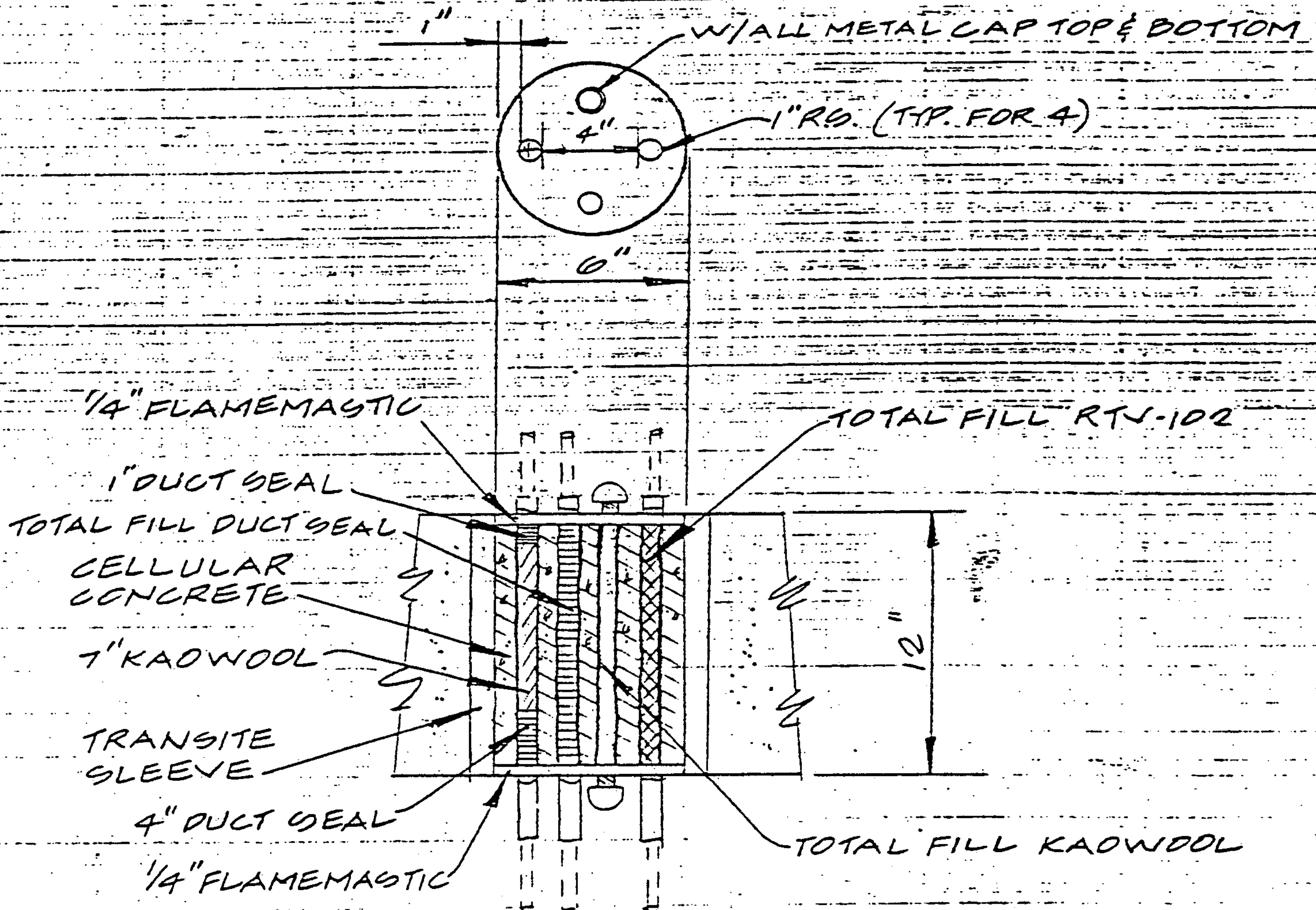
ELECTRICAL CABLE PENETRATION FIRE STOP
FLOOR PENETRATION DESIGN #1
REPAIR PROCEDURE #3



ACTUAL CABLE FILL TESTED - 21.5% (INITIAL)
AREA OF CABLE IN TEST PENETRATION - 10.81 SQ IN.
TEST CONSTRUCTION SKETCH # S-4
ACTUAL CABLES TESTED - 4, V12, 1-250, 4-7P AND 8-2M

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 6460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. FPD-RP-3					

ELECTRICAL CABLE PENETRATION FIRE STOP
FLOOR PENETRATION DESIGN #4



SECTION ROTATED FOR CLARITY

ACTUAL CABLE FILL TESTED - N/A
AREA OF CABLE IN TEST PENETRATION - N/A
TEST CONSTRUCTION SKETCH # S-5
ACTUAL CABLES TESTED - 3-2MS

CABLES TO PORTRUDE 12" ON EITHER SIDE OF SLAB

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO.	0460-023-332				SHEET
		MARK & DWG. NO.	FPD-RP-4				1 OF 1

C. CABLE TRAY PENETRATION TESTS

1. Cable Tray Penetration Designs

There are four basic cable tray penetration fire stop designs W/FTD-1 and W/FTD-2, WTD-1, and FTD-1,) presently in use at DAEC. All of these designs are symmetrical including WTD-1 which represents only one-half of the actual installed penetration design. This cable tray penetration design, WTD-1, is normally used in penetration where the walls are greater than 12 inches thick.

Cable tray penetration fire stop designs WTD-2 and WTD-3 are not currently installed at DAEC. WTD-2, which is similar to WTD-1, was tested to determine the affect that a sheet metal covering, used to protect the marinite board by providing additional structural support, would have on the fire resistance rating of the penetration. WTD-3 was proposed as a fire stop design for use in large, void areas where the addition of insulating materials is difficult to achieve.

In normal plant practice, the addition of cables to a cable tray normally requires that the cable tray fire stop is disassembled and later rebuilt in its original condition. Therefore, no cable tray penetration repair procedures were tested.

a. General Notes for Cable Tray Fire Stops:

1) Standard 24-inch cable trays shall be filled to a maximum design fill of 30% of the 3-inch design depth or 21.6 square inches (for actual cable fill see design drawings).

2) All test specimens shall have 1 triplex cable included in tray cable fill.

3) All cables shall be laid flat and straight and supported to the rungs by tie-wraps. Nylon cable ties shall be used to represent the installed condition, although different cable ties may be used on the unexposed surface to provide cable support in the test fixture.

4) Representative cable tray penetration size is 8 inches by 28 inches unframed.

5) Cable tray penetration repairs restore the penetration to its original design condition negating the need for testing repair procedures.

b. Cable Tray Penetration Designs

Drawing Number	Number of Sheets
1) WTD-1	1
2) WTD-2	1
3) WTD-3	1

c. Wall/Floor Penetration Designs

Drawing Number	Number of Sheets
1. W/FTD-1	1
2. W/FTD-2	1

d. Floor Penetration Designs

Drawing Number	Number of Sheets
WTD-1	1

2. Test Fixture

a. Test Slab

The test slabs used for the electrical cable tray penetration tests were 48 inches square and 12 inches thick with two 8-inch by 28-inch unframed penetrations centered and equally spaced over the 32-inch square test area.

b. Placement of Thermocouples

For each cable tray penetration tested, thermocouples were located in a plane with the unexposed fire stop surface at the midpoint on the exterior side of the tray channels, on the cable bundle surface at the quarter points and midpoint of the bundle, and on the unexposed surface. One additional thermocouple was used to monitor the test slab unexposed surface temperature.

c. Test Configurations

All test configurations represented in the design drawings simulate actual installed conditions with the exception of WTD-1 and WTD-2. These designs represent only one-half of a symmetrical design. For complete test data the results of W/FTD-2 were used to correlate conservative results for a symmetrical design configuration of both WTD-1 and WTD-2.

d. Hose Stream Tests

To provide additional test data on the structural integrity of the cable tray penetration fire stops, the hose stream test specified in ASTM E-119-78 was performed subsequent to the IEEE 634 hose stream test specified in this test procedure.

3. Summary of Results

(TABLE)

CABLE TRAY PENETRATION
FIRE TESTS
SUMMARY OF RESULTS

Penetration Design Number	Test Sketch Number	Interior Cable Bundle Jacket Temp at 3 Hrs (^{o}F)	Cable Bundle Surface Temp - Unexposed Side at 3 Hrs (^{o}F)	Penetration Unexposed Surface Temperature at 3 Hrs	Hose Stream Test	
					IEEE	ASTM
WTD-1	T-4	720	715	305	PASS	FAIL
WTD-2	T-4X	500	500	290	PASS	PASS
WTD-3	T-7	270	270	240	PASS	PASS
W/FTD-1	T-1	570	450	190	PASS	PASS
W/FTD-2	T-2	430	315	160	PASS	PASS
FTD-1	T-6	340	225	180	PASS	PASS

4. Conclusions

The Summary of Results for the electrical cable tray penetration fire stops is similar to that for the floor penetration fire tests wherein the third column reflects the maximum cable jacketing temperature at 3 hours and the fifth column reflects the unexposed surface temperature relative to the ANI test acceptance criteria. From these test results it can be seen that electrical cable tray penetration fire stop designs W/FTD-1, and W/FTD-2, FTD-1, and WTD-3 maintained the cable jacketing temperatures well below the specified 700°F limit and passed both hose stream tests. These designs, therefore, have a 3-hour endurance rating. Fire stop design WTD-1, although failing both the temperature and ASTM hose stream tests, was only one-half of a symmetrical design similar to W/FTD-2. In a symmetrical design, this penetration design would also qualify for a 3 hour endurance rating.

Design WTD-2, which incorporated a sheet metal cover into the WTD-1 design, passed both hose stream tests and maintained a cable jacketing temperature below the 700°F limit. The addition of the sheet metal, therefore, improved the overall performance as fire stop in addition to providing protection for the marinite board.

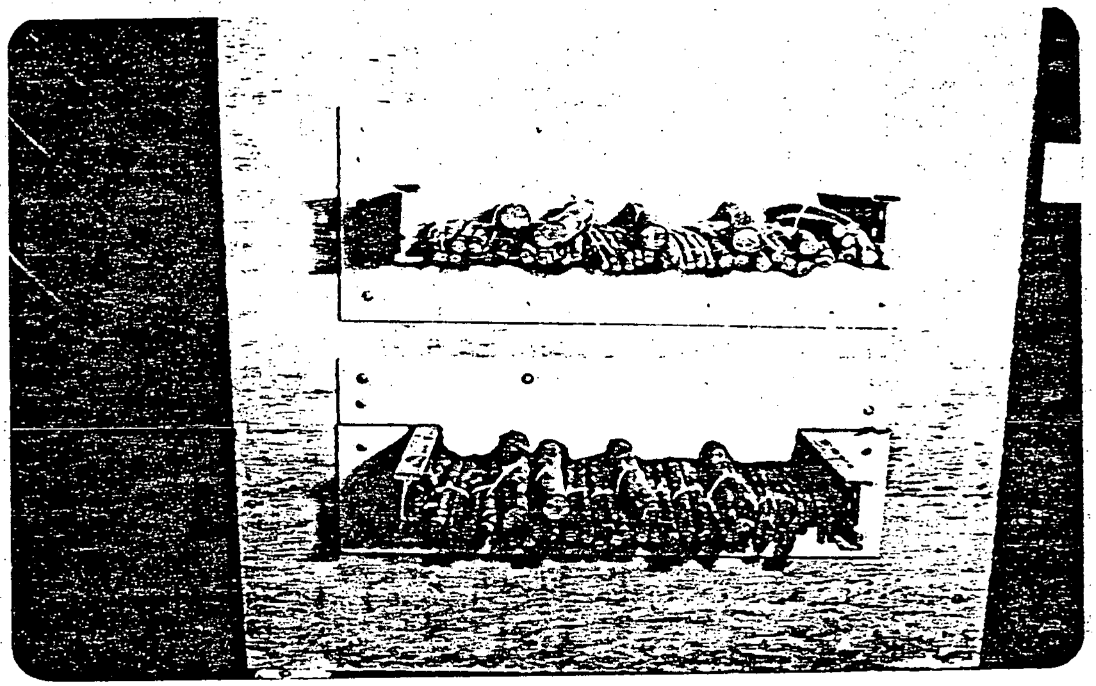
From the enclosed photographs, it can be seen that electrical cable penetration fire stop design WTD-3 allowed some water to seep under the unexposed marinite board during the ASTM hose stream test. Upon a careful examination, it was determined that there were no through openings in the penetration and it was concluded that WTD-3 had passed the ASTM specified hose stream test.

All symmetrical designs will meet ANI acceptance criteria.

5. Photographs

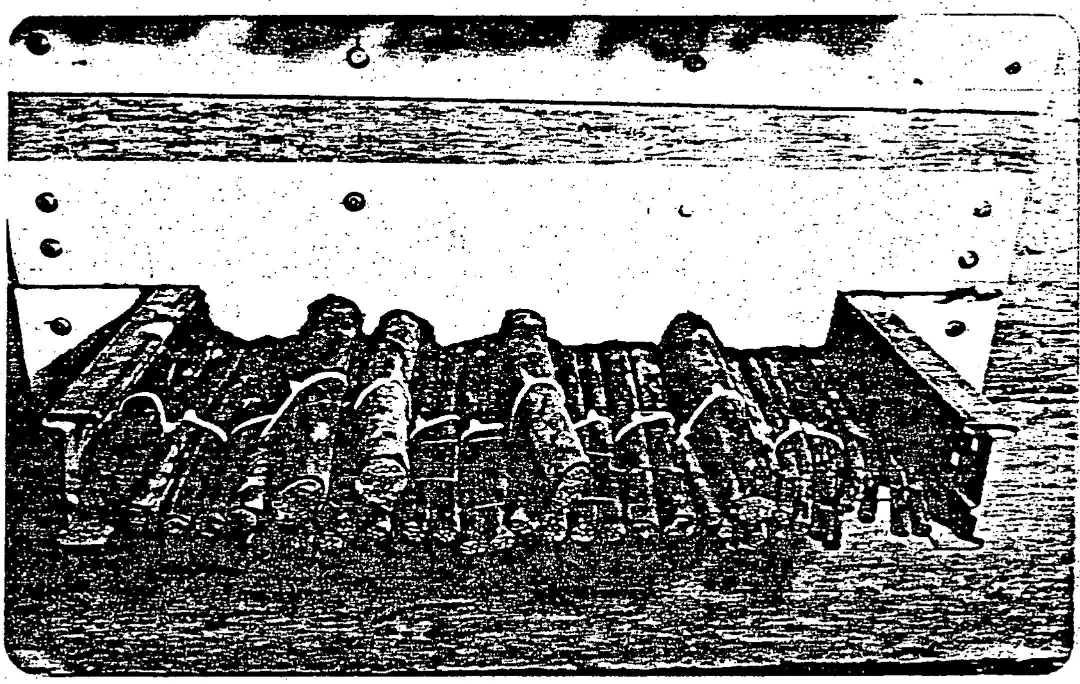
CABLE TRAY PENETRATION FIRE STOP TESTS

W/FTD-1 and WTD-1

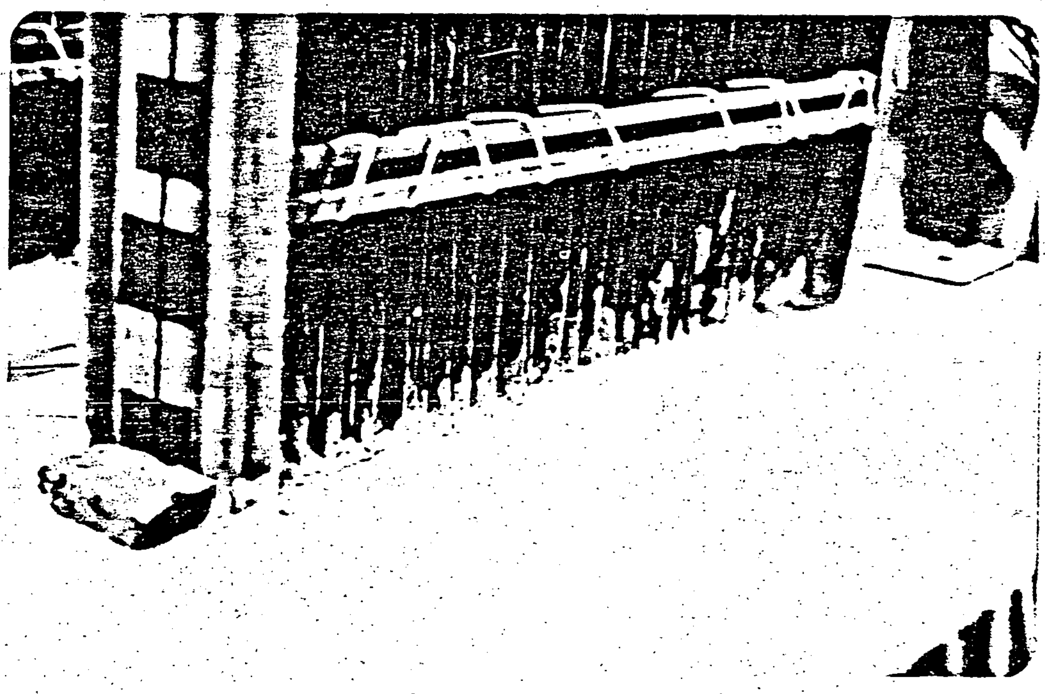


exposed surface
W/FTD-2 (top) and FTD-1

CABLE TRAY PENETRATION FIRE STOP TESTS

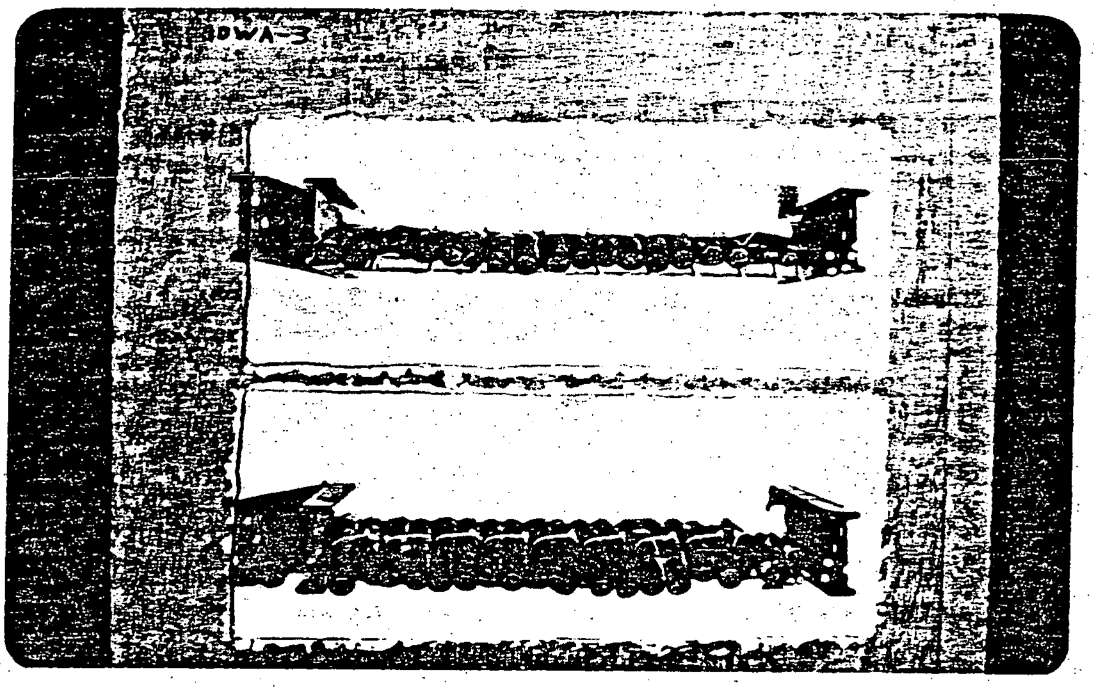


Cable Fill in FTD-1

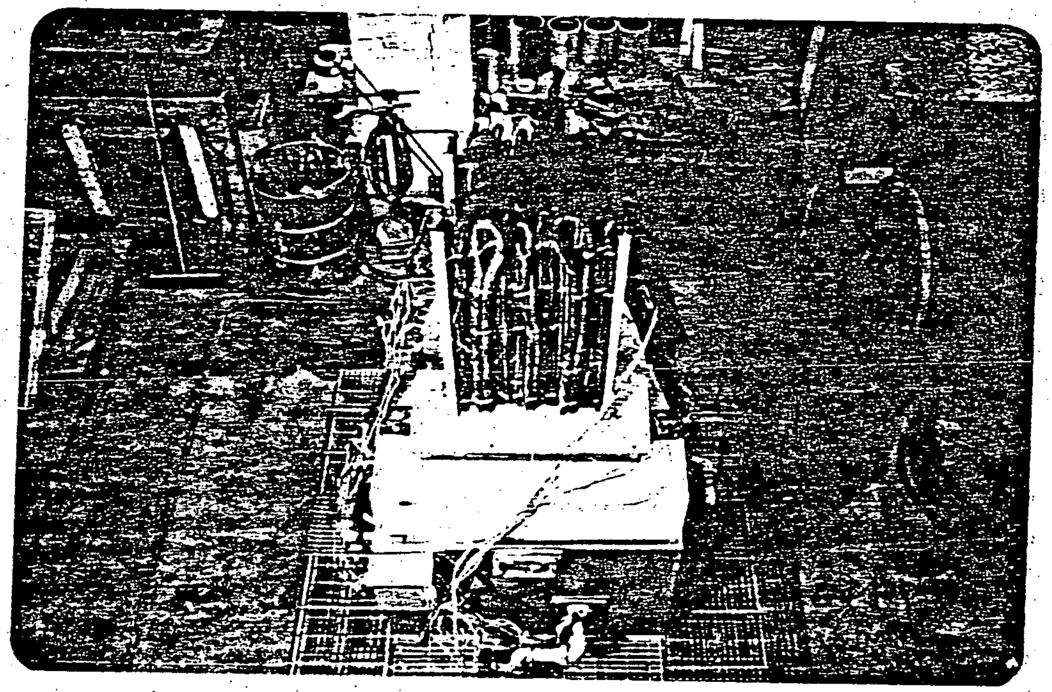


Top View of FTD-1

CABLE TRAY PENETRATION FIRE STOP TESTS

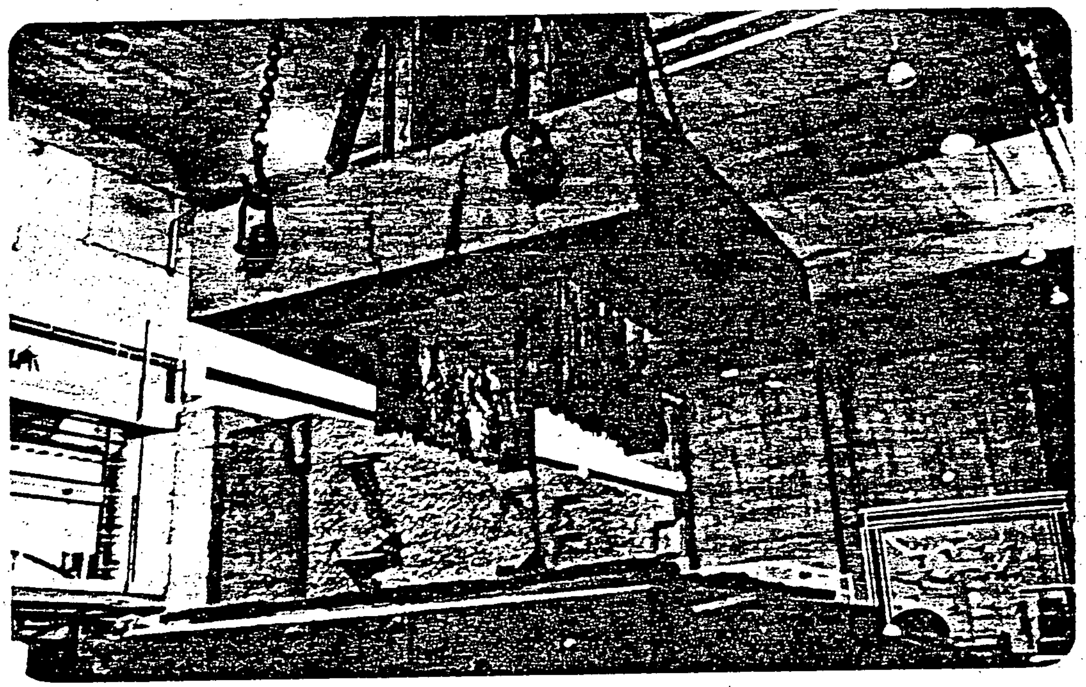


Cable Fill in WTD-3 (Top) and WTD-2

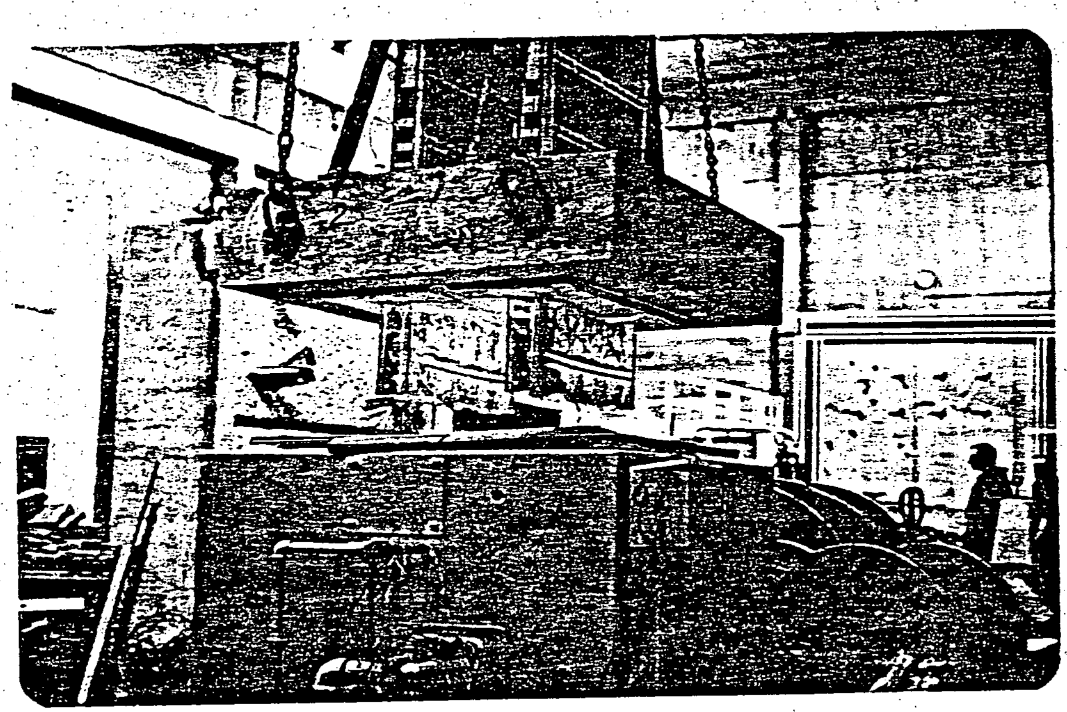


Test Slab on Furnace

CABLE TRAY PENETRATION FIRE STOP TESTS

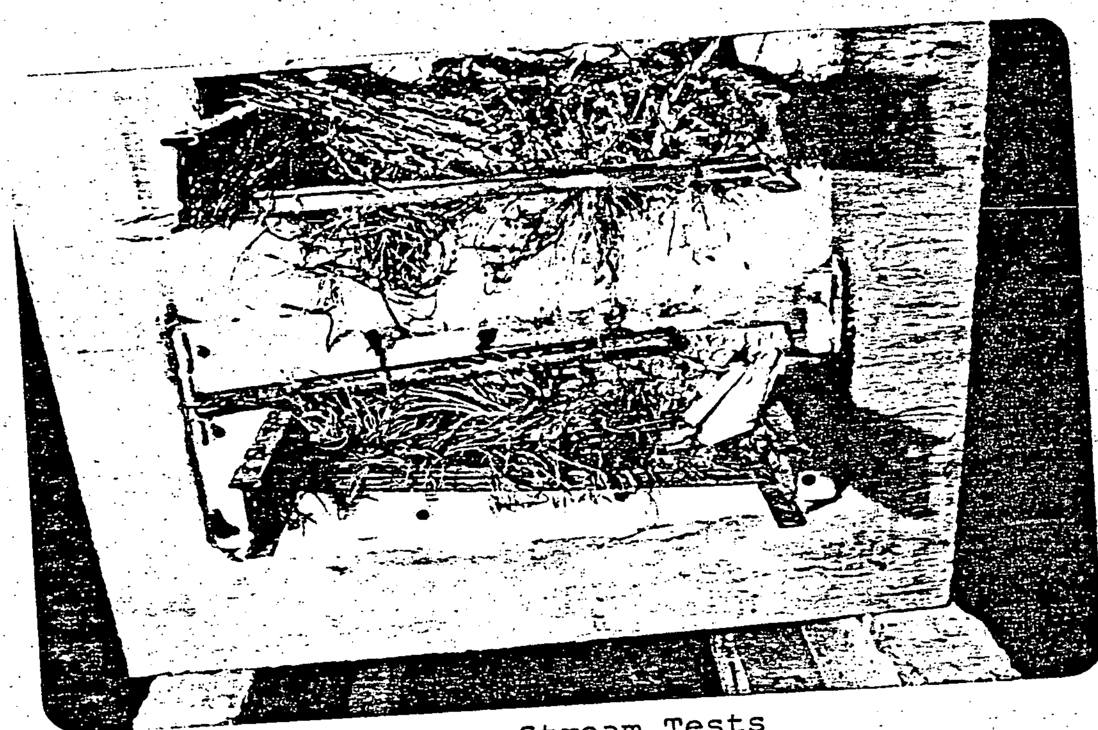


Removing Test Slab From Furnace
WTD-1 (L) and W/FTD-1 (R)

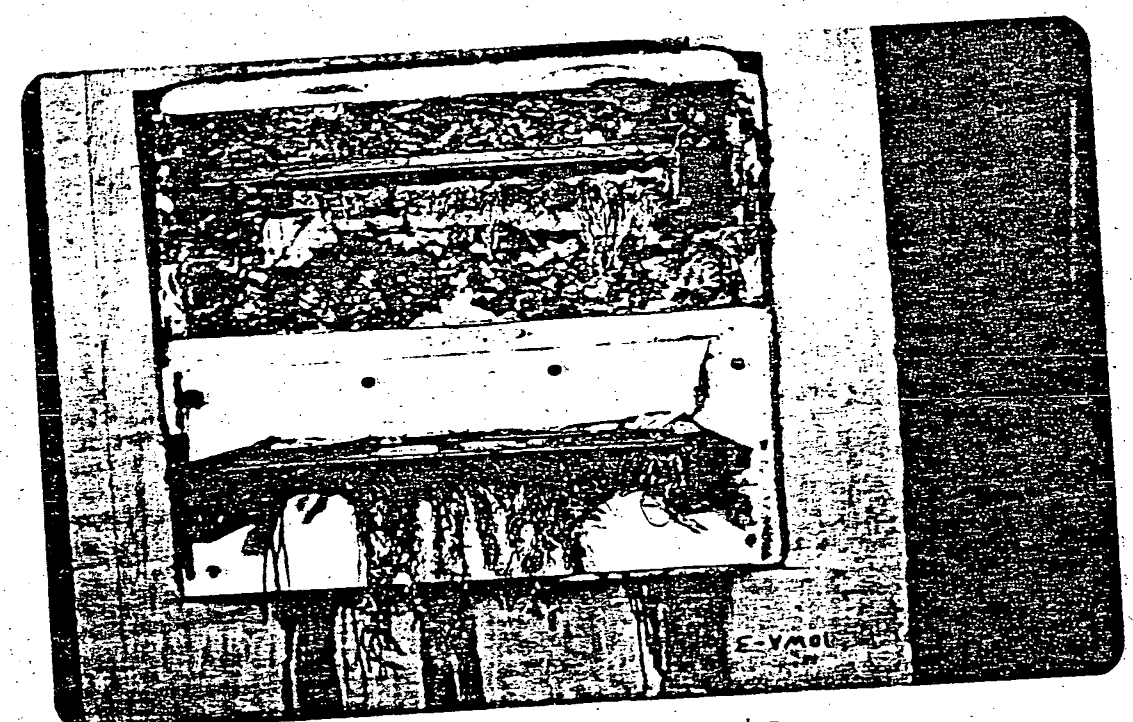


Removing Test Slab From Furnace
W/FTD-2 (L) and FTD-1 (R)

CABLE TRAY PENETRATION FIRE STOP TESTS

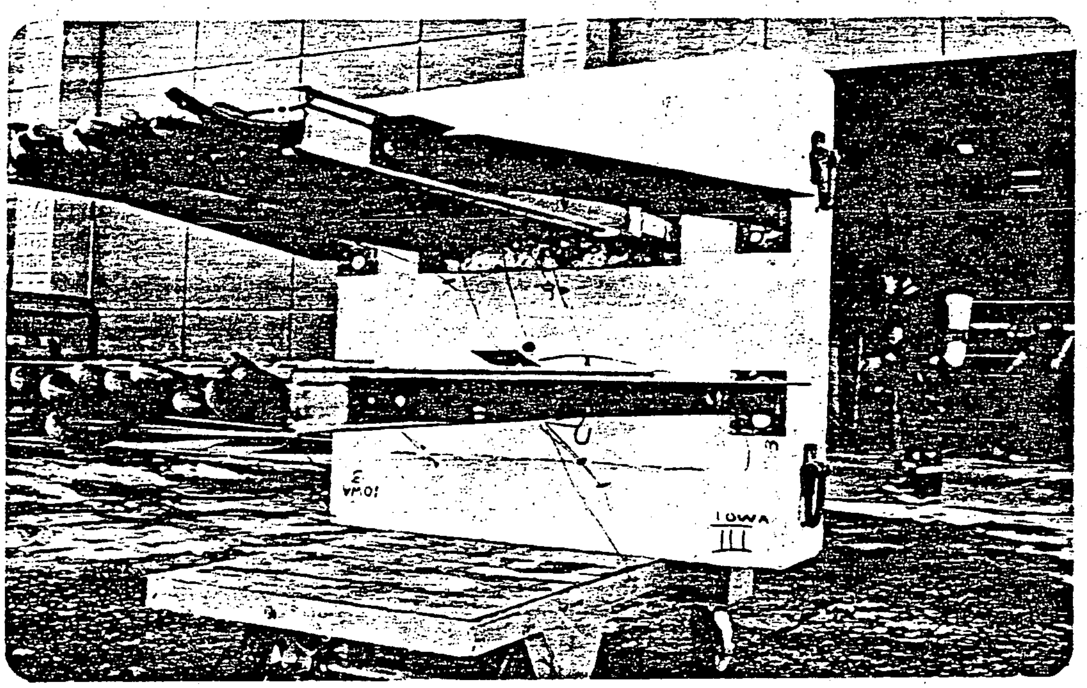


After Hose Stream Tests
W/FTD-1 (T) and WTD-1 (B)

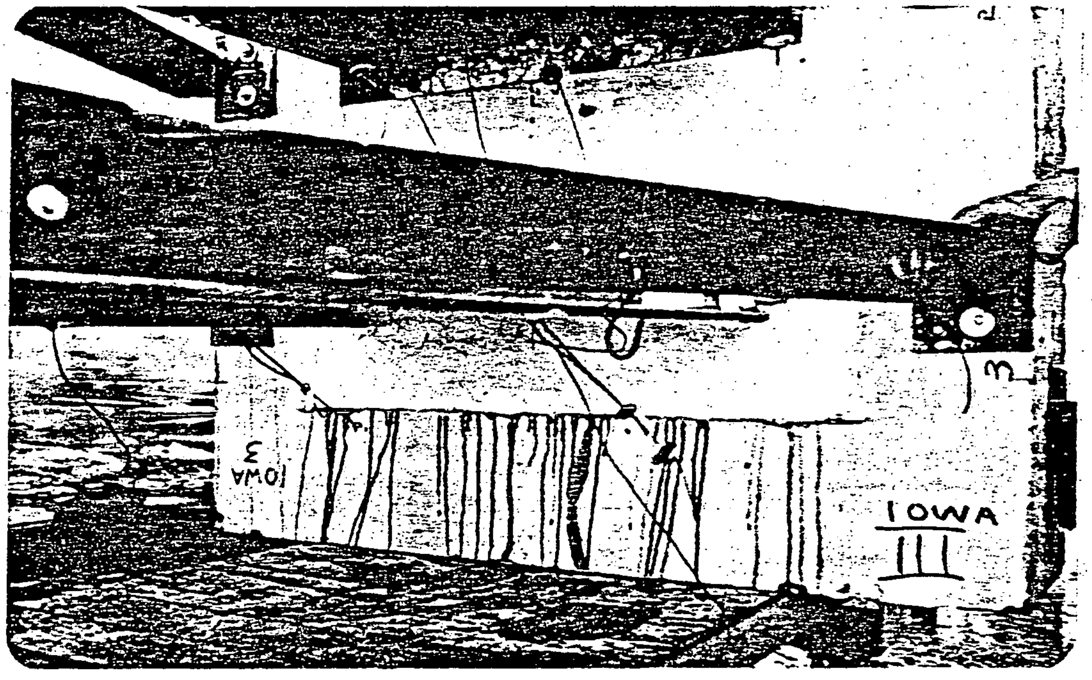


After Hose Stream Tests
WTD-2 (T) and WTD-3 (B)

CABLE TRAY PENETRATION FIRE STOP TESTS

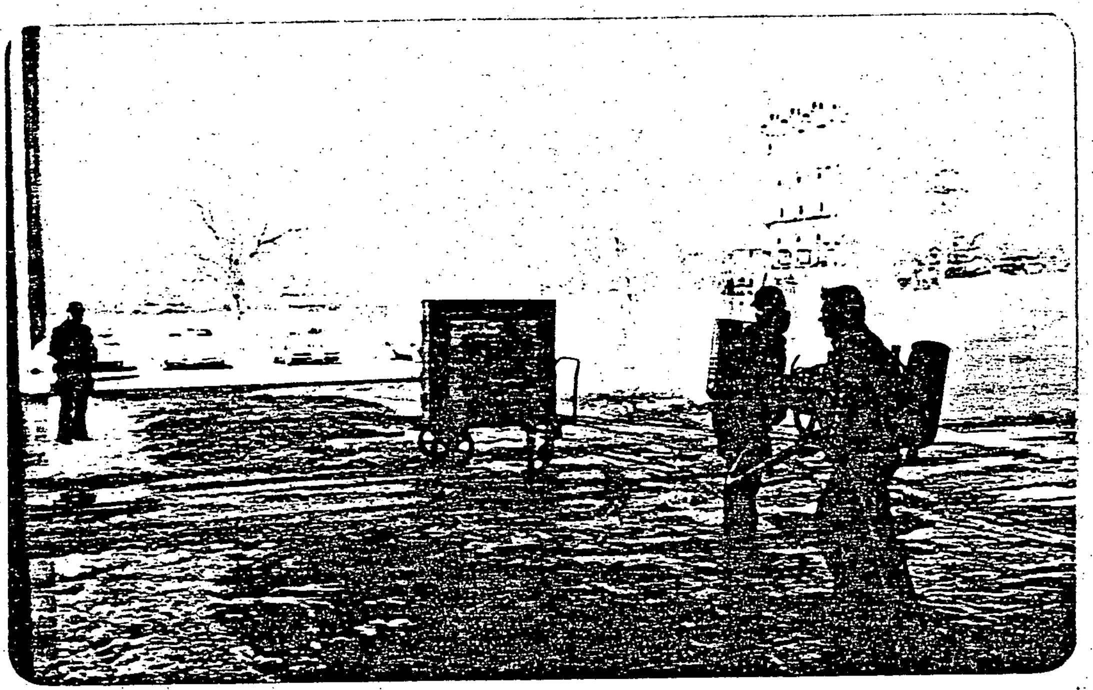


Before Hose Steam Test
WTD-2 (T) and WTD-3 (B)

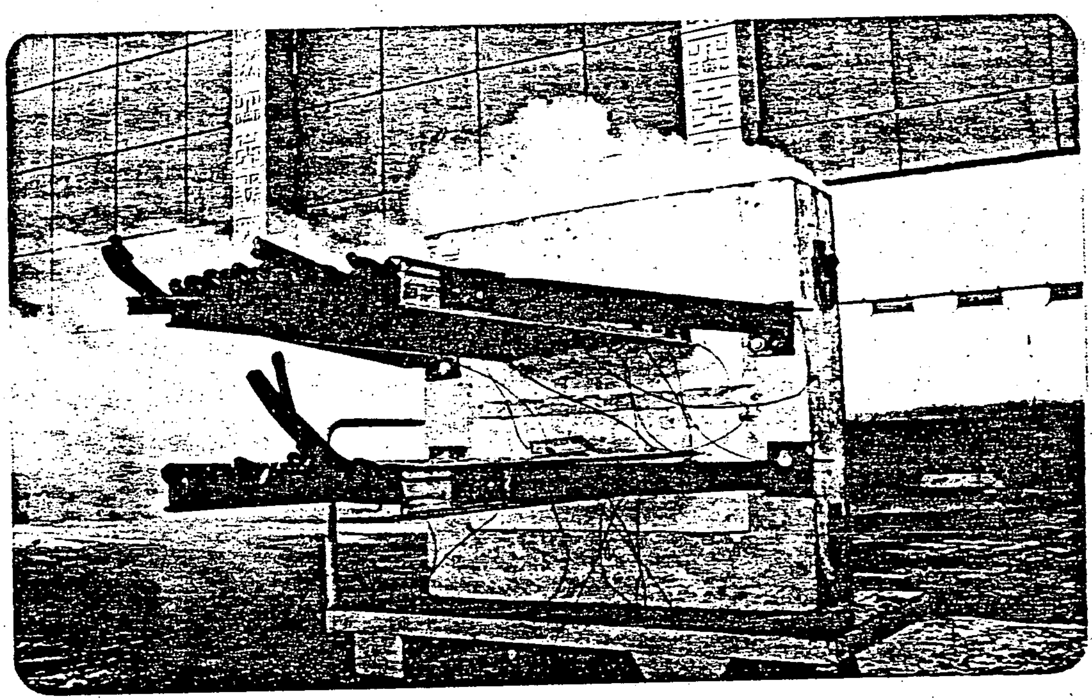


After Hose Stream Test
WTD-2 (T) and WTD-3 (B)

CABLE TRAY PENETRATION FIRE STOP TESTS



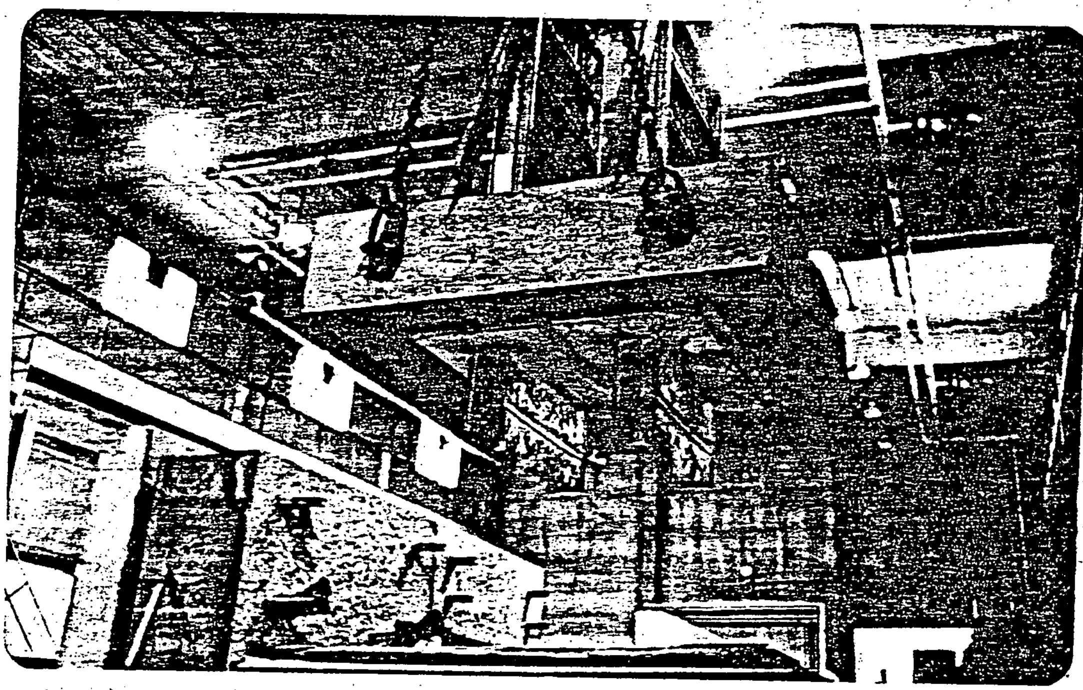
Witnessing Hose Stream Tests



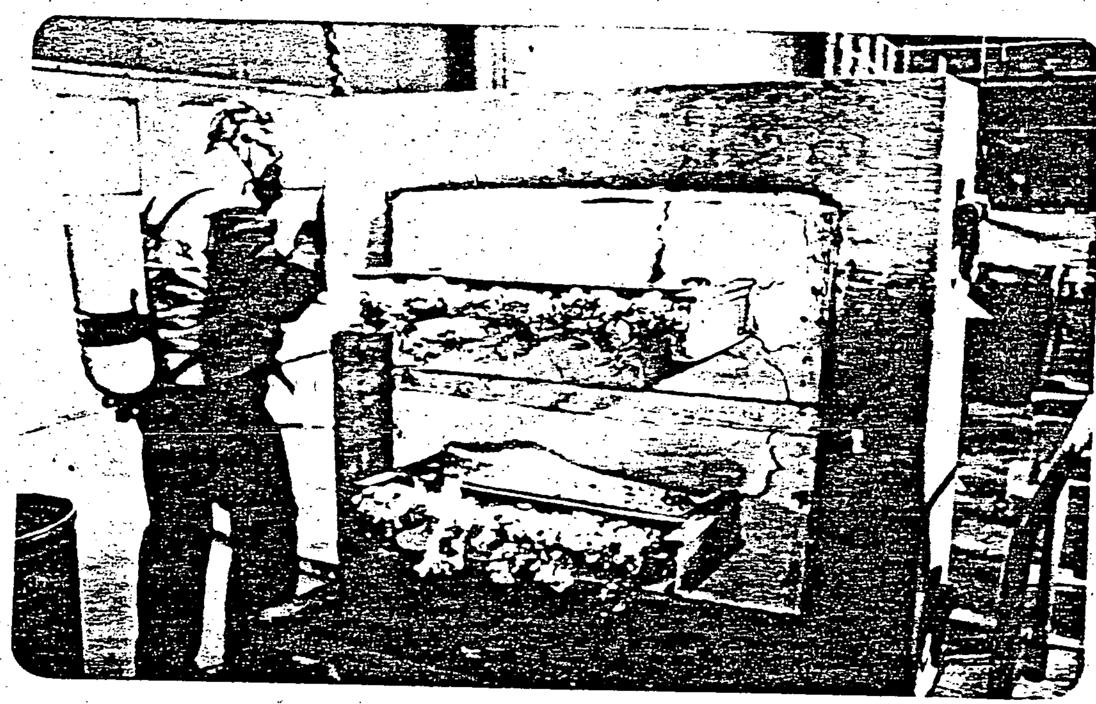
After Hose Stream Tests

FTD-1 (T) and W/FTD-2 (B)

CABLE TRAY PENETRATION FIRE STOP TESTS



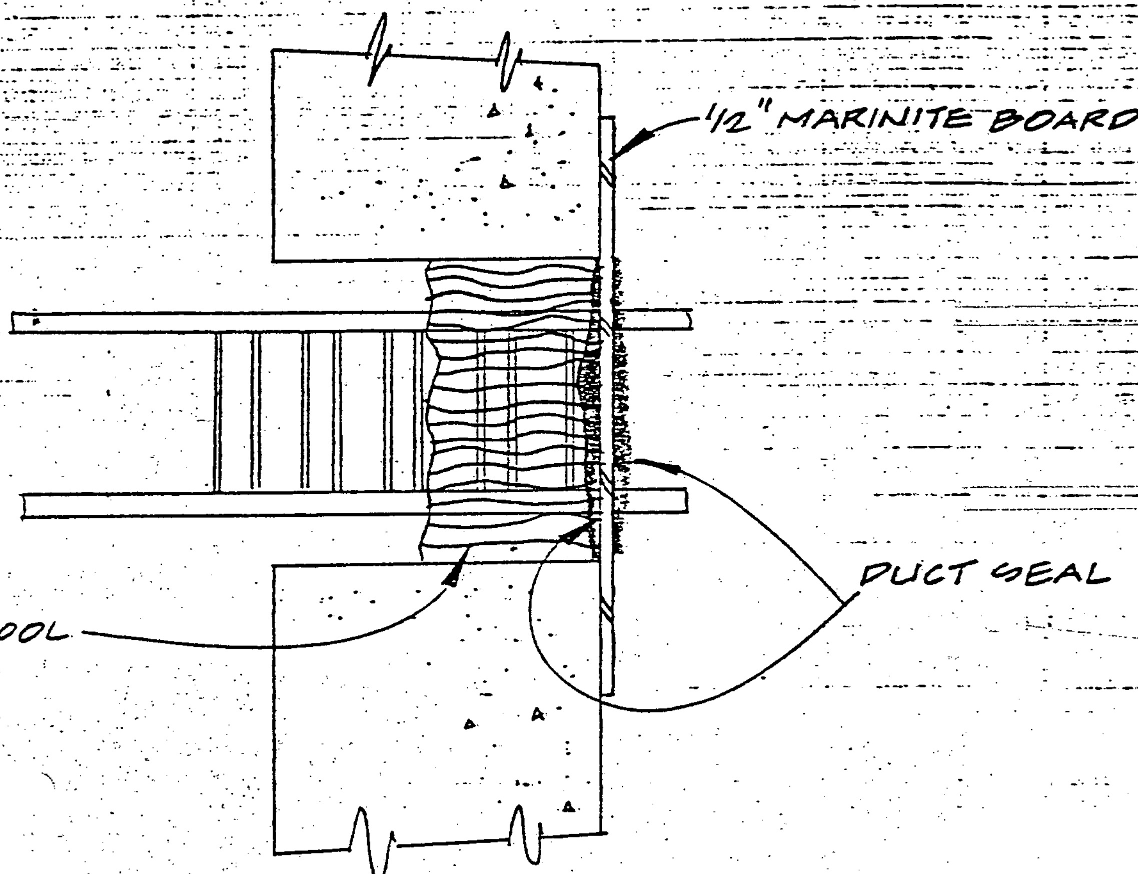
Removing Test Slab From Furnace
WTD-3 (L) and WTD-2 (R)



Prior to Hose Stream Test
FTD-1 (T) and W/FTD-2 (B)

Cable Tray Penetration Designs

ELECTRICAL CABLE TRAY FIRE STOP
WALL DESIGN # 1



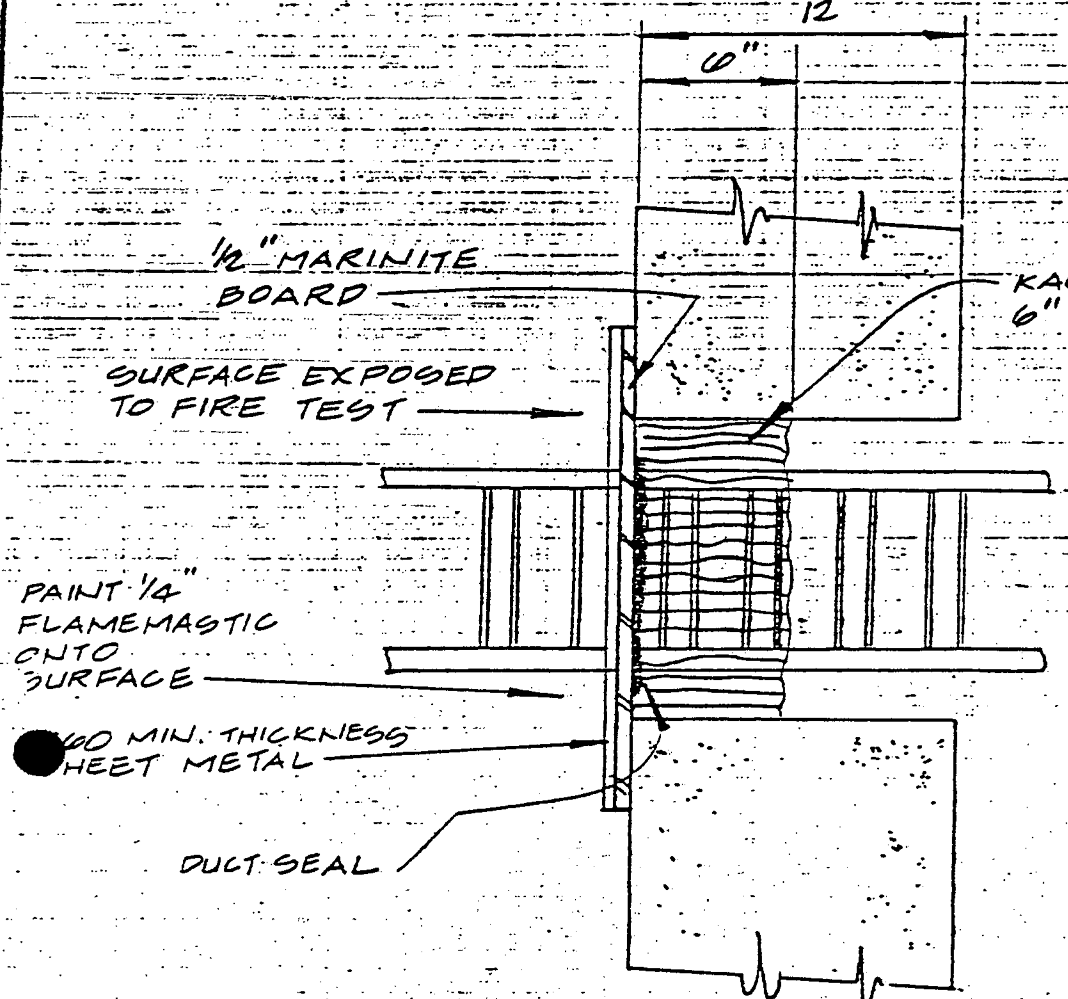
ACTUAL CABLE FILL TESTED - 30 %
AREA OF CABLE IN TEST PENETRATION - 22.01 SQ. IN.
TEST CONSTRUCTION SKETCH # T-4
ACTUAL CABLES TESTED - 2-914, 12-714, 4-514, 4-V12, 2-19R, 12-2M, 4-375 & 3-710

(1) PENET. BLOCK-OUT IS 28" X 8"

(2) TRAY IS 4 FT. LONG ON UNEXPOSED SIDE; 1 FT. LONG ON EXPOSED SIDE

(3) CABLES LENGTH OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL WIRES FOR TOP RUNGS

		DRN	DES	CHK	APP	DATE	REV
eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.						0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. WTD-1					1 OF 1



ACTUAL CABLE FILL TESTED - 30%

AREA OF CABLE IN TEST PENETRATION - 21.8 SQ. IN.

TEST CONSTRUCTION SKETCH # T-4X

ACTUAL CABLES TESTED - 4-514, 1-25T & 16-7P

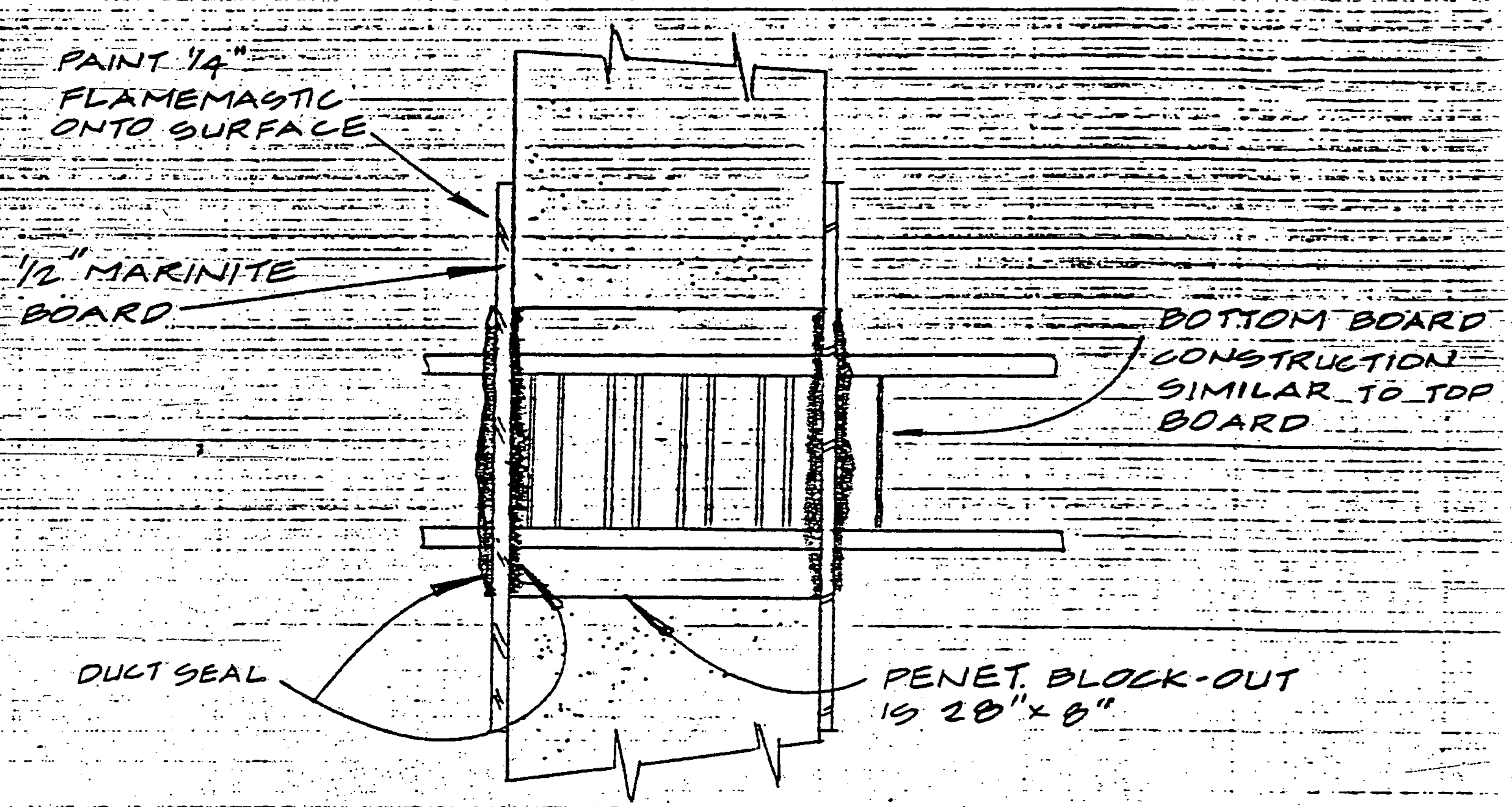
(1) ~~PENET. BLOCK-OUT IS 28" x 8"~~

(2) ~~TRAY IS 4 FT. LONG ON~~ UNEXPOSED SIDE; 1 FT. LONG ON EXPOSED SIDE.

(3) ~~CABLES RUN LENGTH~~ OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL ~~WIRES FOR TOP RUNG.~~

(4) ~~CUT SHEET METAL TO~~ PATTERN MARINITE BOARD

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO.	0460-023-332				SHEET
		MARK & DWG. NO.	WTD-2				1 OF 1



ACTUAL CABLE FILL TESTED - 30%

AREA OF CABLE IN TEST PENETRATION - 21.8 SQ. IN.

TEST CONSTRUCTION SKETCH # T-7

ACTUAL CABLES TESTED - 4-5/4, 1-25T & 16-7P

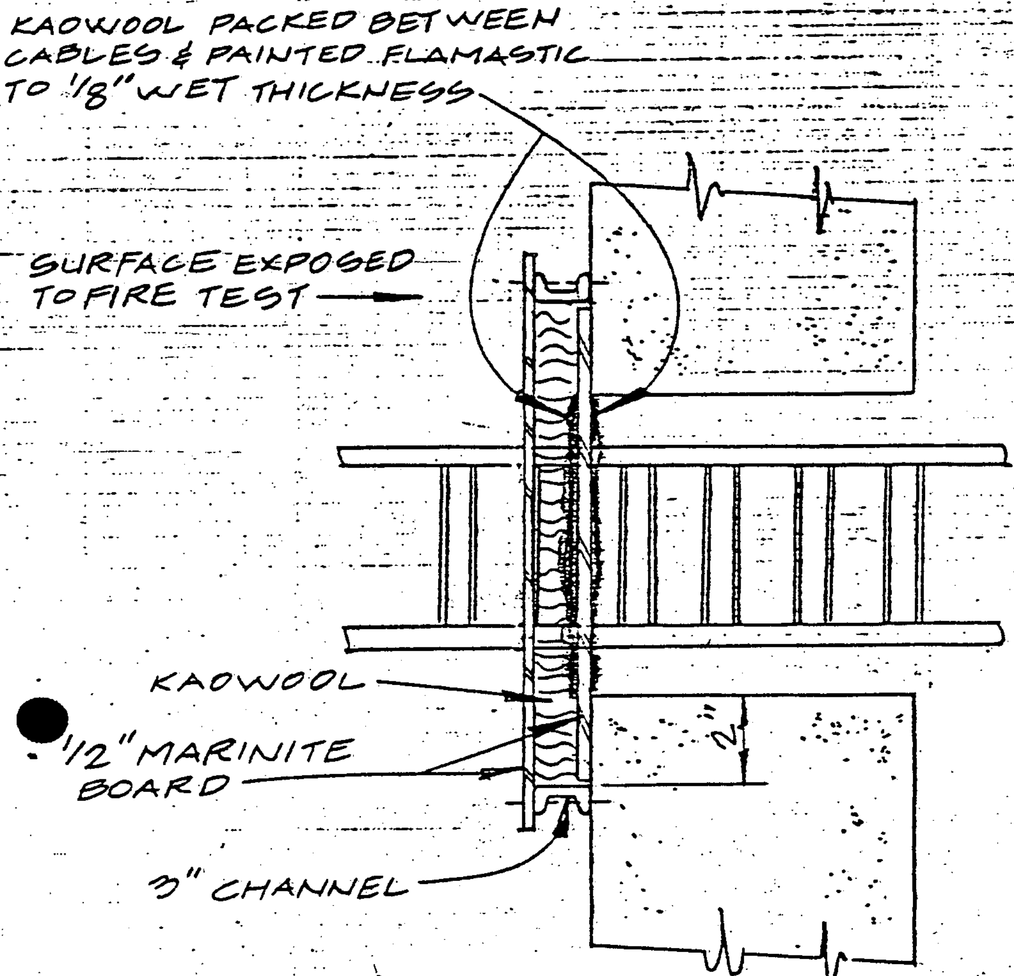
(1) INCLUDE TRIPLEXED CABLE

(2) TRAY IS 4 FT. LONG ON UNEXPOSED SIDE

(3) CABLES RUN LENGTH OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL WIRES FOR TOP RUNGS

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. WTD-3					

ELECTRICAL CABLE TRAY FIRE STOP
WALL/FLOOR DESIGN #1

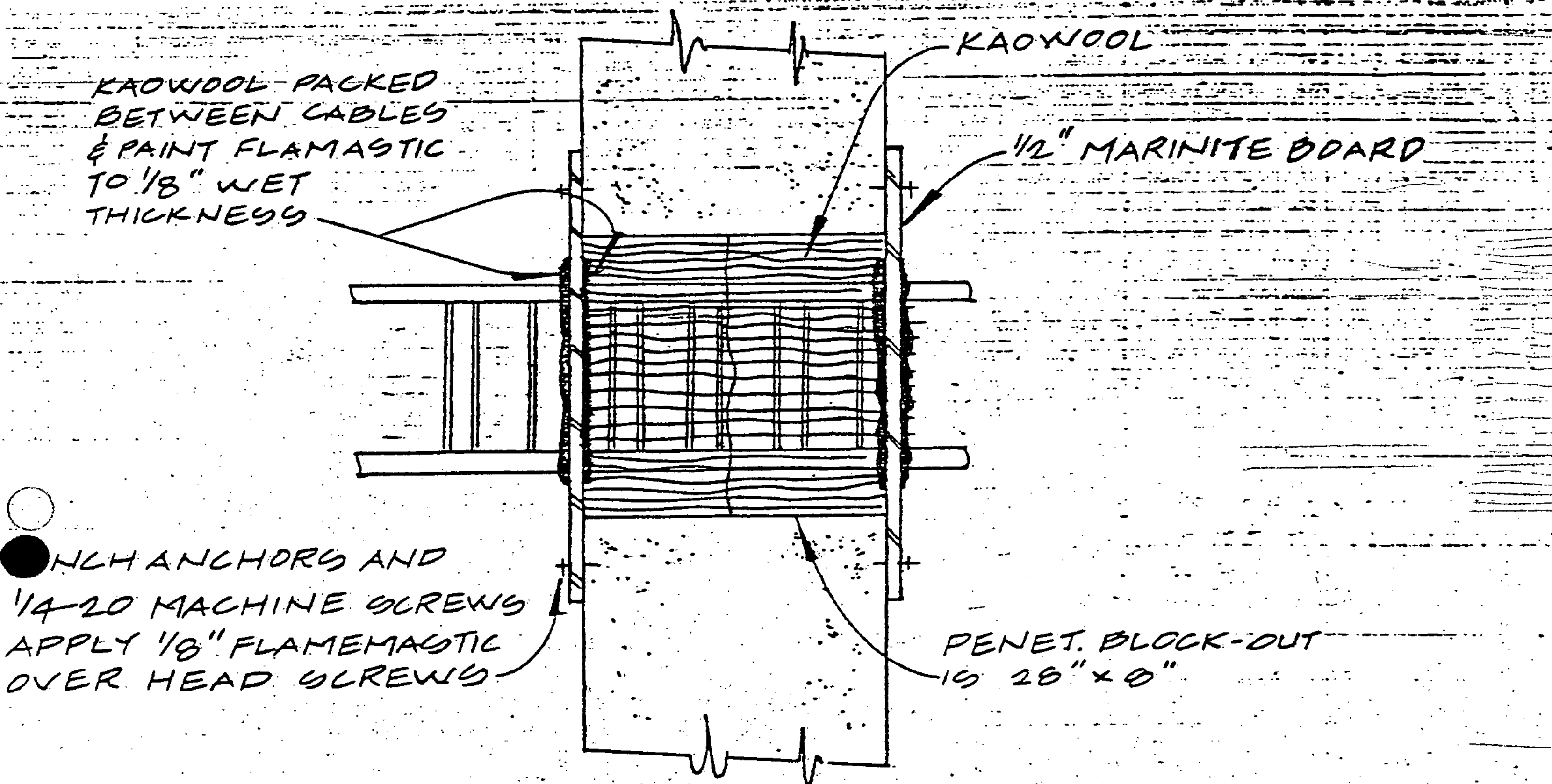


ACTUAL CABLE FILL TESTED - 30 %
AREA OF CABLE IN TEST PENETRATION - 22.83 SQ. IN.
TEST CONSTRUCTION SKETCH # T-1
ACTUAL CABLES TESTED - 4914, 10-714, 6-514, 4-V12, 2-19R, 12-2M, 4-379 & 3-710

1) PENET. BLOCK-OUT IS 28"×8"
2) TRAY IS 4 FT. LONG ON UNEXPOSED SIDE; 1 FT. LONG ON EXPOSED SIDE
3) CABLES RUN LENGTH OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL WIRES FOR TOP RUNGS

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV
							0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET
		MARK & DWG. NO. W/F TD-1					1 OF 1

ELECTRICAL CABLE TRAY FIRE STOP
WALL/FLOOR DESIGN #2

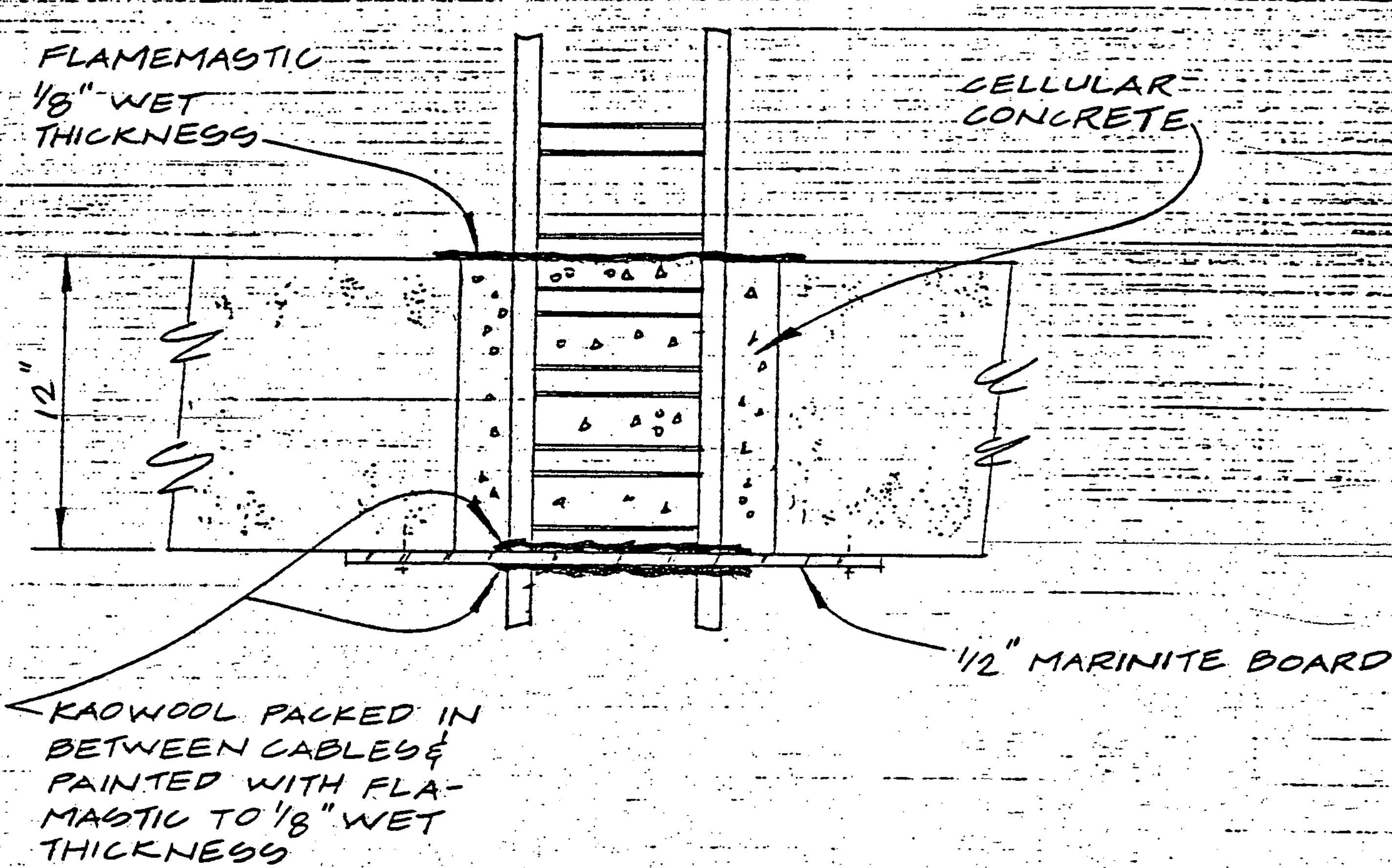


ACTUAL CABLE FILL TESTED - 30%
AREA OF CABLE IN TEST PENETRATION - 21.8 SQ.IN.
TEST CONSTRUCTION SKETCH # T-2
ACTUAL CABLES TESTED - 1-25T, 4-49S, 4-37S, 12-71O, 14-2MS & 2-19R

(1) INCLUDE TRIPLEXED CABLE
(2) TRAY IS 4 FT. LONG ON UNEXPOSED SIDE; 1 FT. LONG ON EXPOSED SIDE.
(3) CABLES RUN LENGTH OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL WIRES FOR TOP RUNGS

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. W/FTD-2					

ELECTRICAL CABLE TRAY FIRE STOP
FLOOR DESIGN #1



ACTUAL CABLE FILL TESTED - 30%

AREA OF CABLE IN TEST PENETRATION - 21.8 SQ.IN.

TEST CONSTRUCTION SKETCH # T-6

ACTUAL CABLES TESTED - 1-25T, 4-49S, 4-37S, 12-7IO, 14-2MS & 2-19R

(1) PENET. BLOCK-OUT IS 28" X 8"

(2) TRAY IS 4FT. LONG ON UNEXPOSED SIDE; 1FT. LONG ON EXPOSED SIDE

(3) CABLES RUN LENGTH OF TRAY; TIE WRAP WITH NYLON, BUT USE METAL WIRES FOR TOP RUNG

eds nuclear	EDS NUCLEAR, INC. SAN FRANCISCO, CALIF.	DRN	DES	CHK	APP	DATE	REV 0
	IOWA ELECTRIC DUANE ARNOLD ENERGY CENTER	JOB. NO. 0460-023-332					SHEET 1 OF 1
		MARK & DWG. NO. FTD-1					

VI. TEST PROGRAM SUMMARY

From mid-December of 1979 through March 1980, seven fire tests were conducted to establish fire endurance ratings on the electrical cable and cable tray penetration fire stop designs at DAEC. As stated in Section V, the test results indicate that all fire stop designs successfully completed a 3-hour endurance test.

As part of an evaluation of the fire protection design at the DAEC, the Iowa Electric Light and Power Company performed an extensive Fire Hazards Analysis to determine the potential severity of fire in all areas of the plant. The results of this analysis indicated that all essential areas of the plant did not have sufficient combustible material to support a 1-hour fire. When considering that:

- Minimum material thickness and maximum cable fills were used in qualifying the fire stop designs.
- All five stops were tested in a floor test fixture and subjected to both the IEEE 634 and ASTM E-119 hose stream tests.
- The cable jacketing material did not self-ignite at temperatures in excess of 700°F.
- A significant margin exists between the potential fire severity and the fire endurance ratings of the fire stops and fire barriers at DAEC;

it can be concluded that the electrical cable and cable tray penetration fire stops at the DAEC are conservatively designed and provide an adequate margin of safety for the plant fire protection design.

TEST SLAB NUMBER 1

DATE: 12/28/79

FIRE STOP DESIGNS TESTED: W/FTD-1
WTD-1

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

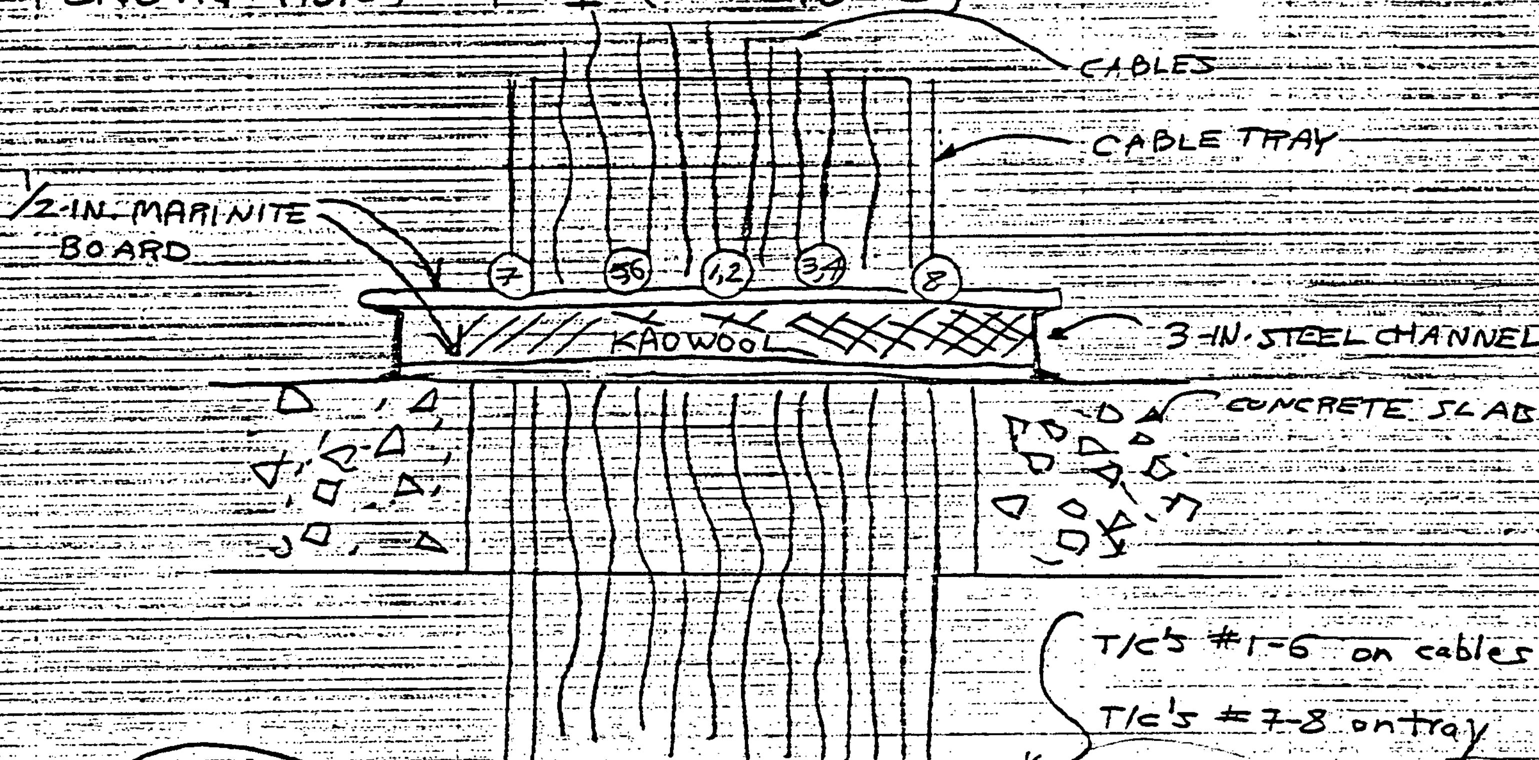
Test Witnessed by:

M. S. Abrams, PCA

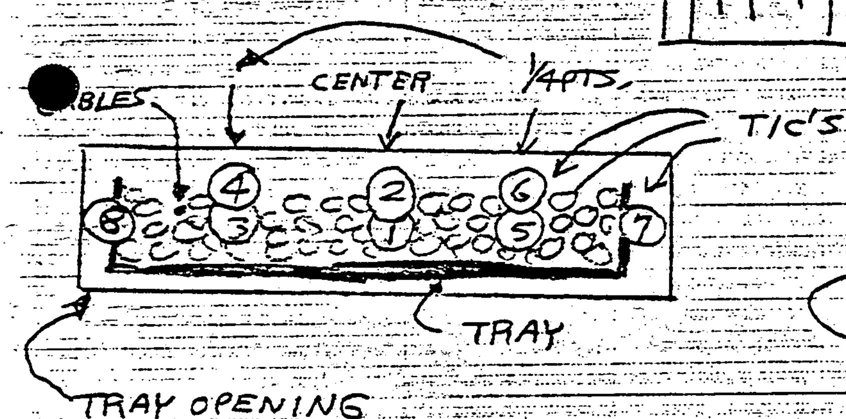
R H. Hollenbacher, EDS

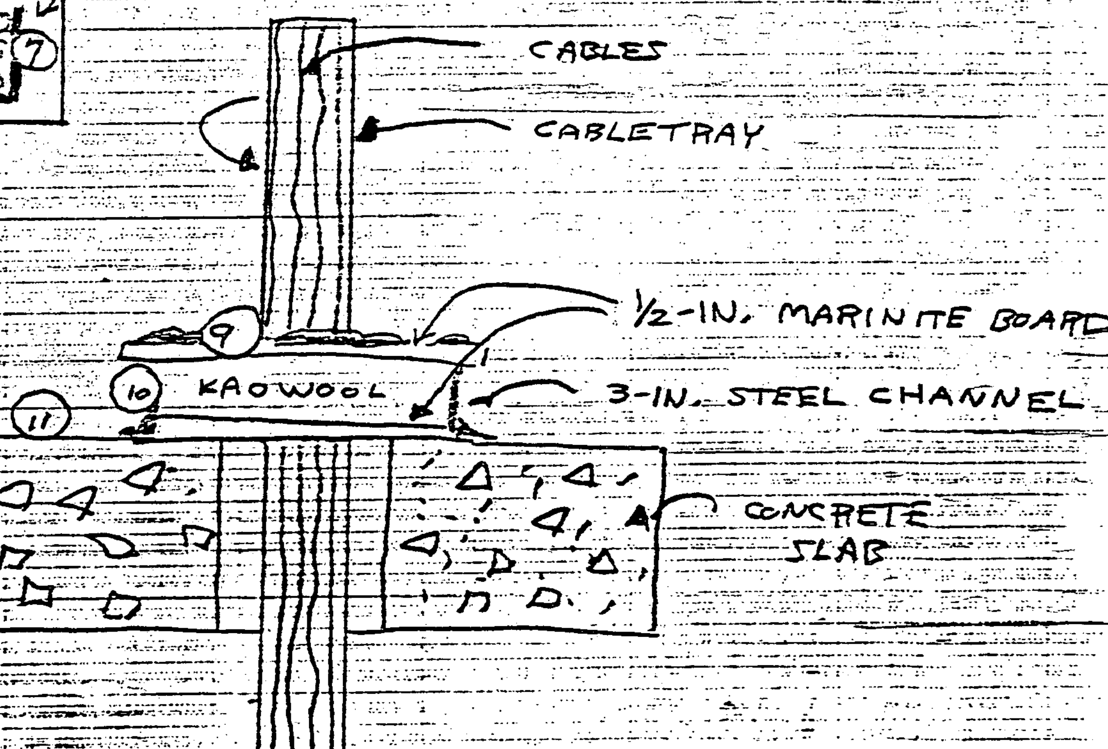
R. Lewis, IEL&P

PENETRATION; T-1 (W/ETD-1)



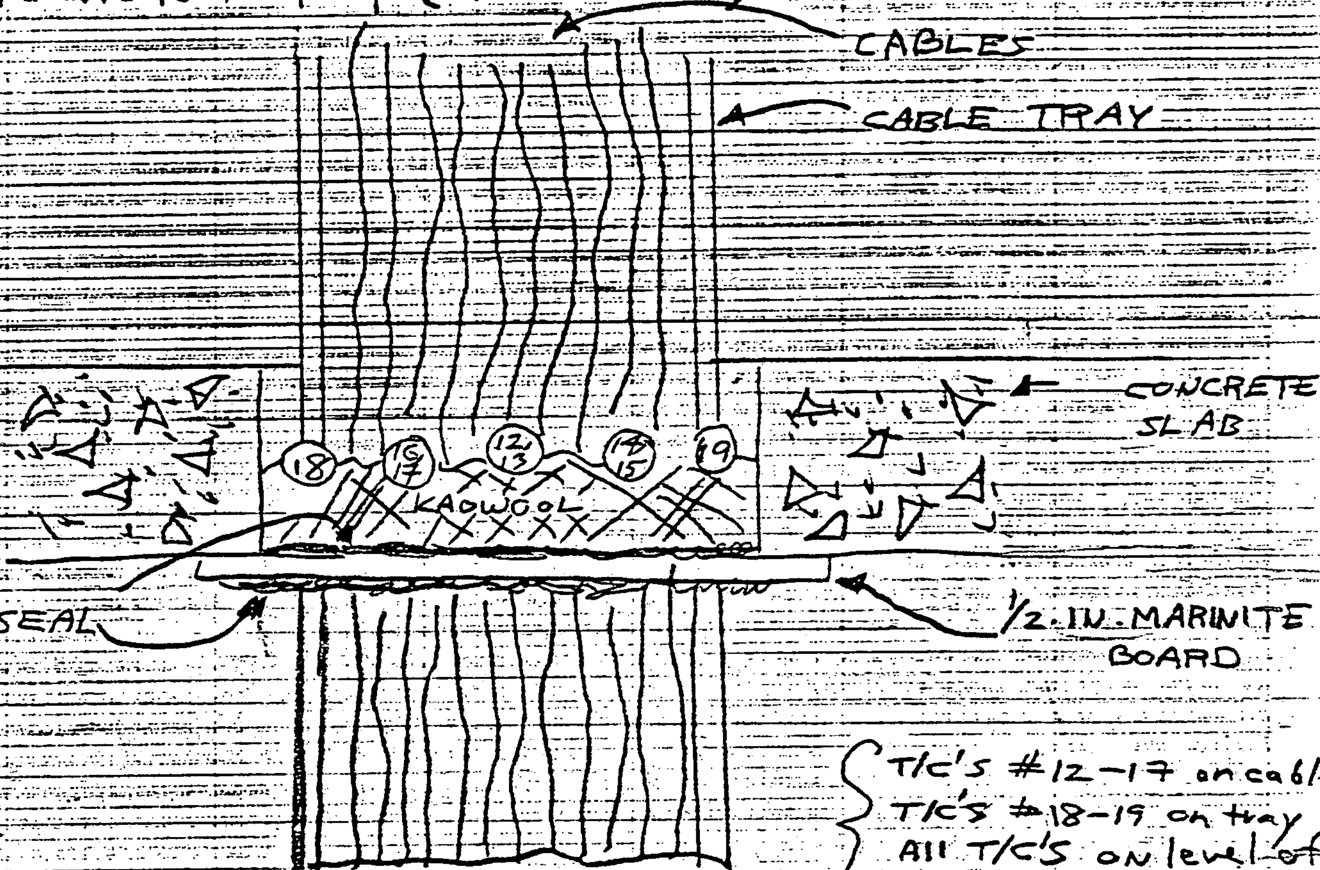
* T/C's #1-6 on cables
T/C's #7-8 on tray
T/C's #1-8 on same level as upper Marinit board



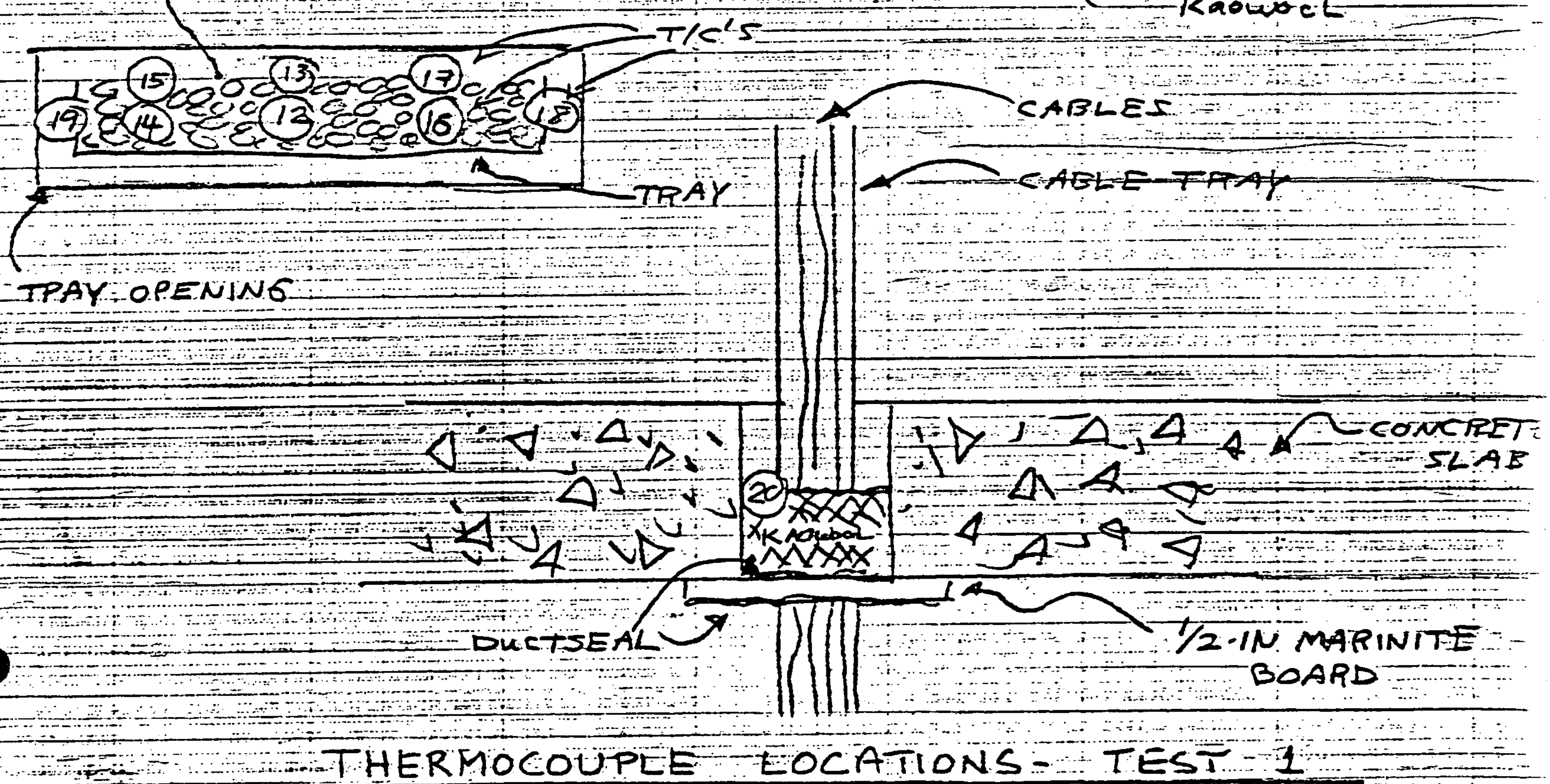


THERMOCOUPLE LOCATIONS - TEST 1

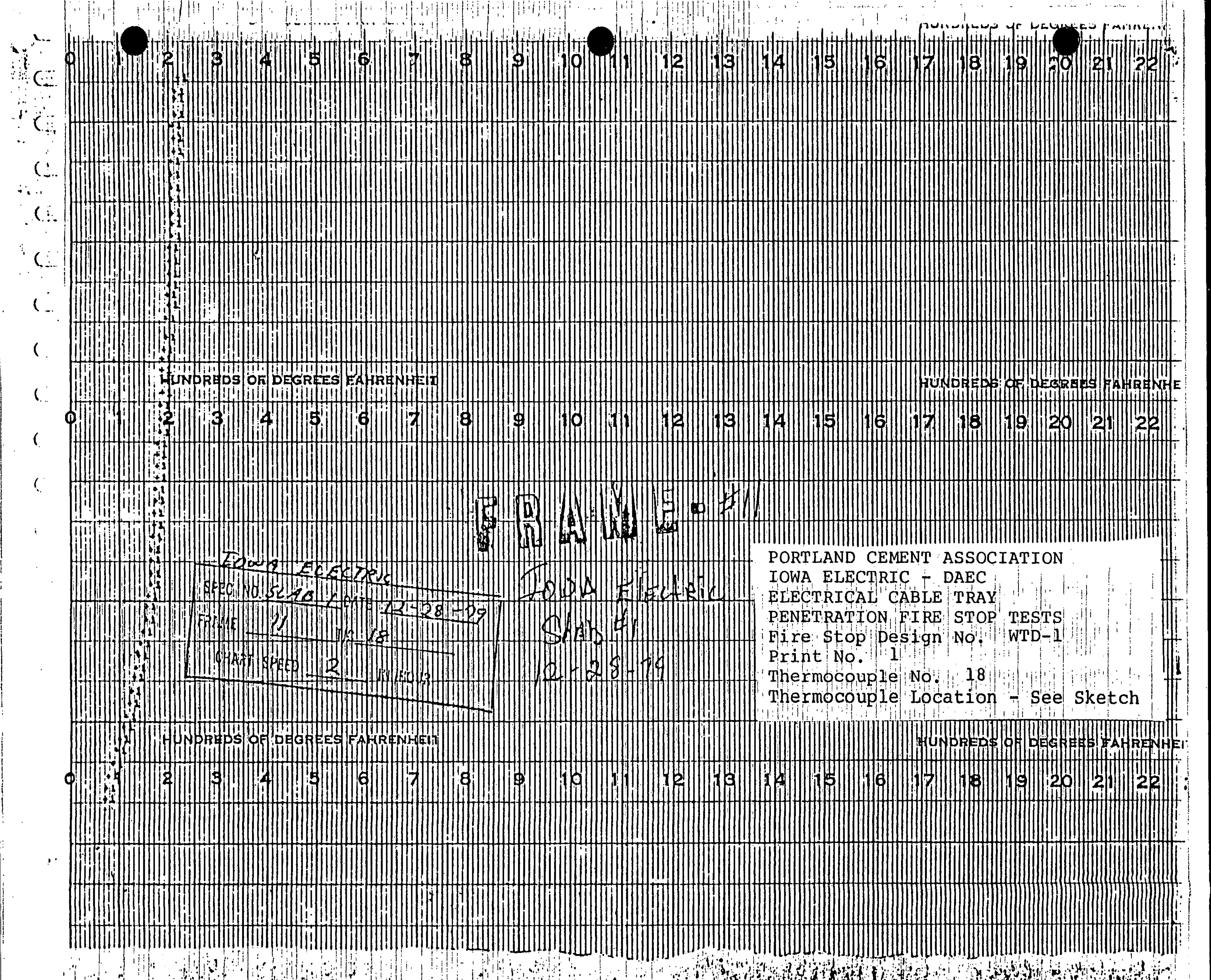
PENETRATION: T-4 (WTD-1)



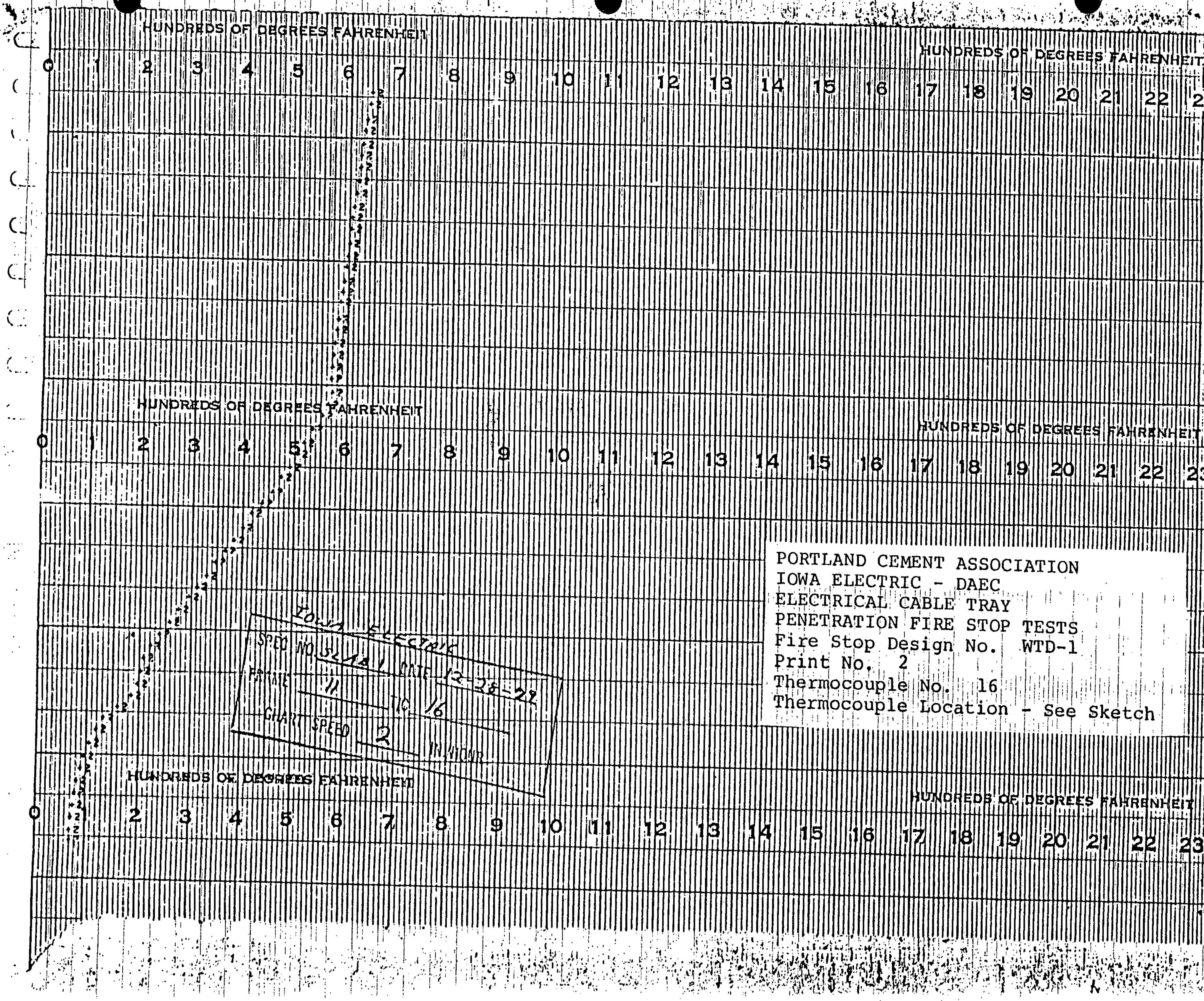
T/C's #12-17 on cable
T/C's #18-19 on tray
All T/C's on level of
Kaowool



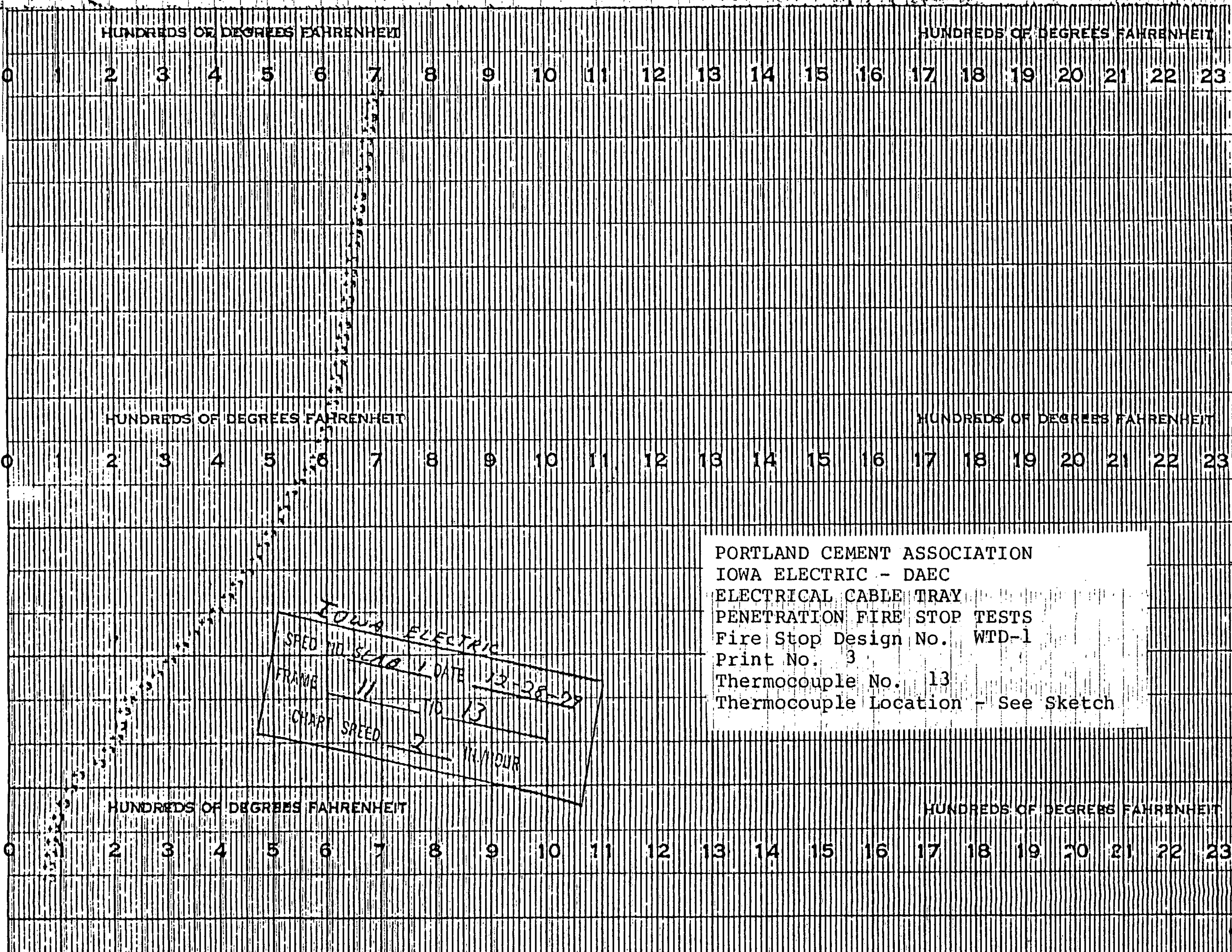
THERMOCOUPLE LOCATIONS - TEST 1



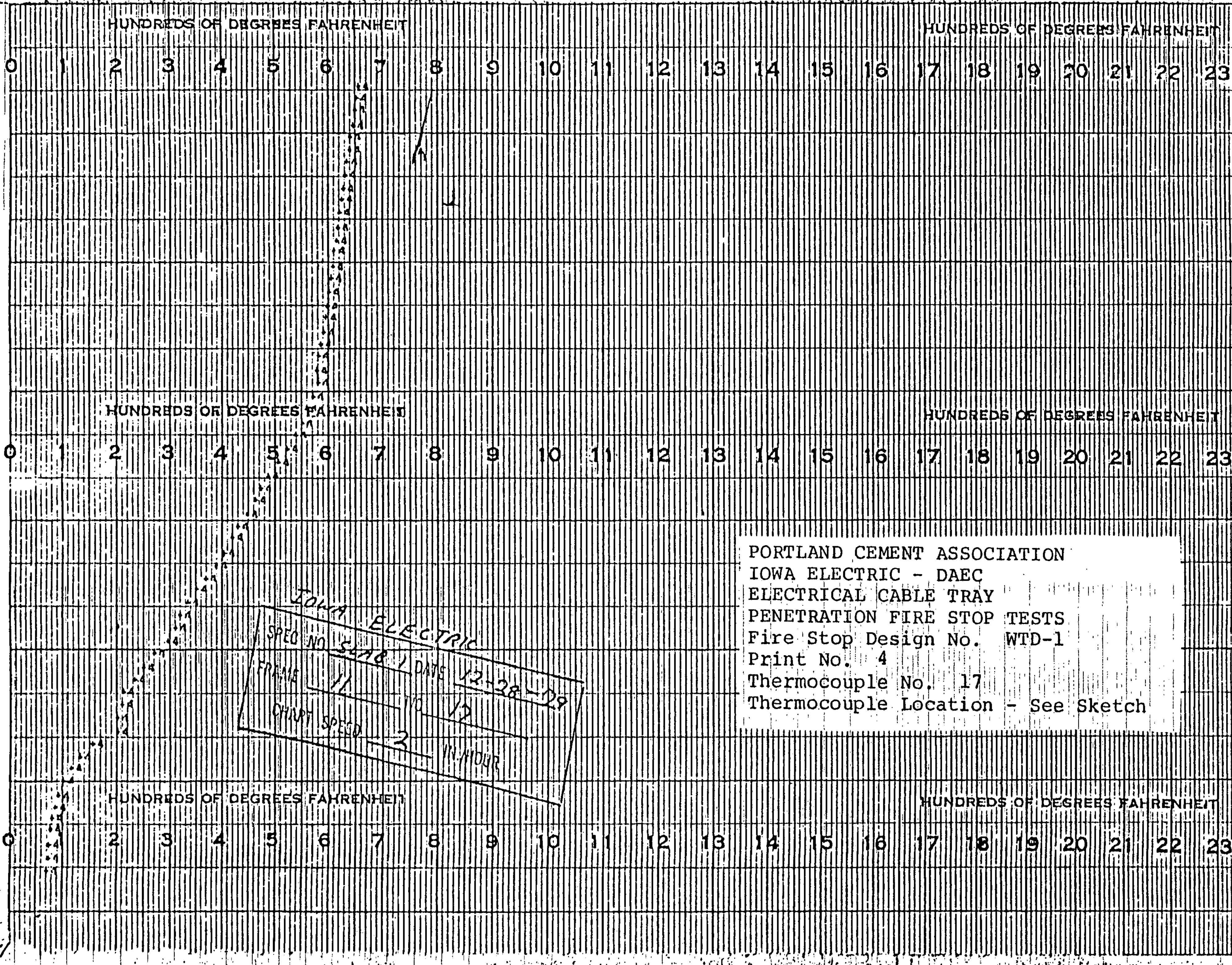
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 1
Thermocouple No. 18
Thermocouple Location - See Sketch



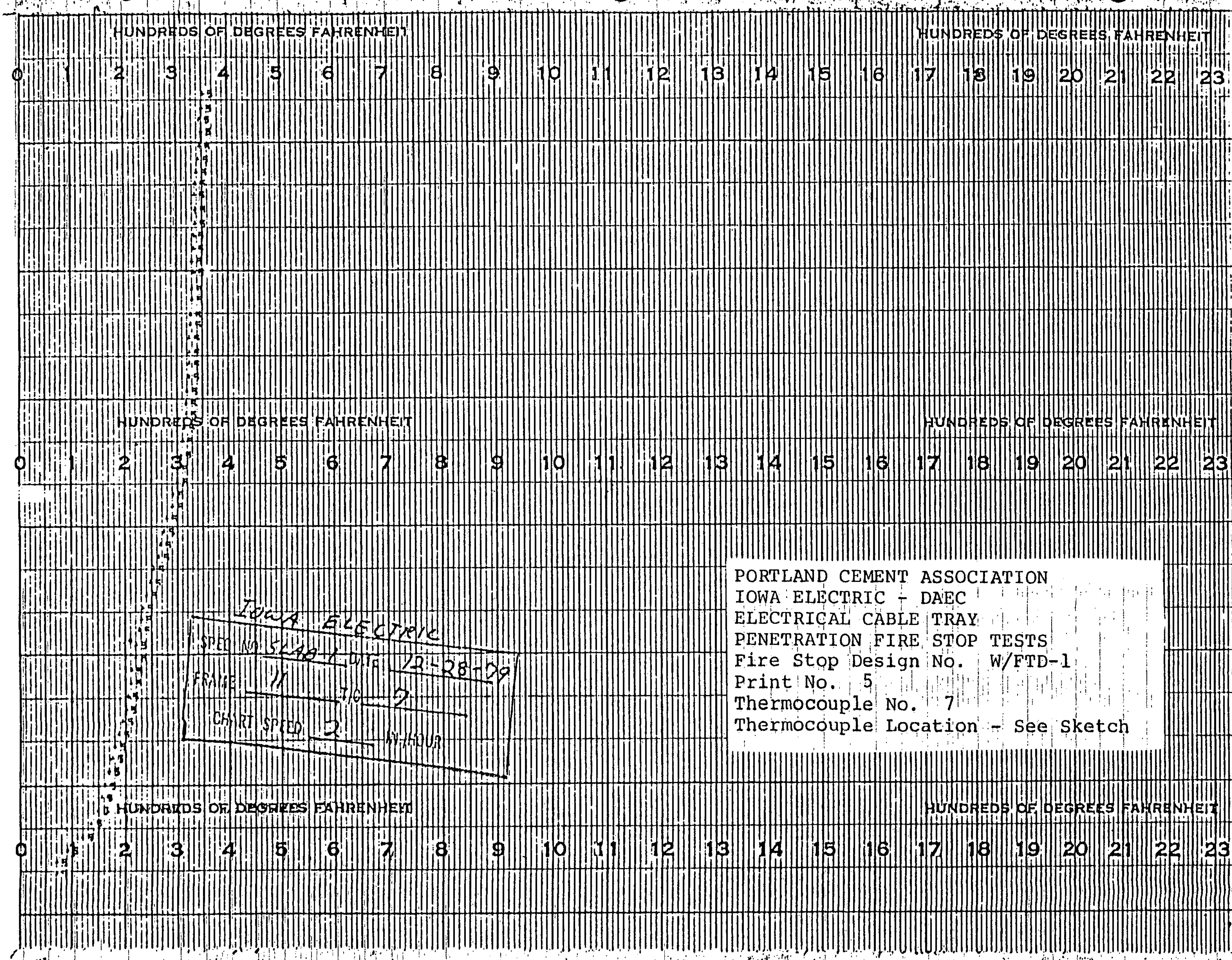
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 2
Thermocouple No. 16
Thermocouple Location - See Sketch

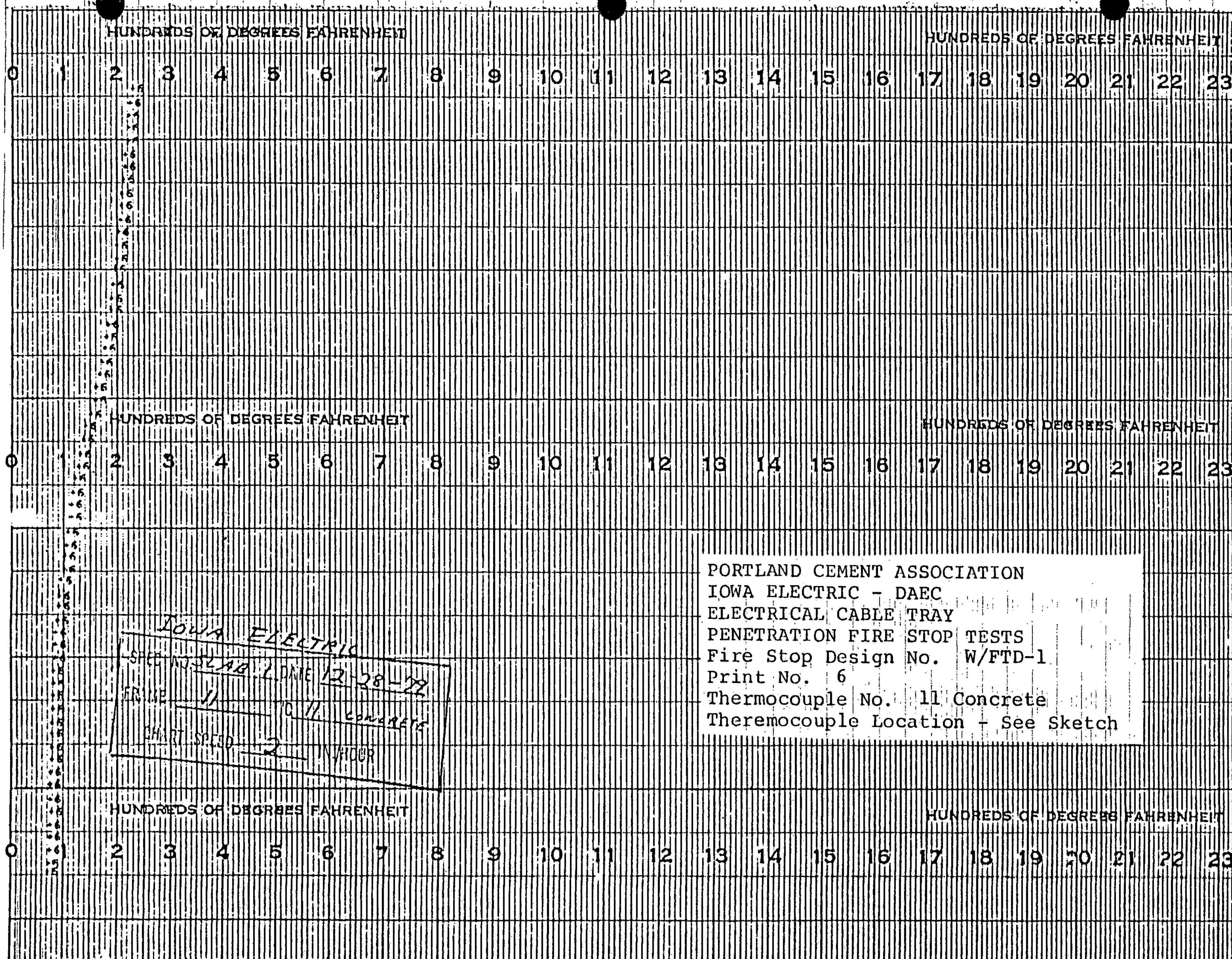


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 3
Thermocouple No. 13
Thermocouple Location - See Sketch

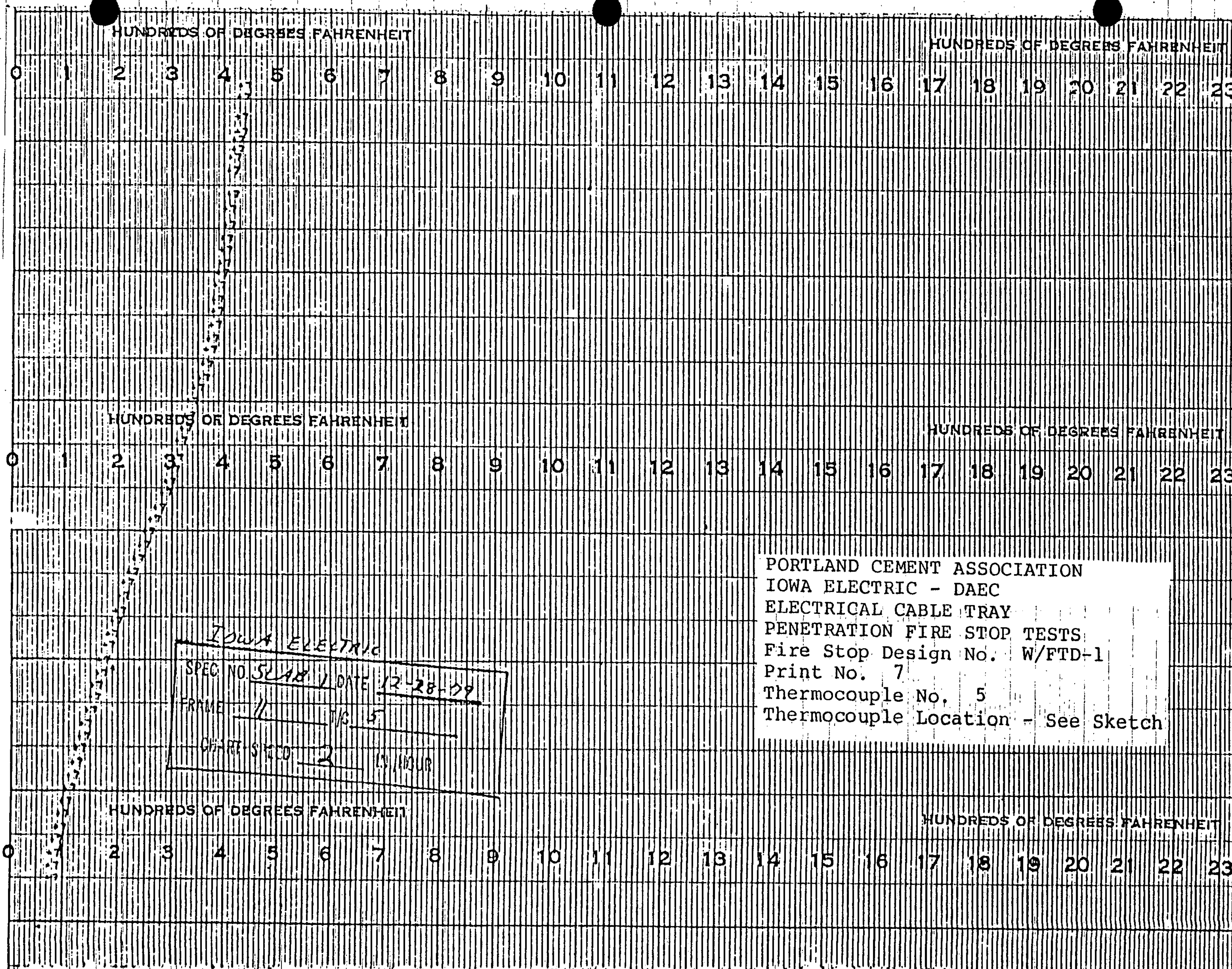


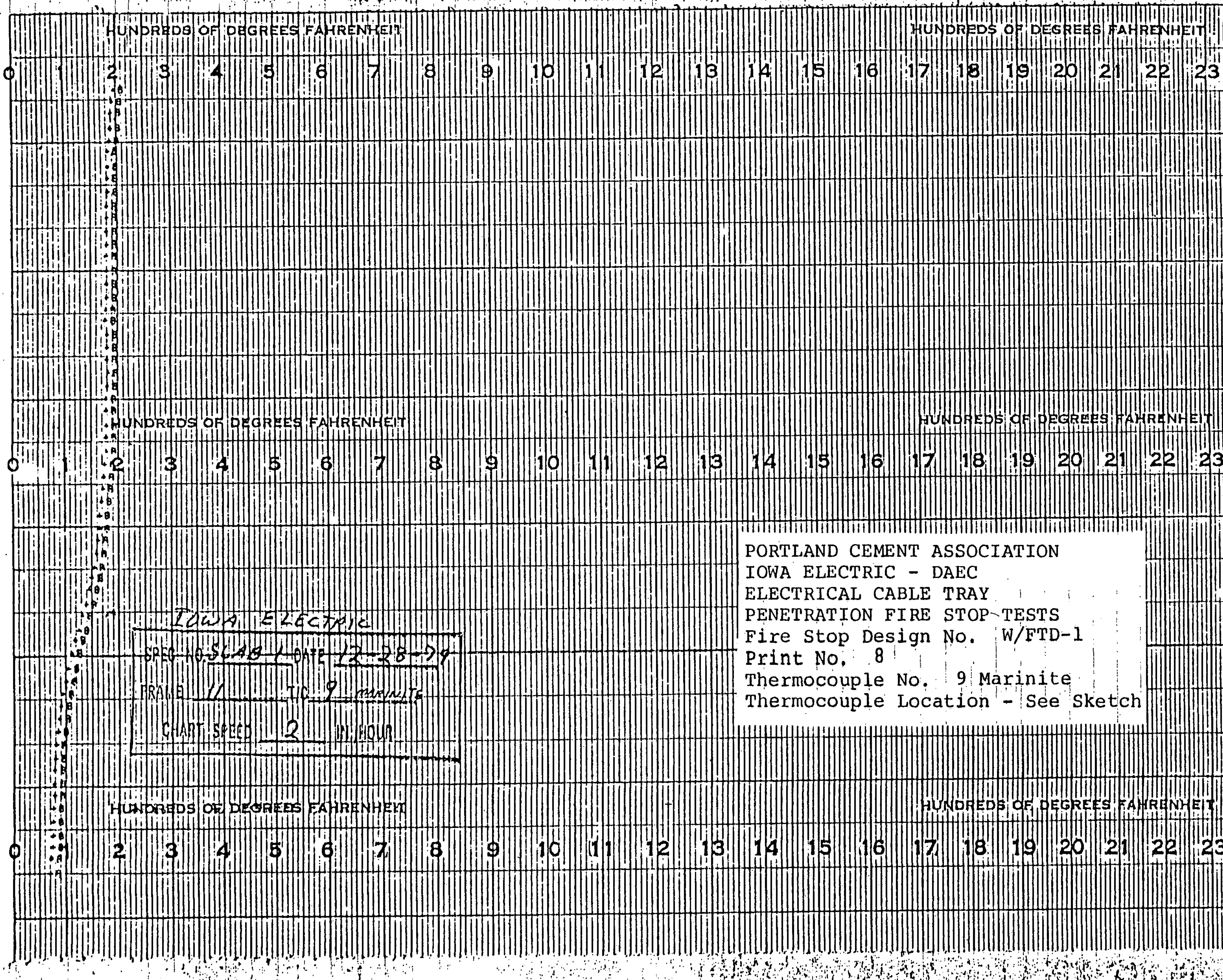
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 4
Thermocouple No. 17
Thermocouple Location - See Sketch


HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
IOWA ELECTRIC
SPEC NO SLAB-1 DATE 12-28-79
FRAME 11 TO 7
CHART SPEED 2 IN/HOUR
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 5
Thermocouple No. 7
Thermocouple Location - See Sketch

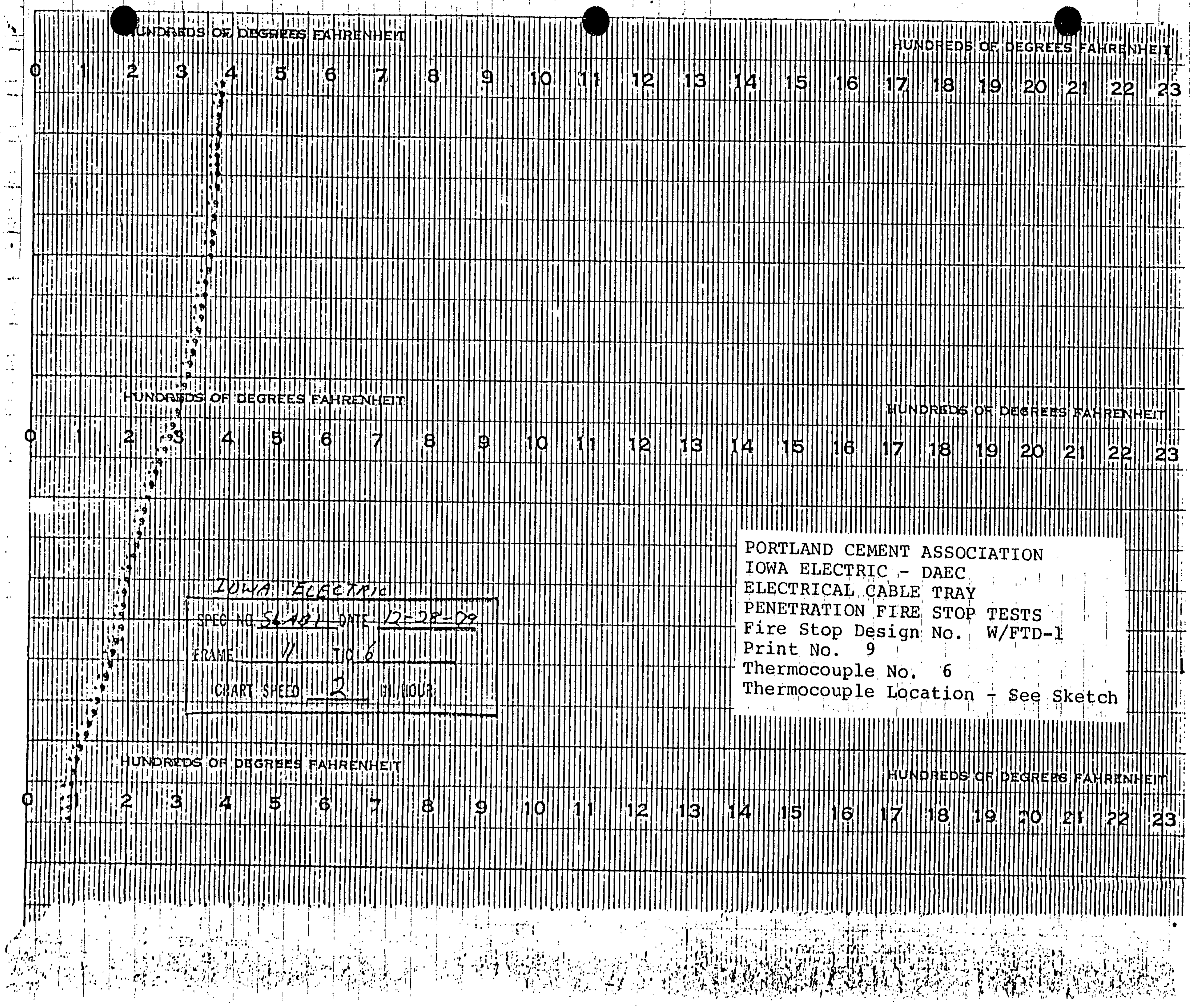


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 6
Thermocouple No. 11 Concrete
Theremocouple Location - See Sketch


HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
IOWA ELECTRIC
SPEC NO. SLAB 1 DATE 12-28-79
FRAME 11 T/C 5
CHART SPEED 2 IN/HOUR
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 7
Thermocouple No. 5
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 8
Thermocouple No. 9 Marinite
Thermocouple Location - See Sketch


HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
IOWA ELECTRIC
SPEC NO.
DATE 12-28-79
FRAME 11 TO 6
CHART SPEED 2 IN HOUR
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 9
Thermocouple No. 6
Thermocouple Location - See Sketch

HUNDREDS OF DEGREES FAHRENHEIT

HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

HUNDREDS OF DEGREES FAHRENHEIT

HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

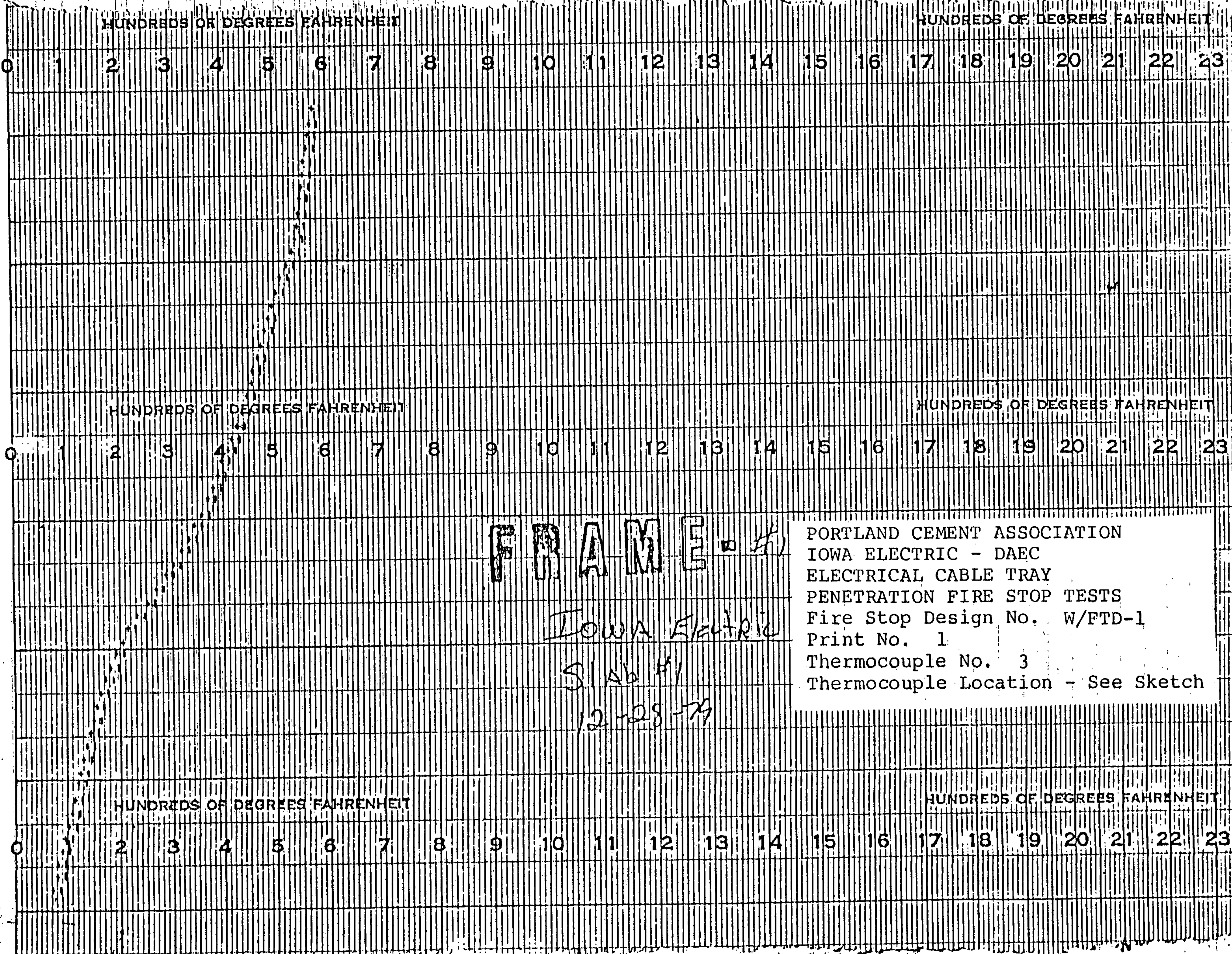
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 11
Thermocouple No. 2
Thermocouple Location - See Sketch

IOWA ELECTRIC
SPEC NO. SLAB 1 DATE 12-28-79
FRAME 11 T/C 2
CHART SPEED 2 IN/HOUR

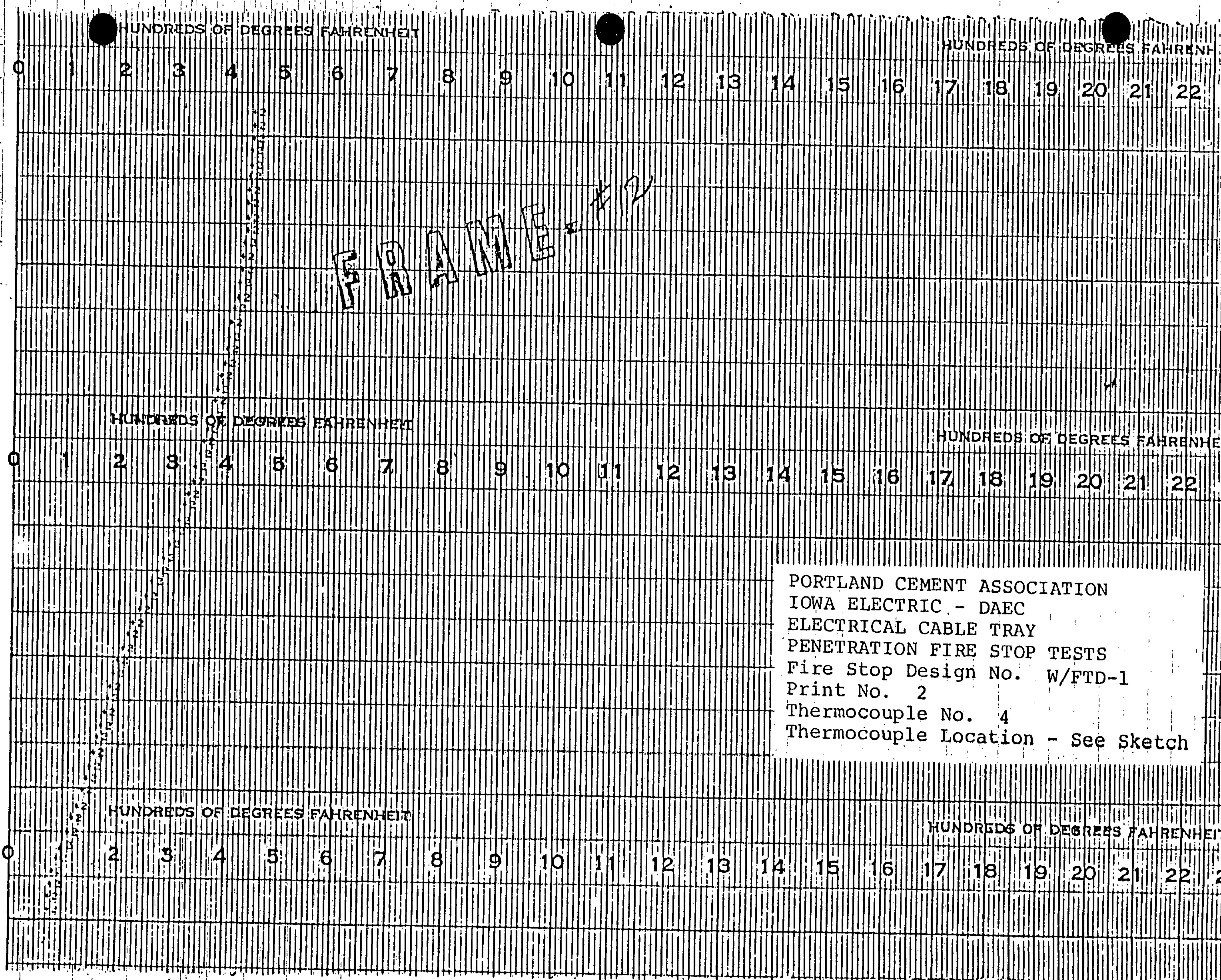
HUNDREDS OF DEGREES FAHRENHEIT

HUNDREDS OF DEGREES FAHRENHEIT

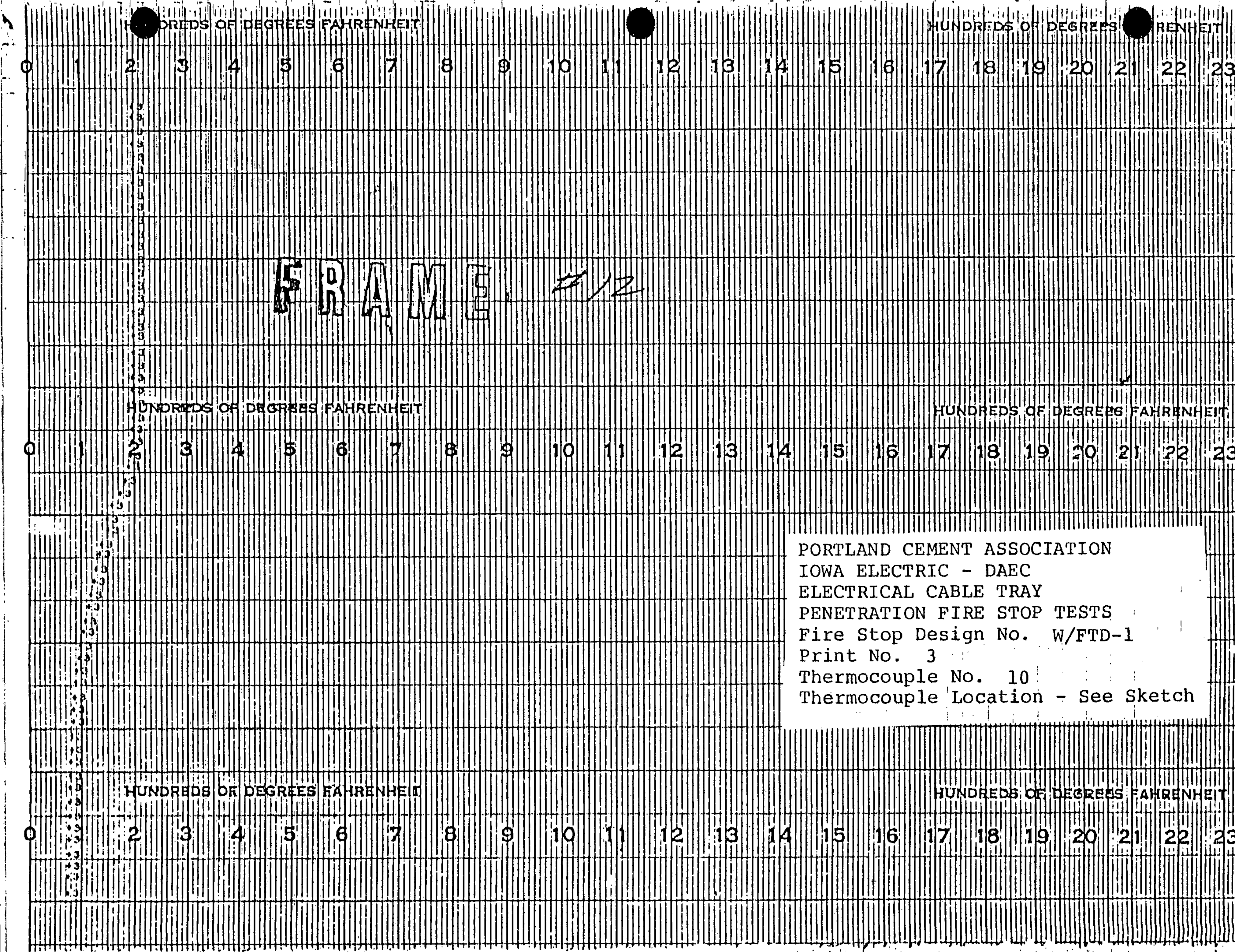
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



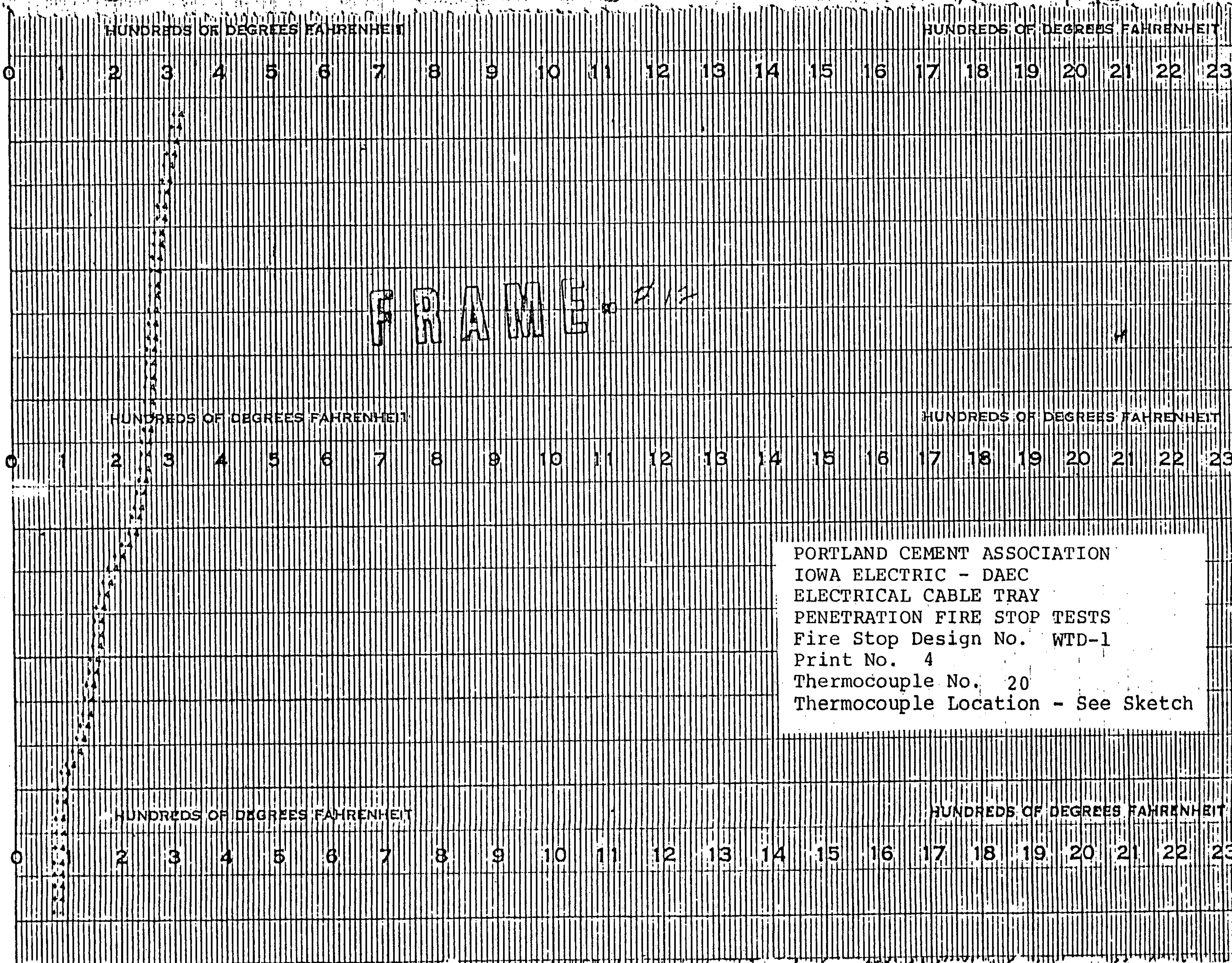
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 1
Thermocouple No. 3
Thermocouple Location - See Sketch



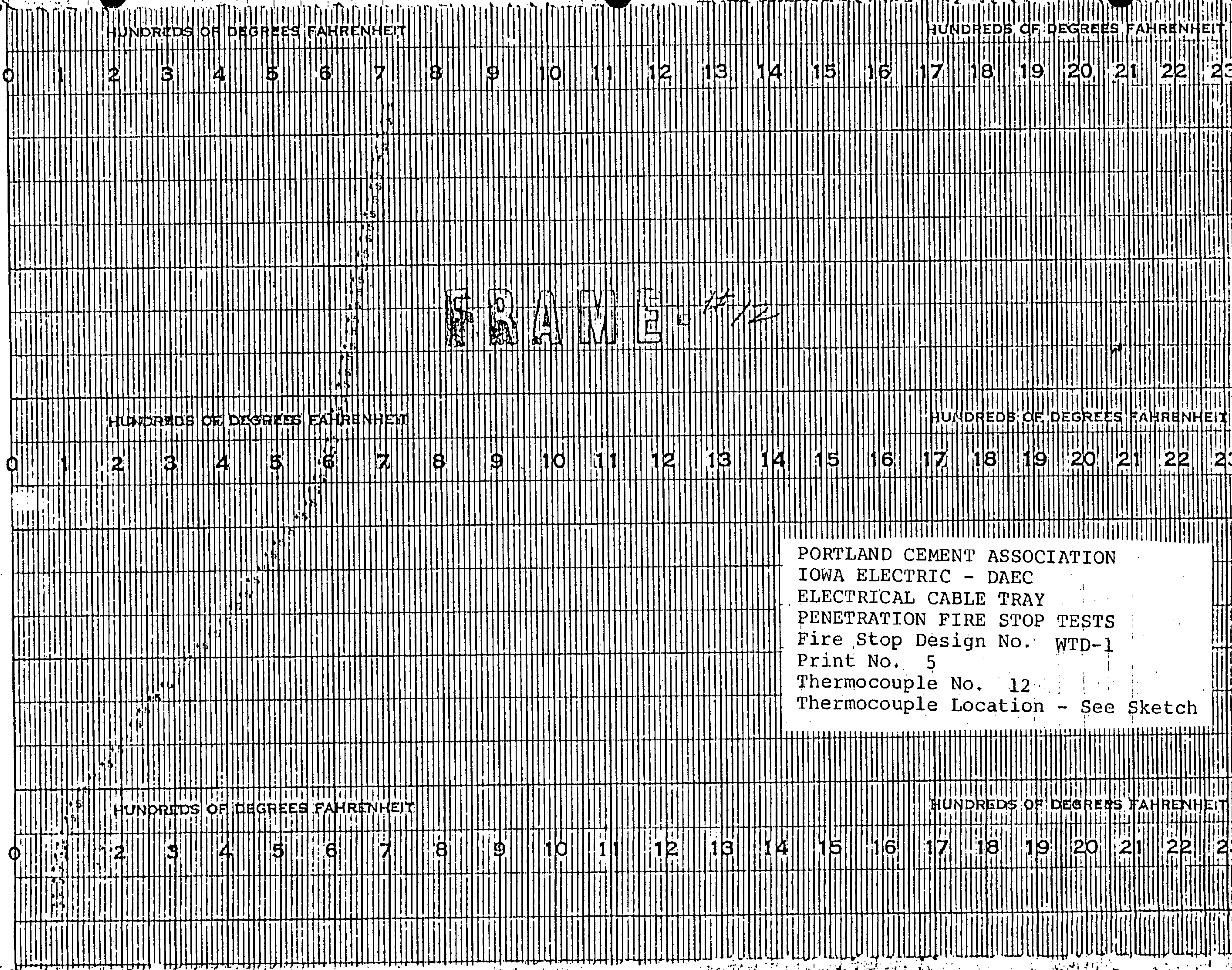
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 2
Thermocouple No. 4
Thermocouple Location - See Sketch



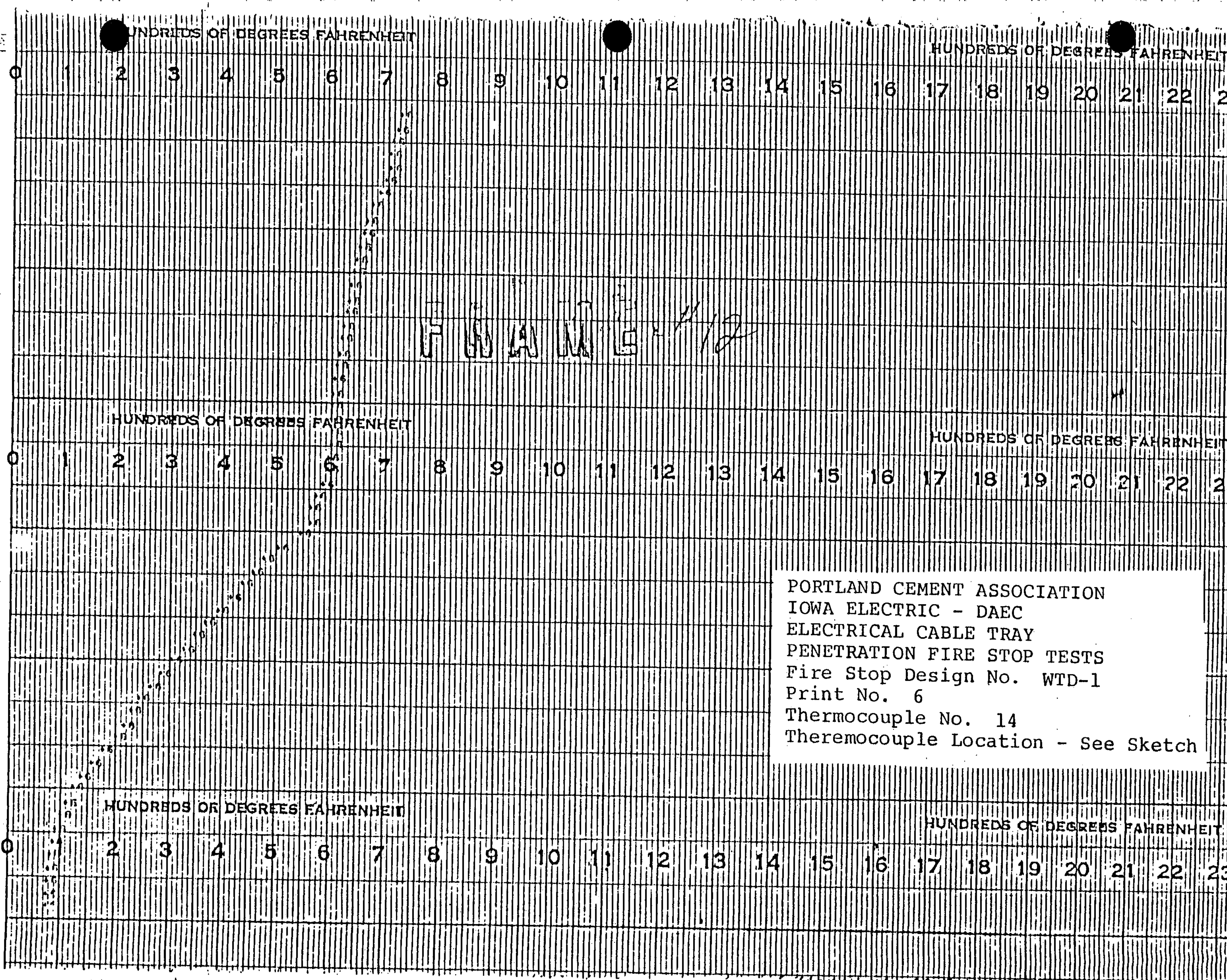
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 3
Thermocouple No. 10
Thermocouple Location - See Sketch



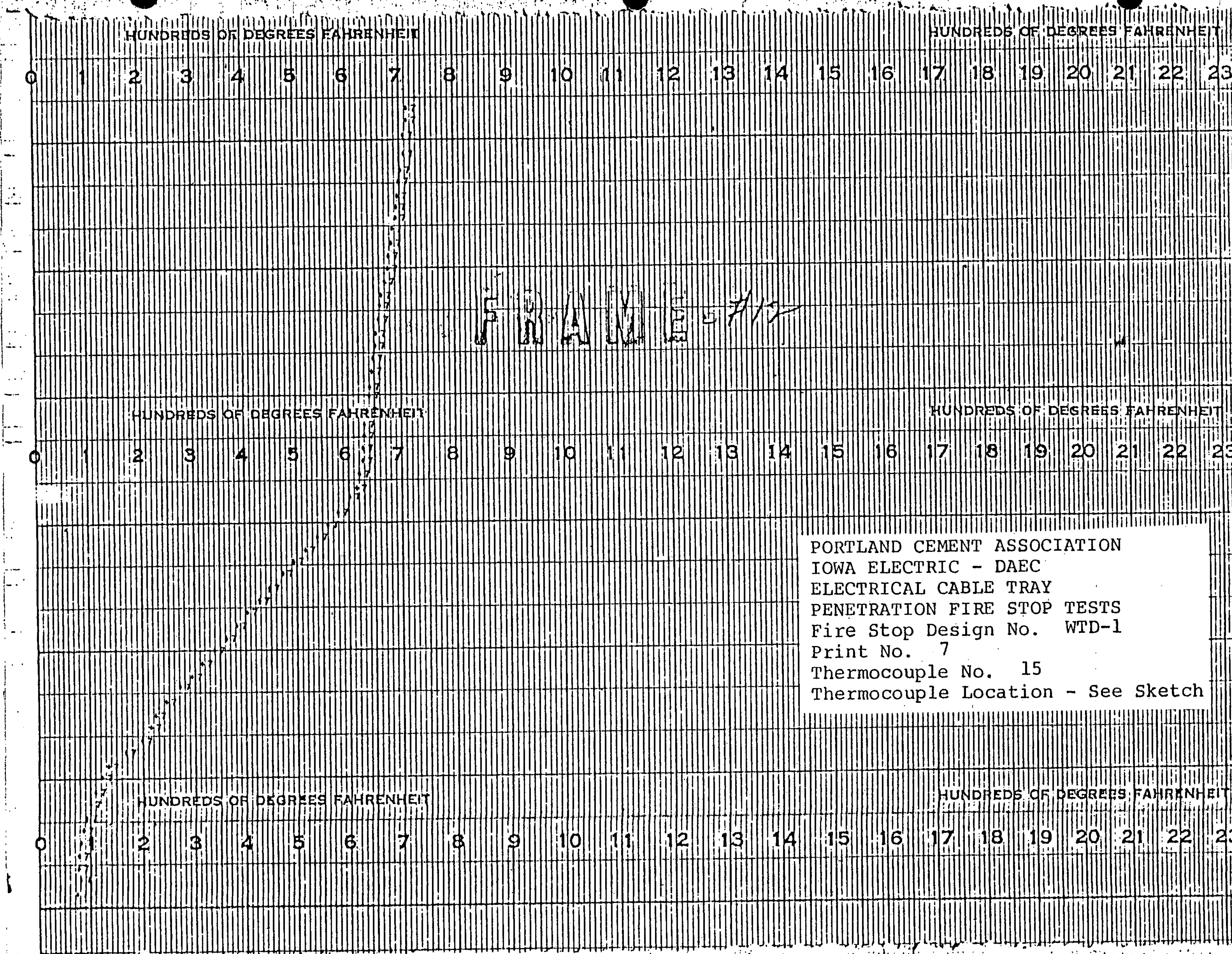
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 4
Thermocouple No. 20
Thermocouple Location - See Sketch



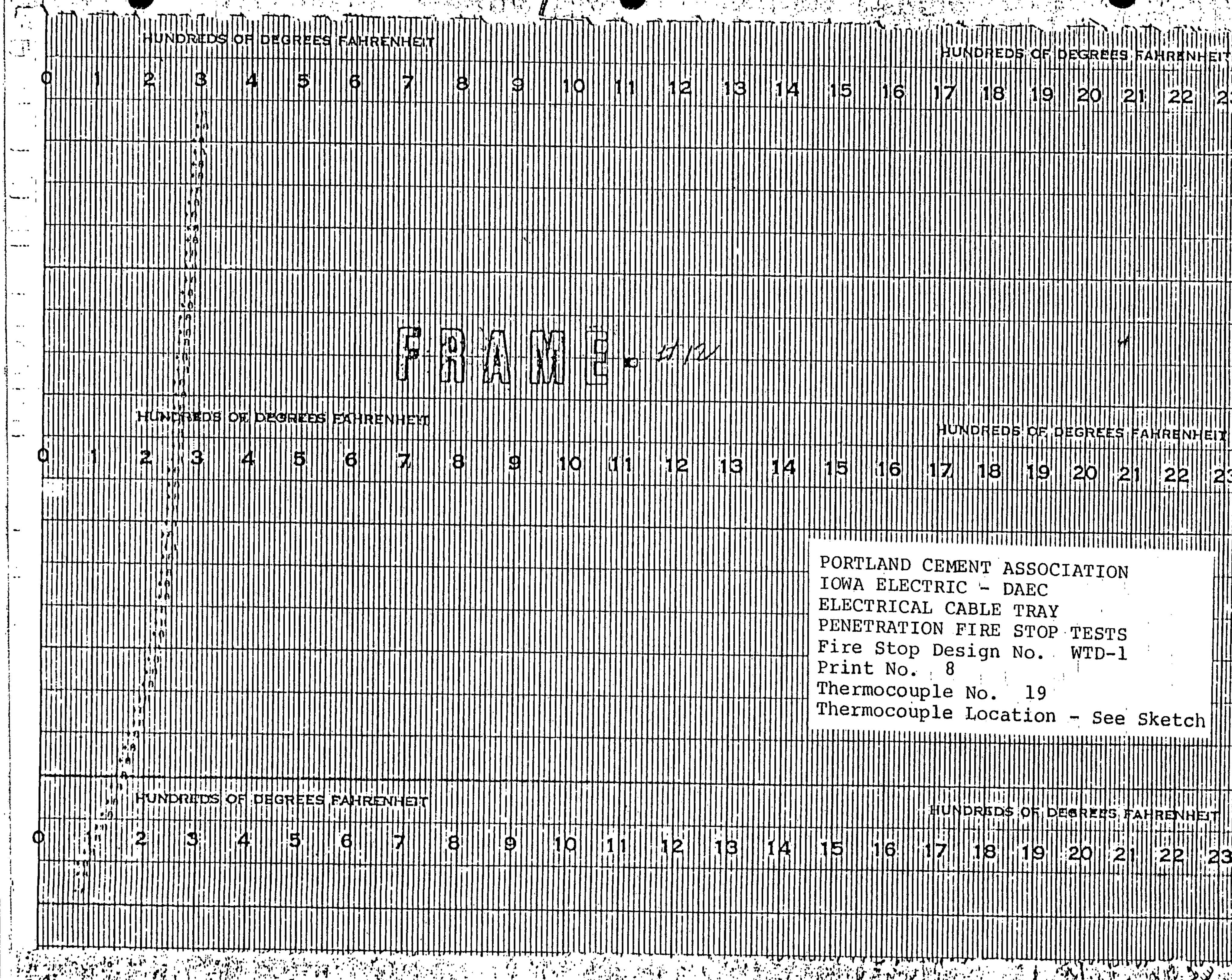
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 5
Thermocouple No. 12
Thermocouple Location - See Sketch



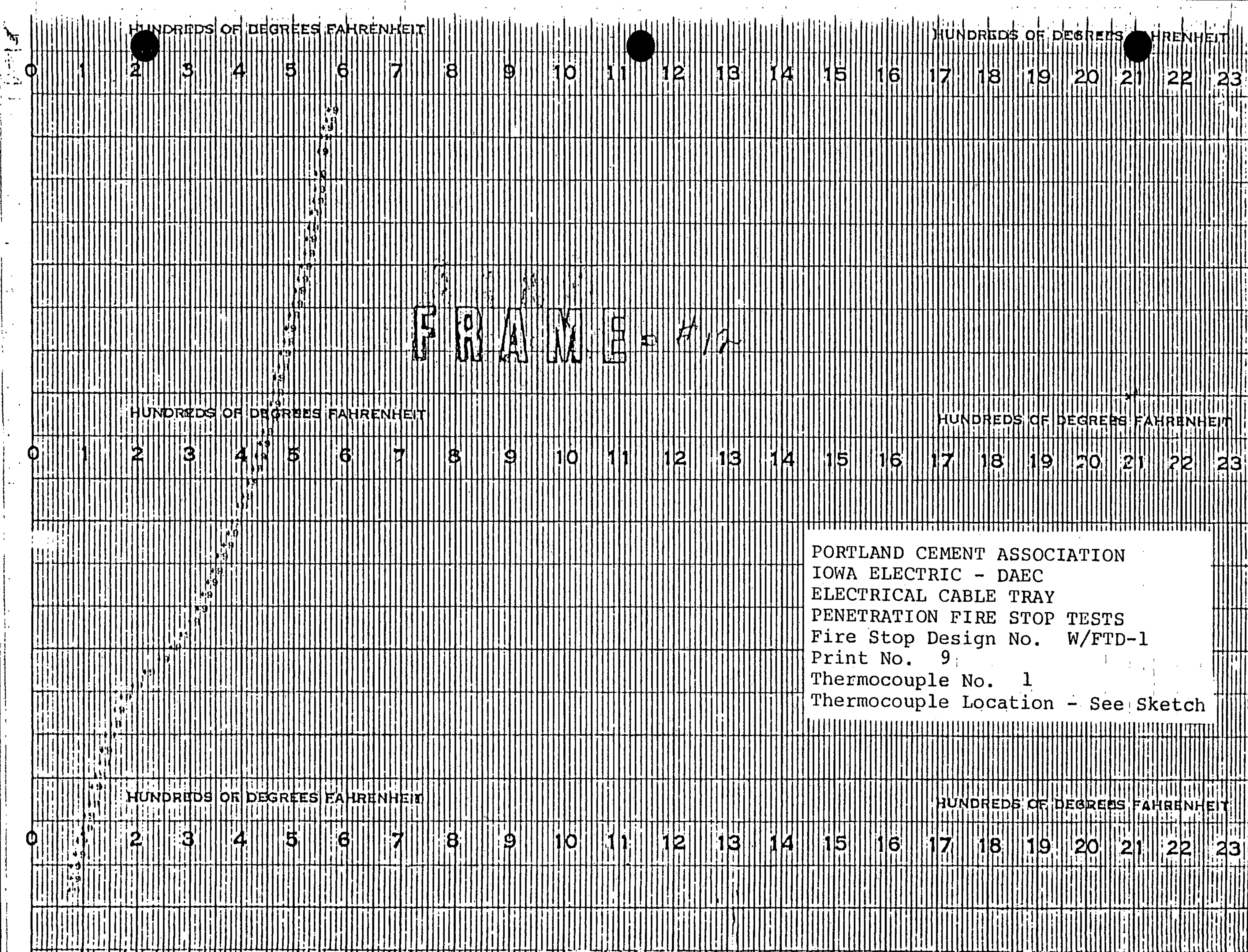
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 6
Thermocouple No. 14
Theremocouple Location - See Sketch



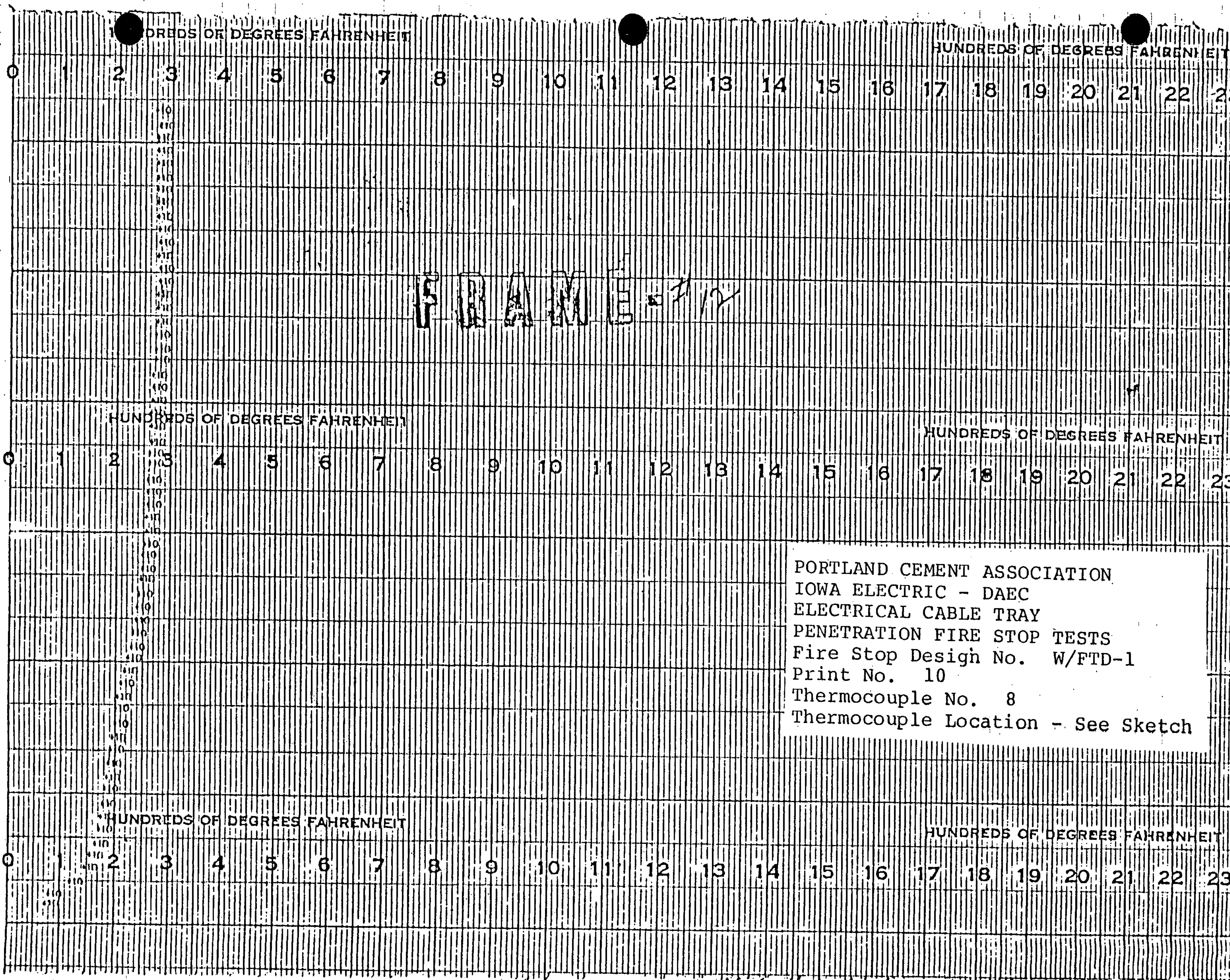
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 7
Thermocouple No. 15
Thermocouple Location - See Sketch



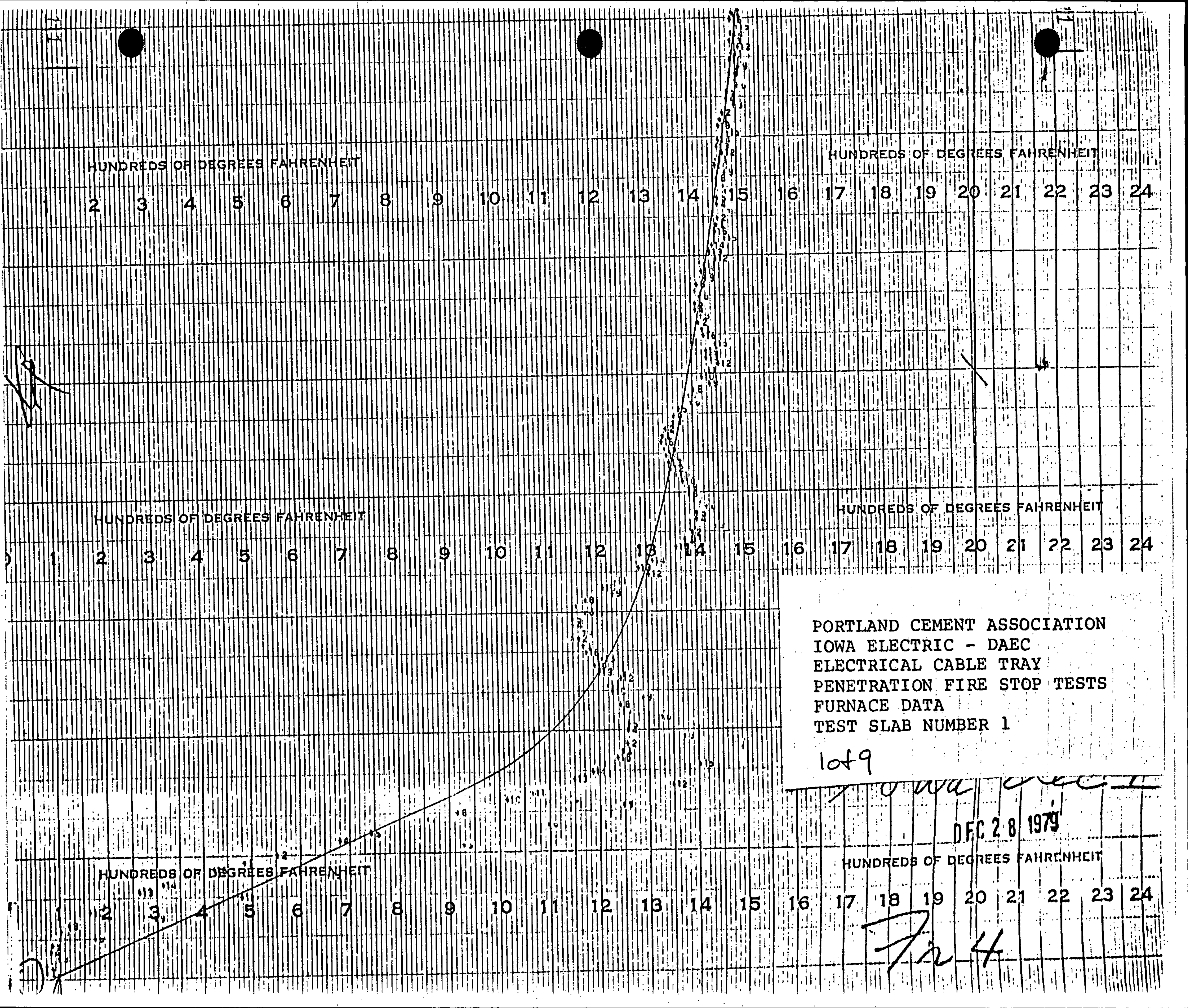
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-1
Print No. 8
Thermocouple No. 19
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 9
Thermocouple No. 1
Thermocouple Location - See Sketch

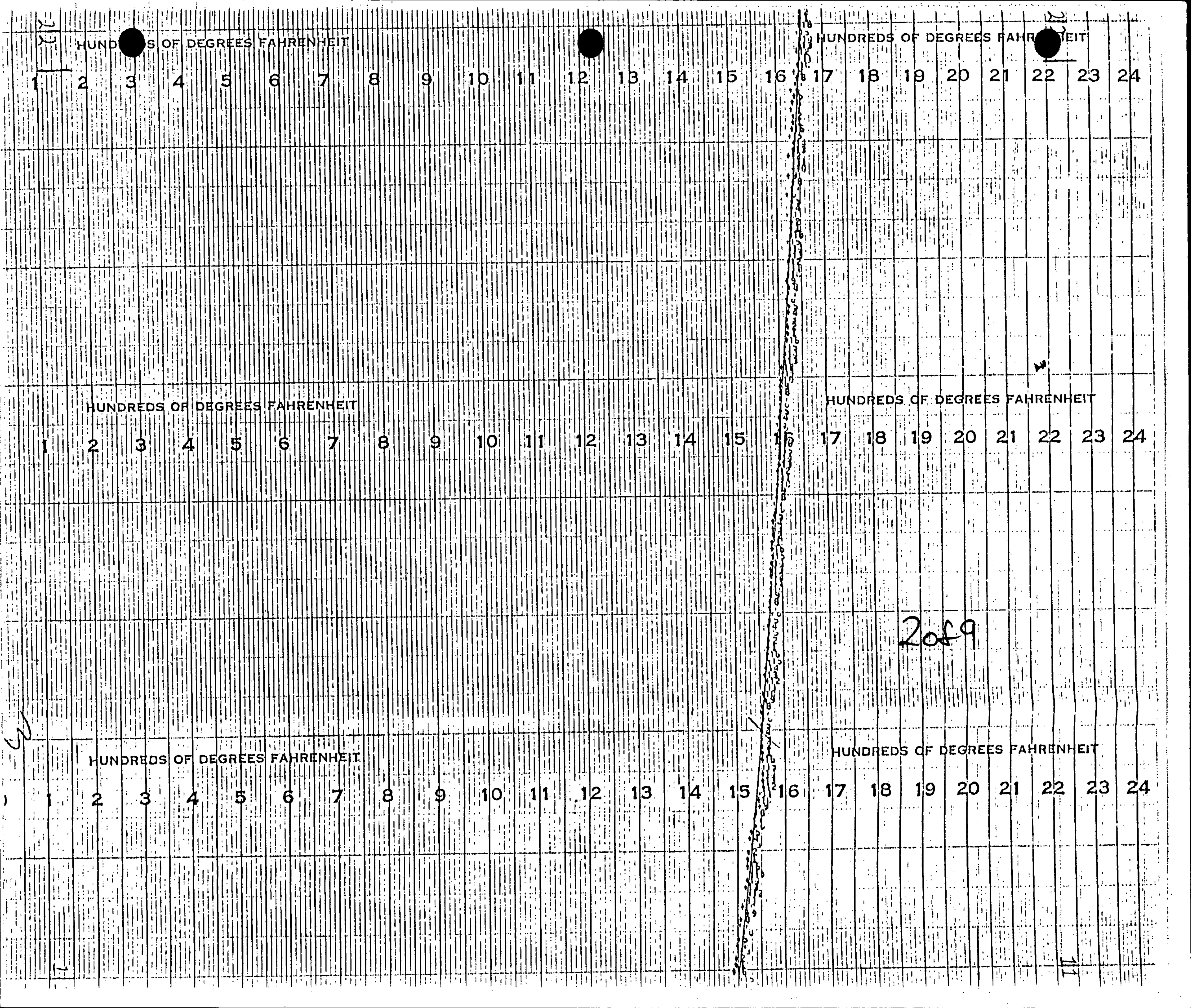


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-1
Print No. 10
Thermocouple No. 8
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 1

1of9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HUNDREDS OF DEGREES FAHRENHEIT
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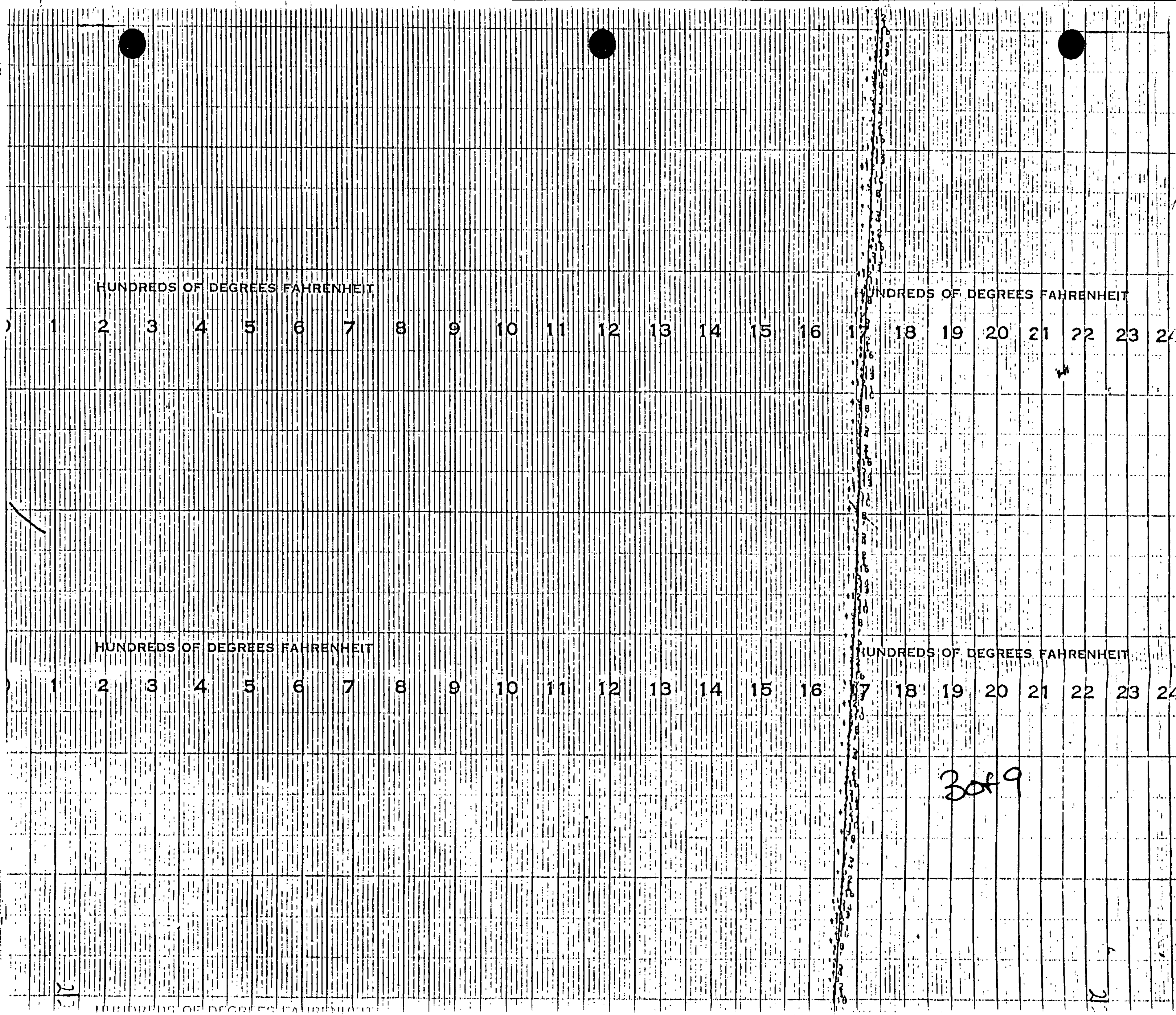
2of9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HUNDREDS OF DEGREES FAHRENHEIT

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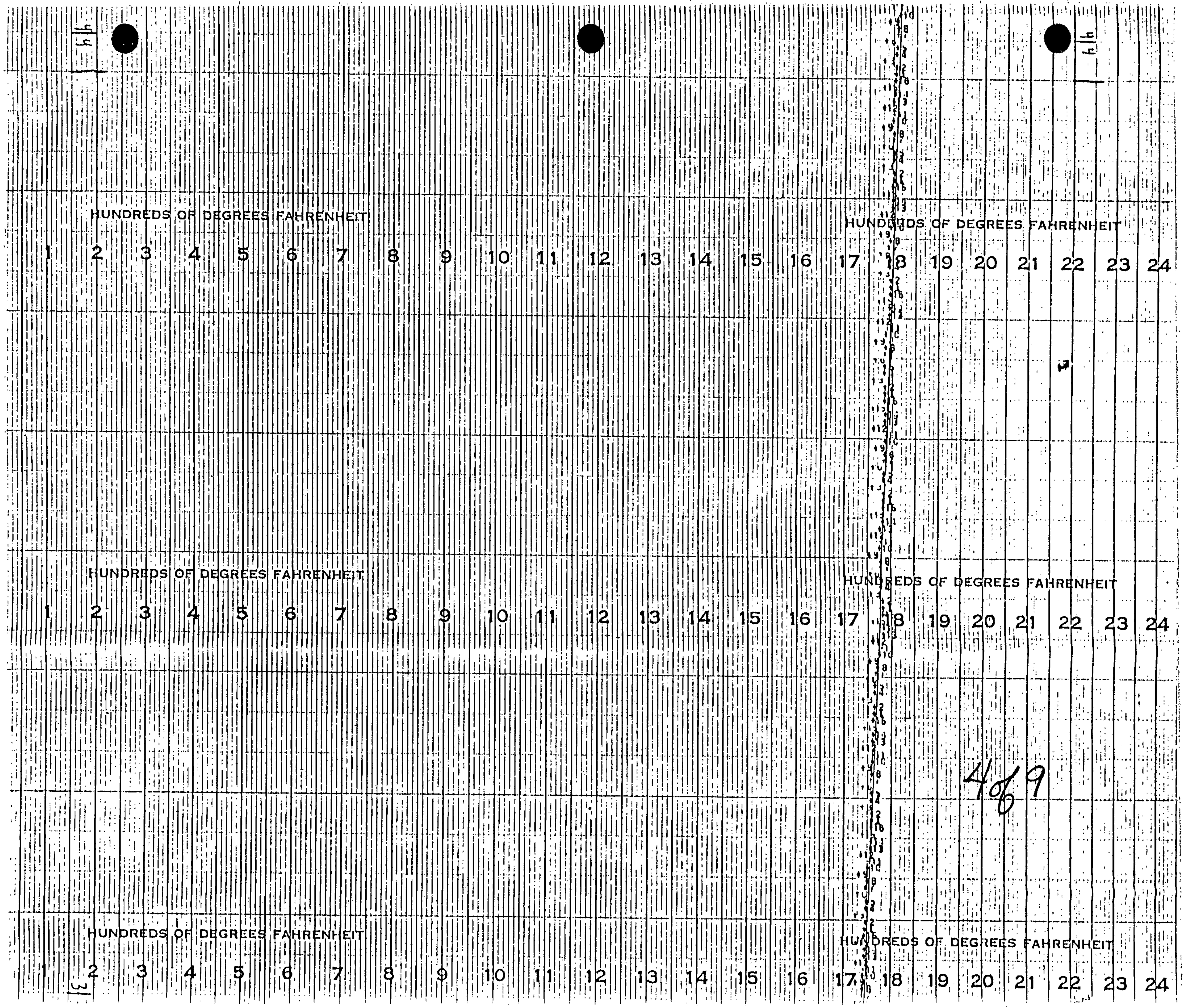
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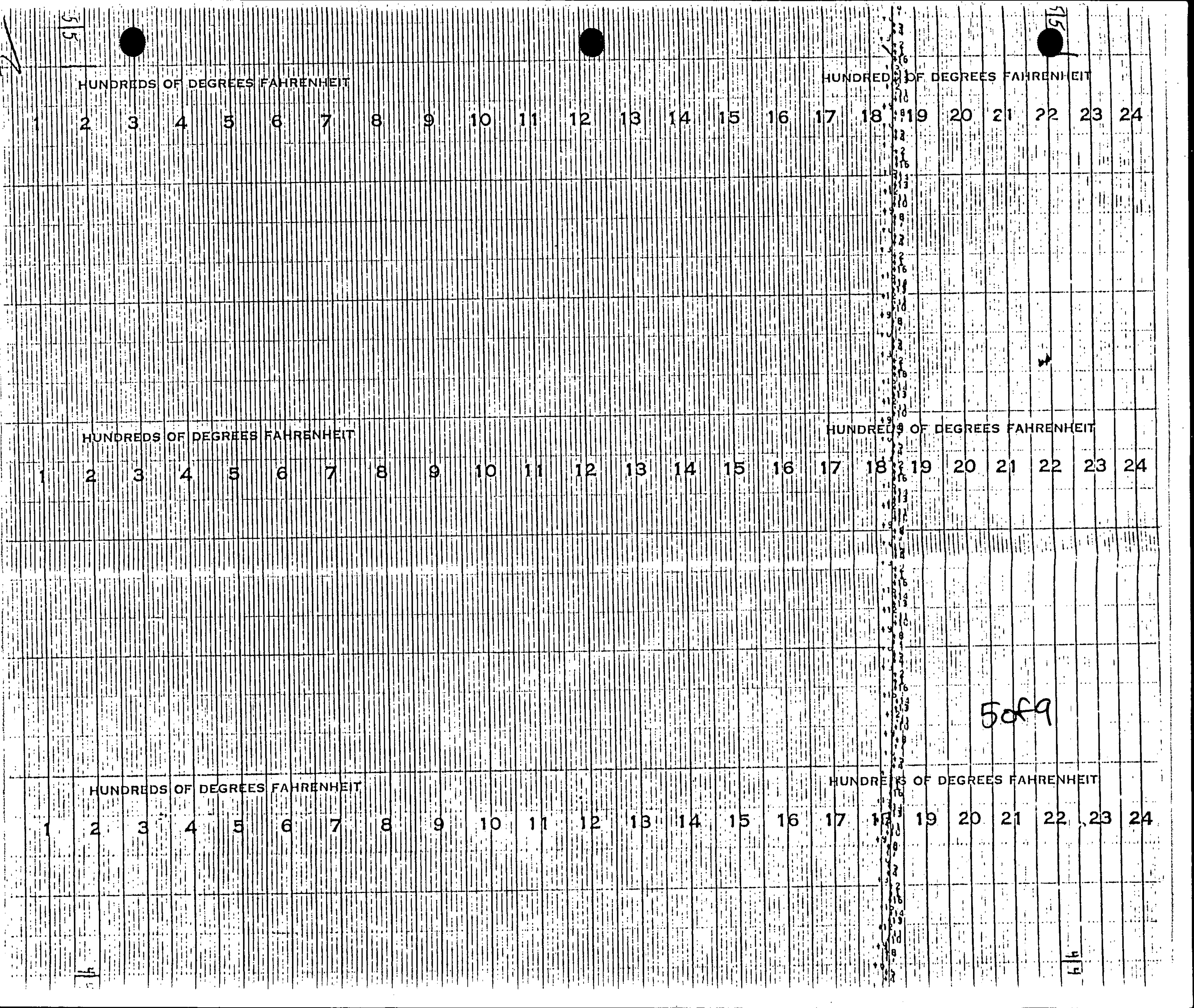
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HUNDREDS OF DEGREES FAHRENHEIT
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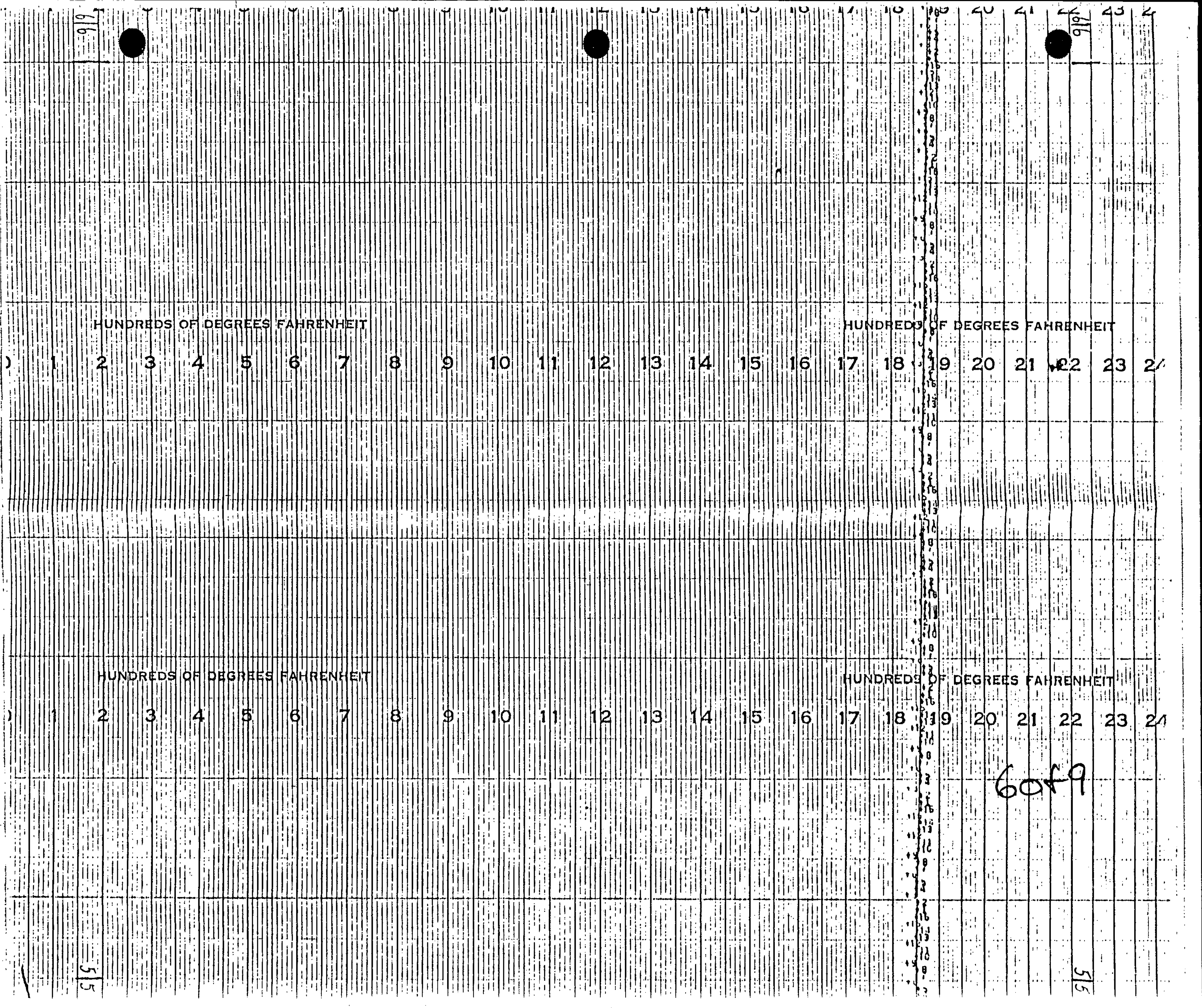
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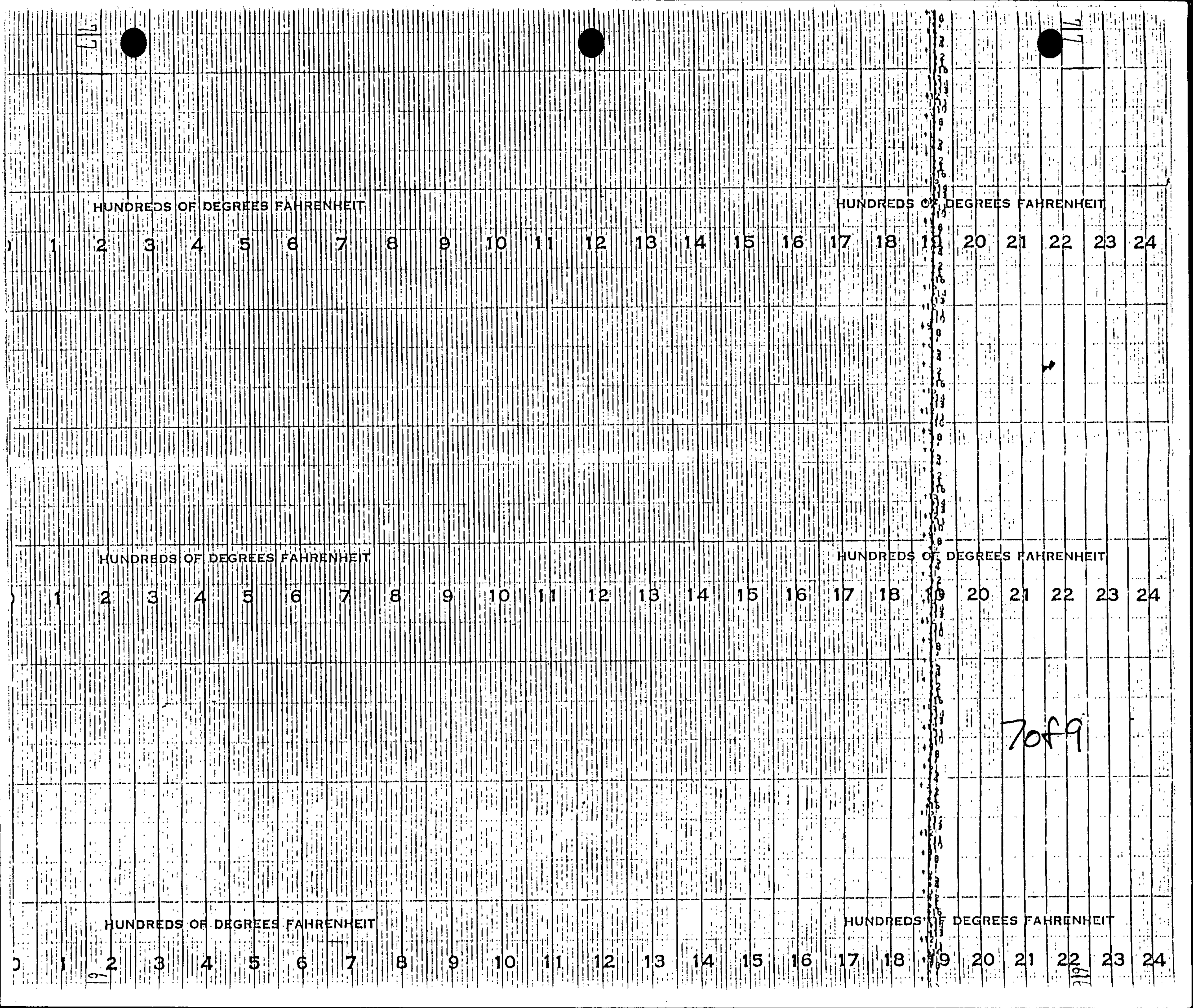
6 of 9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HUNDREDS OF DEGREES FAHRENHEIT
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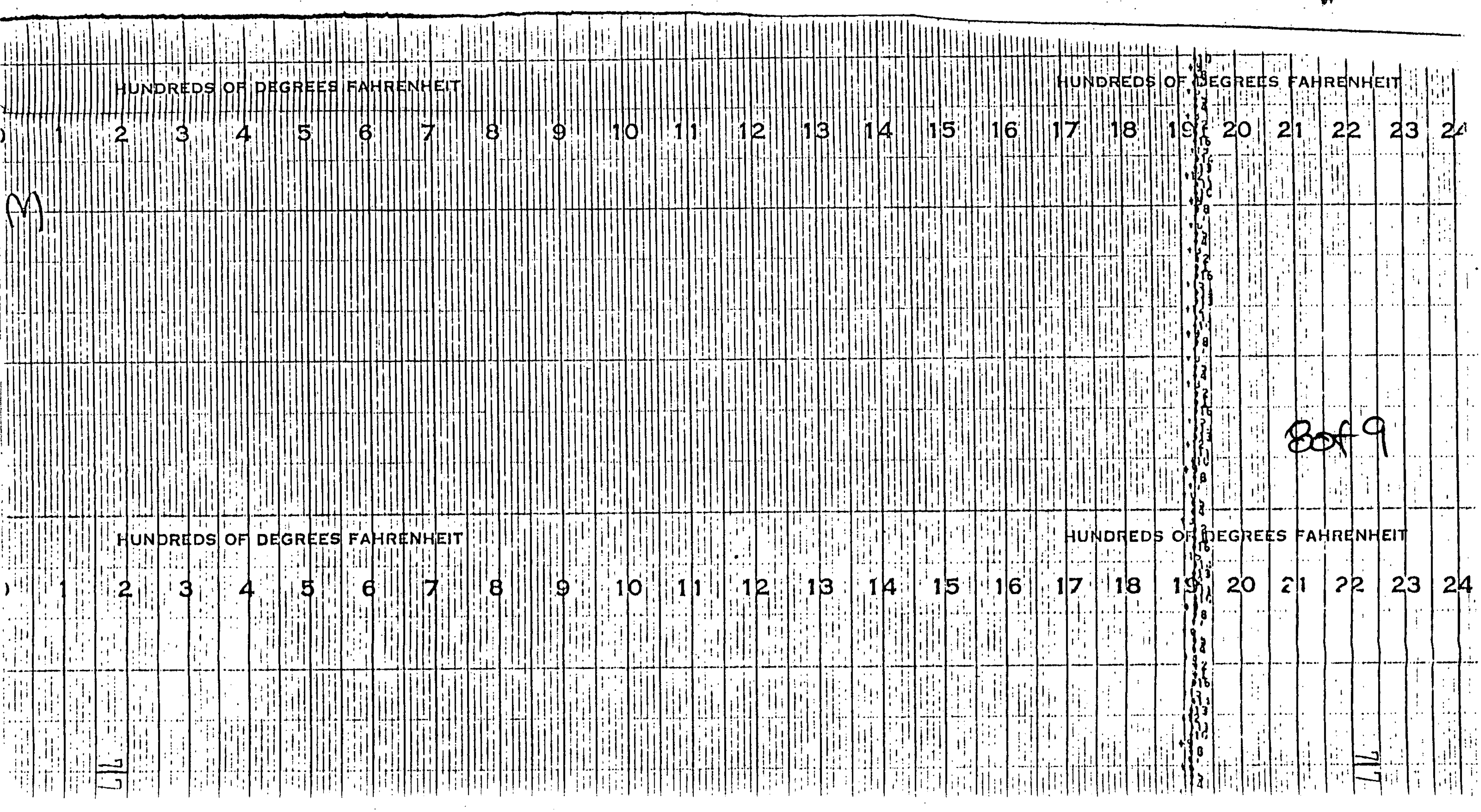
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HUNDREDS OF DEGREES FAHRENHEIT
8 of 9
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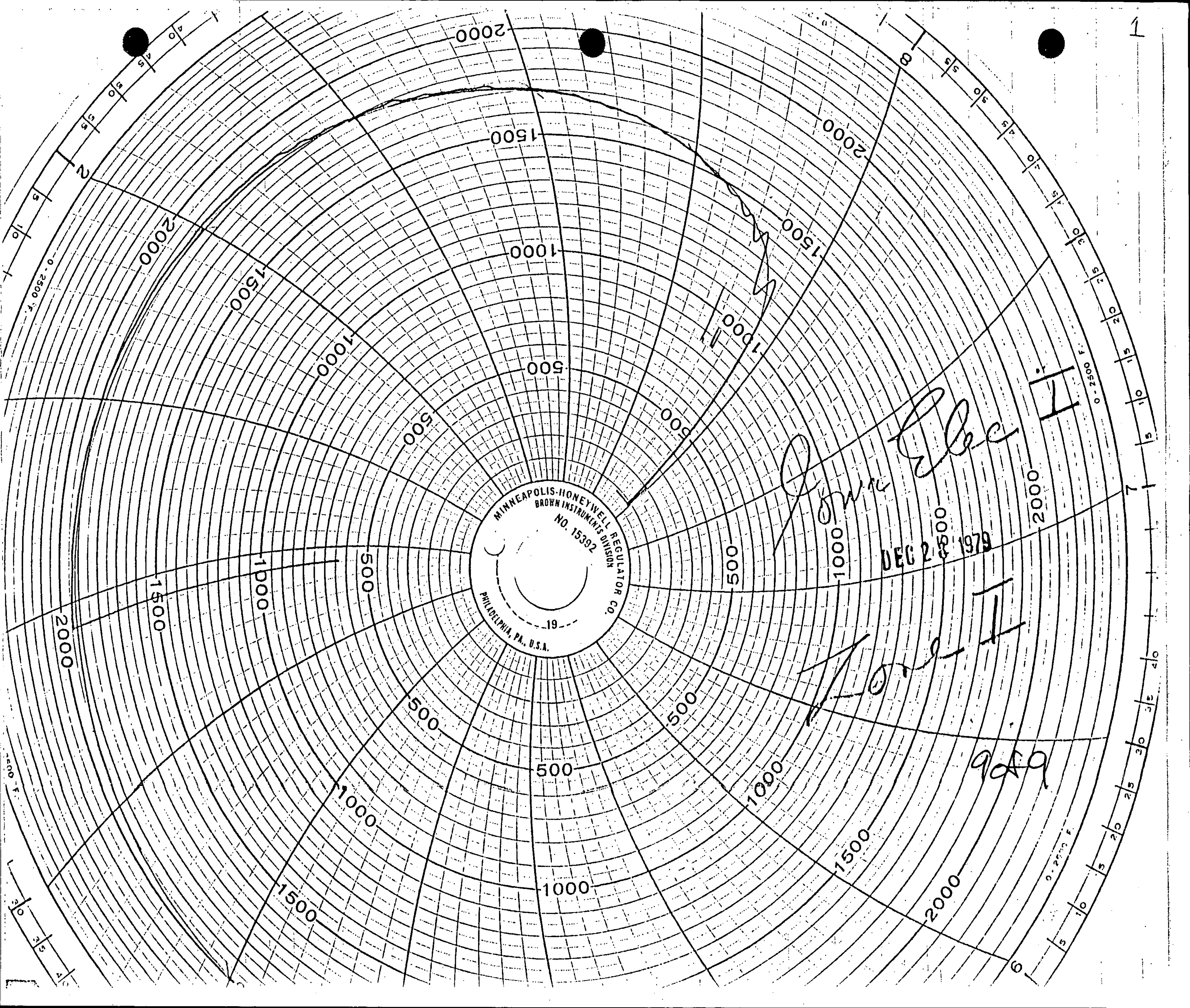
HUNDREDS OF DEGREES FAHRENHEIT


MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA., U.S.A.
19
DEC 28 1979

TEST SLAB NUMBER 2

DATE: 01/29/80

FIRE STOP DESIGNS TESTED: W/FTD-2
FTD-1

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

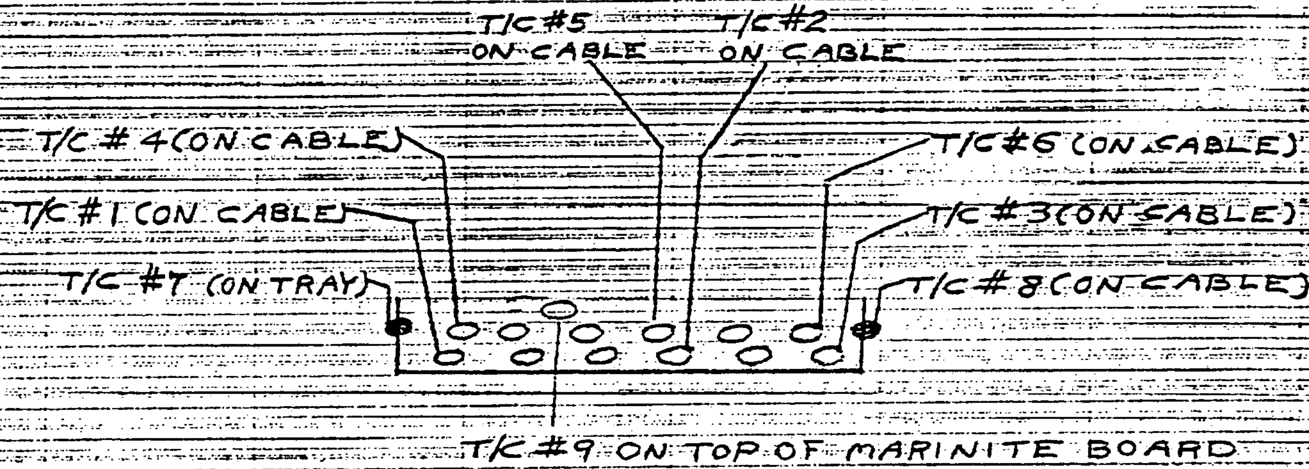
Test Witnessed by:

M. Gillen, PCA

R. Hollenbacher, EDS

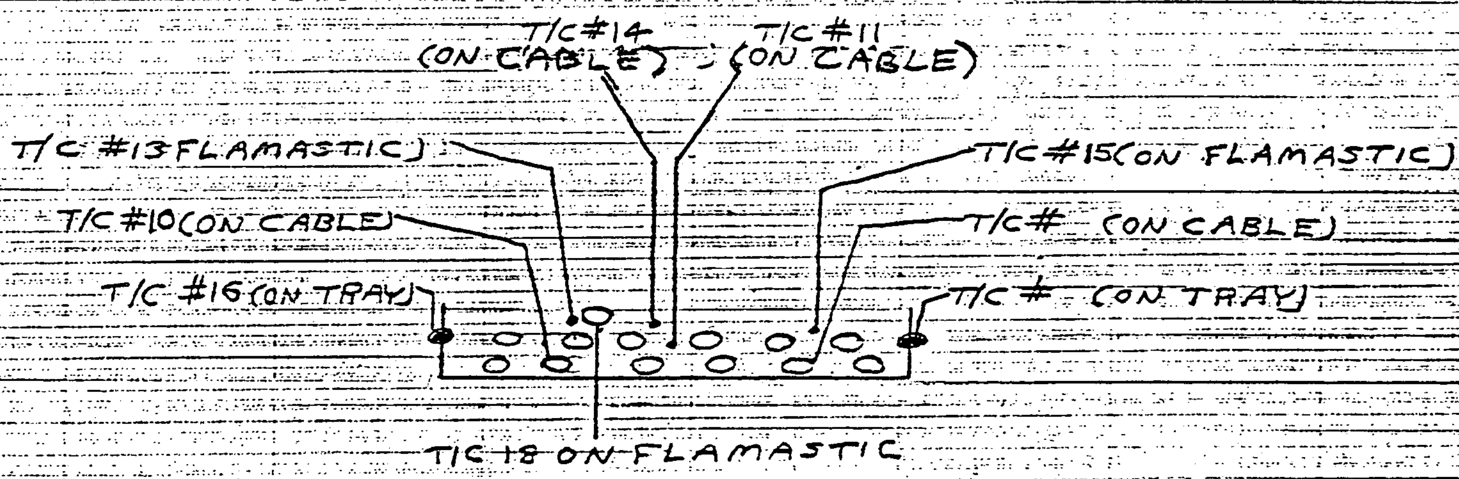
SLAB 2

W/FTD-2 (T-2)

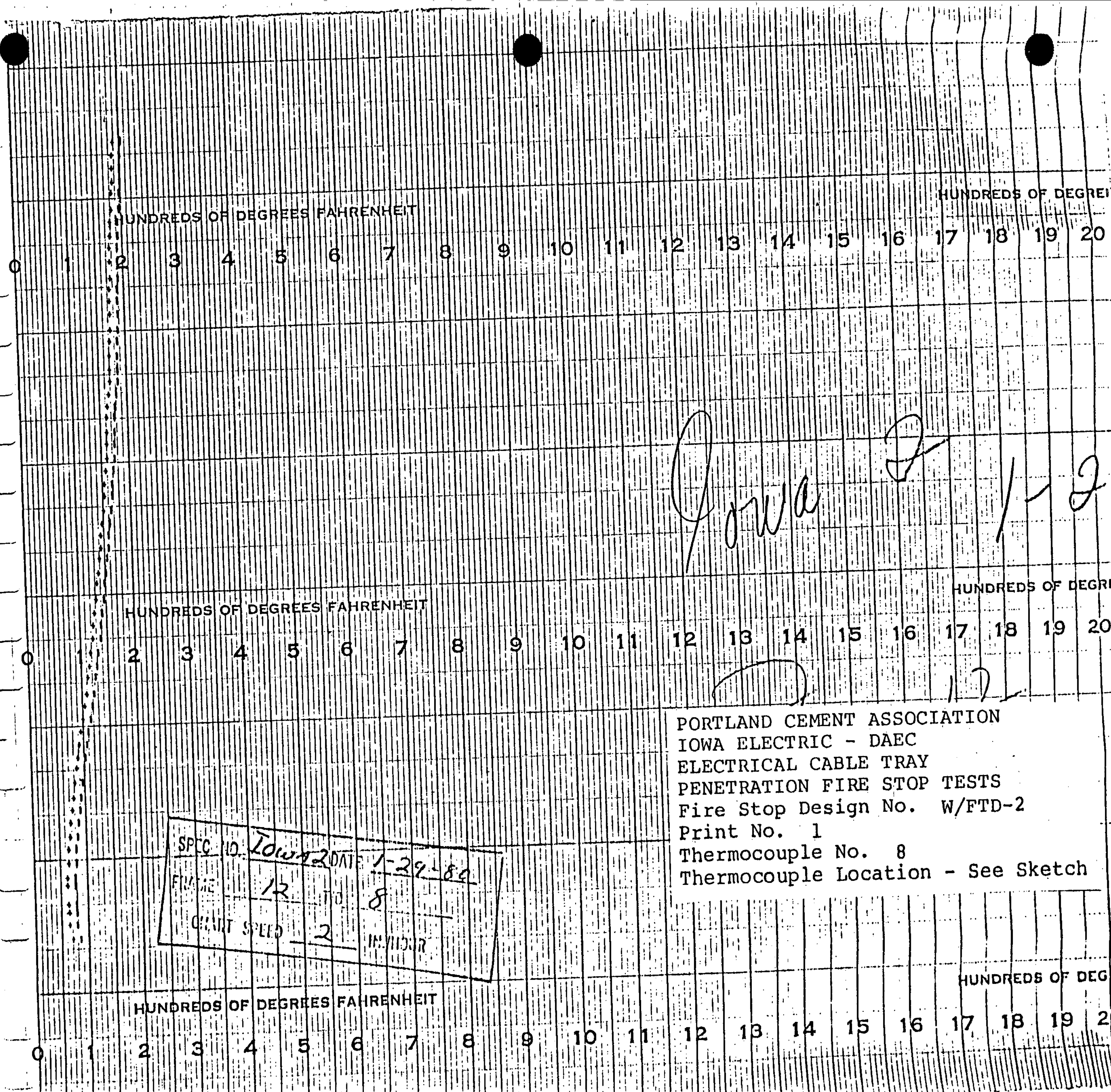


ALL ON UNEXPOSED SURFASE AT BOARD INTERFACE

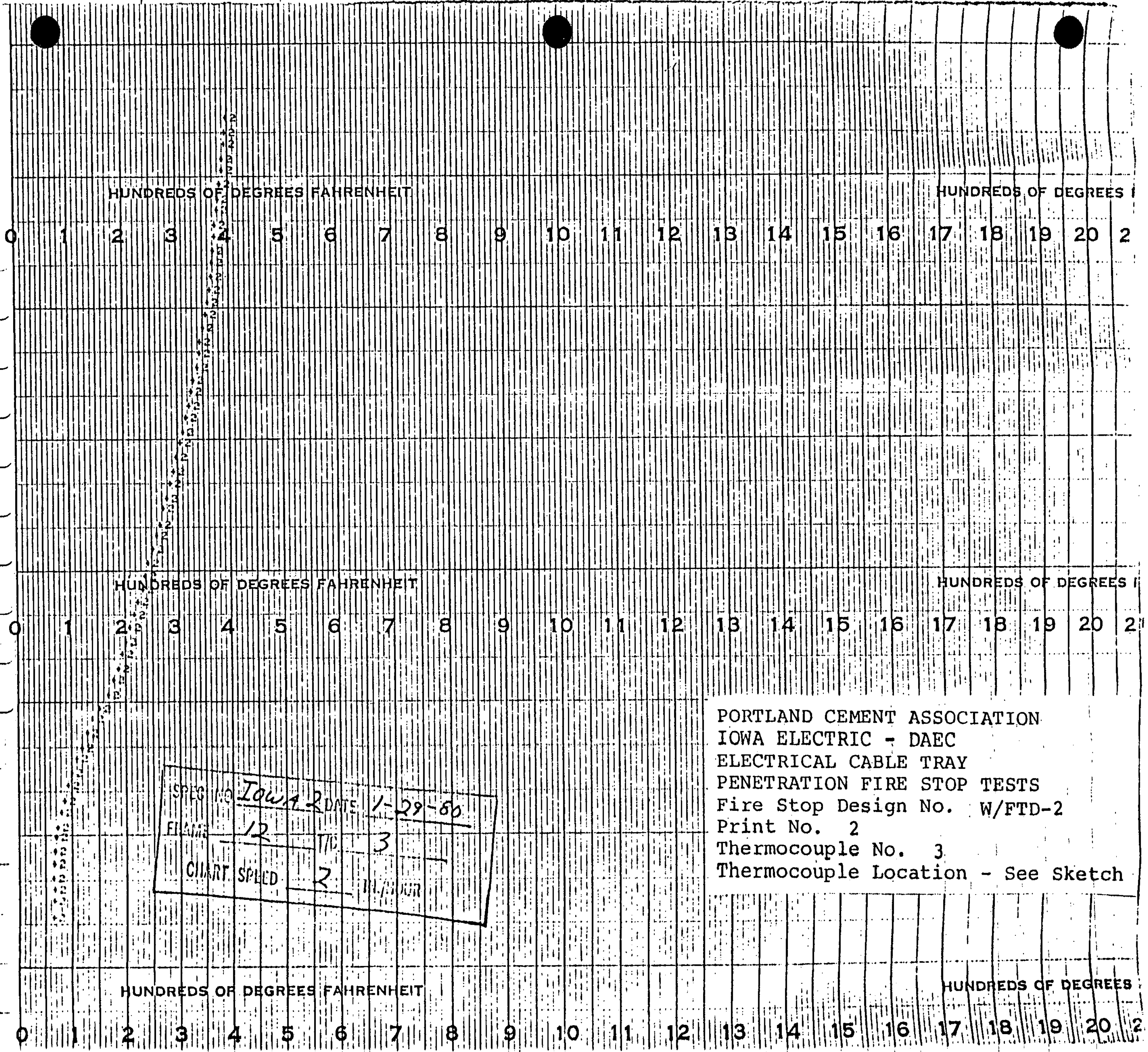
FTD - 1 (T-6)



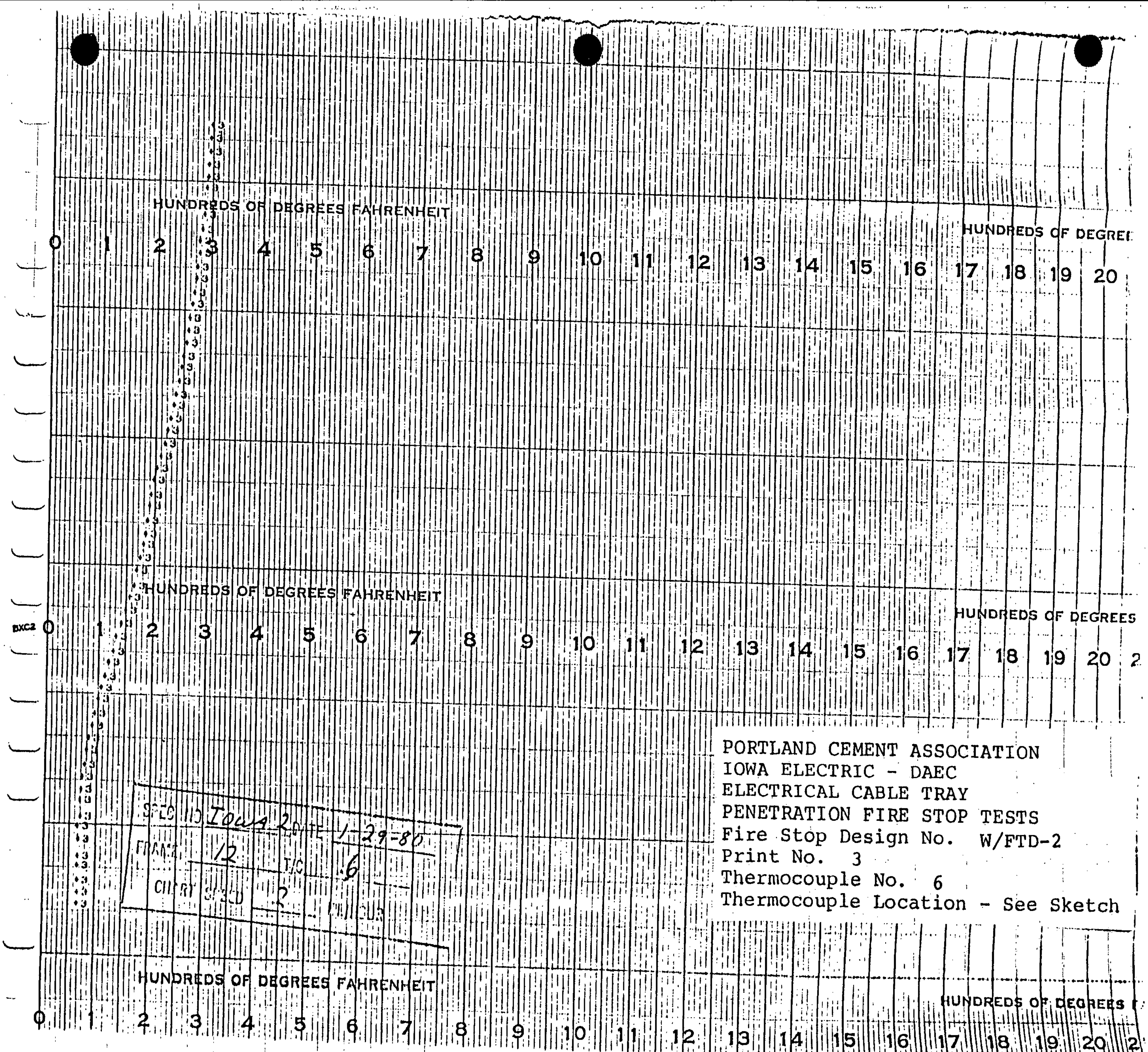
THERMOCOUPLE LOCATIONS - TEST 2



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 1
Thermocouple No. 8
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 2
Thermocouple No. 3
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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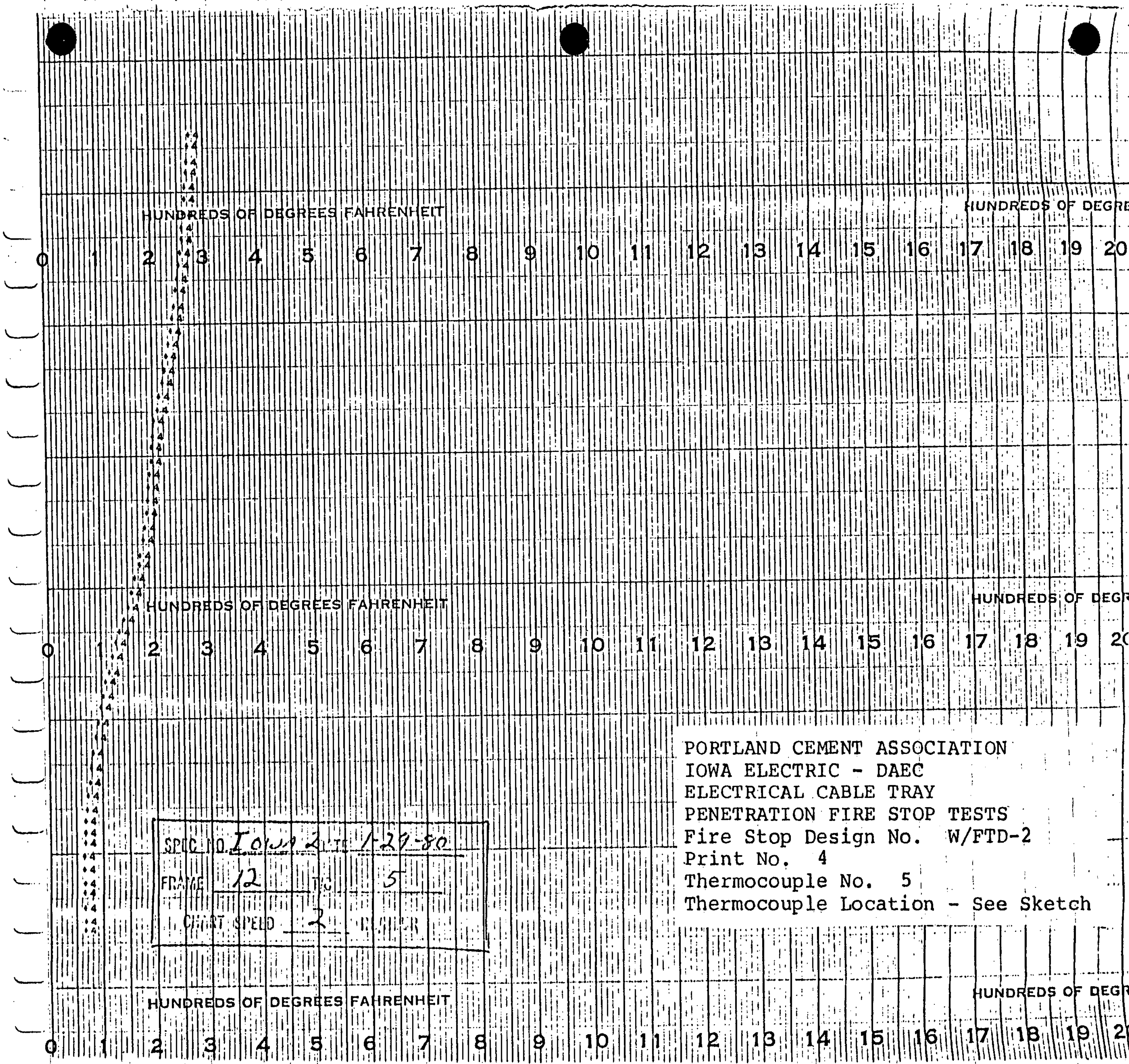
Print No. 3
Thermocouple No. 6
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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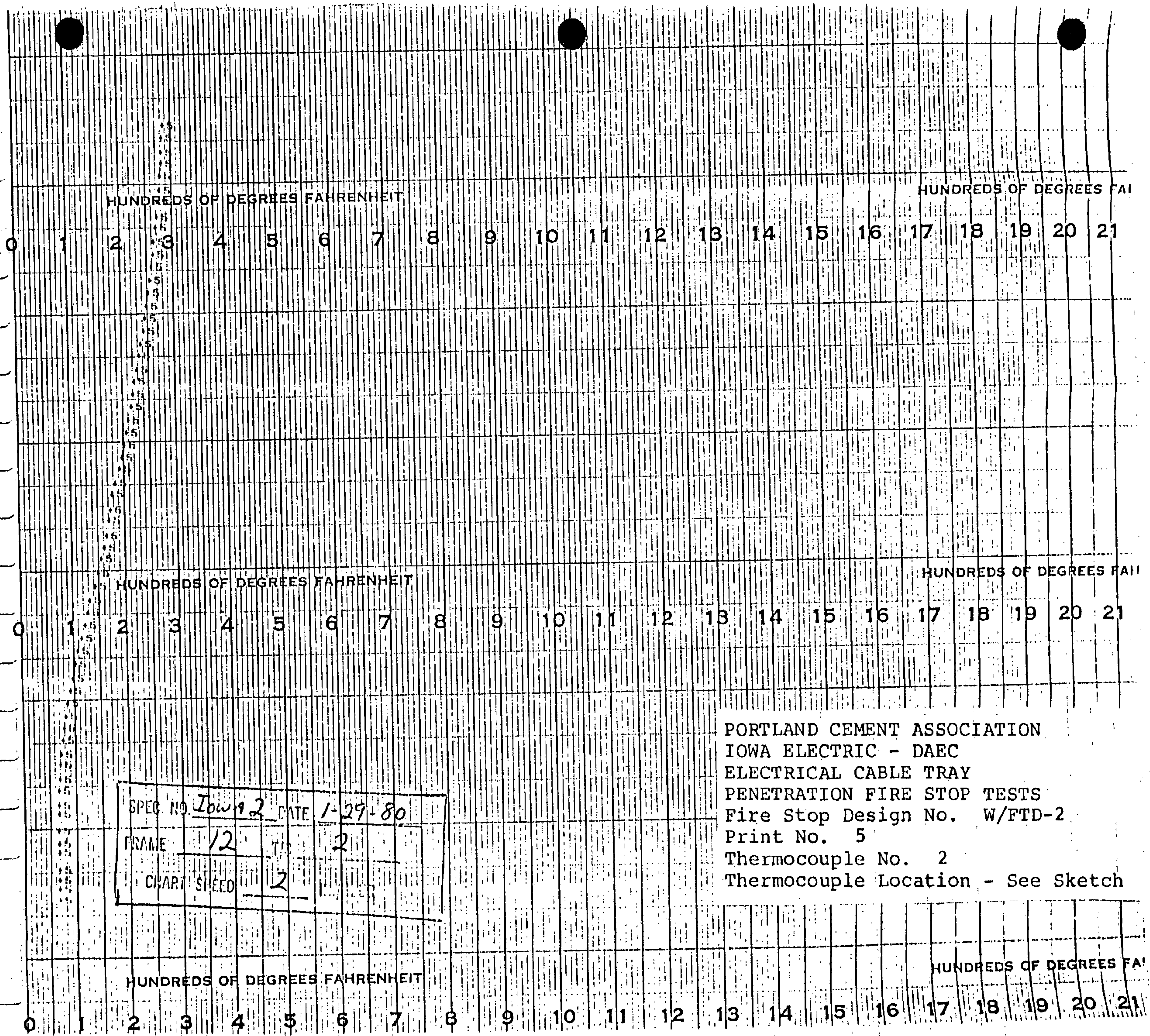
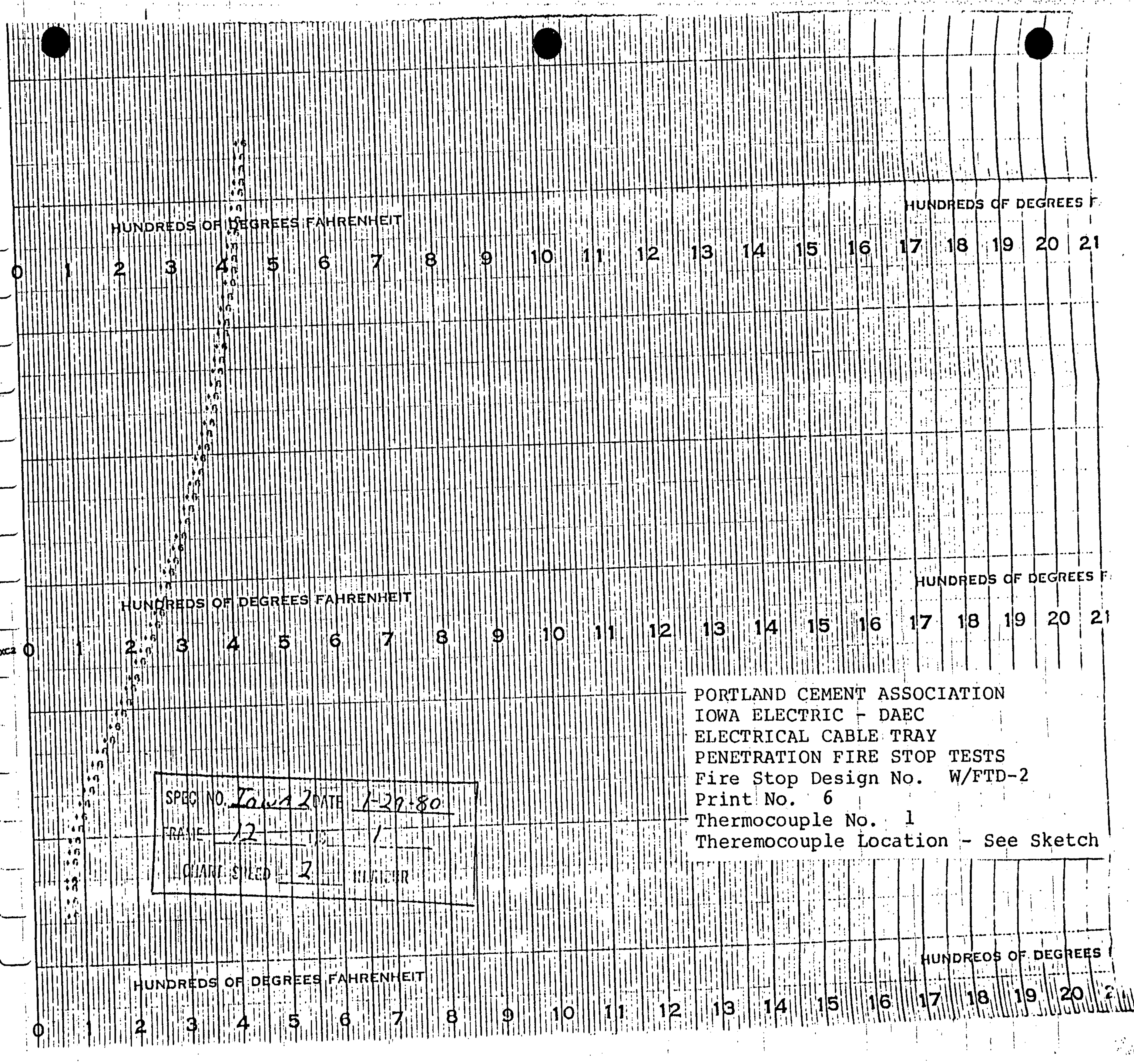
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 4
Thermocouple No. 5
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 5
Thermocouple No. 2
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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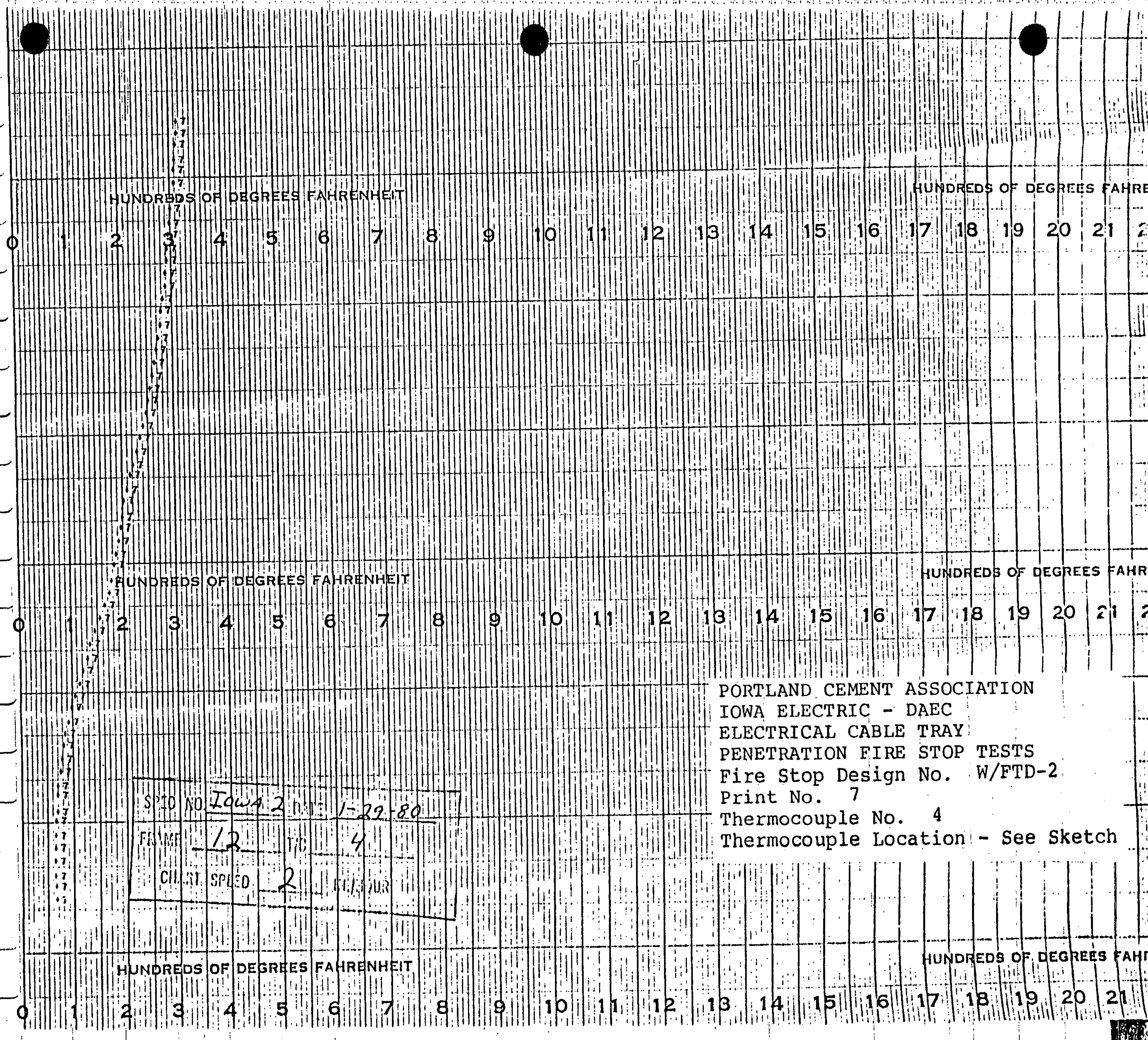
Thermocouple No. 1
Theremocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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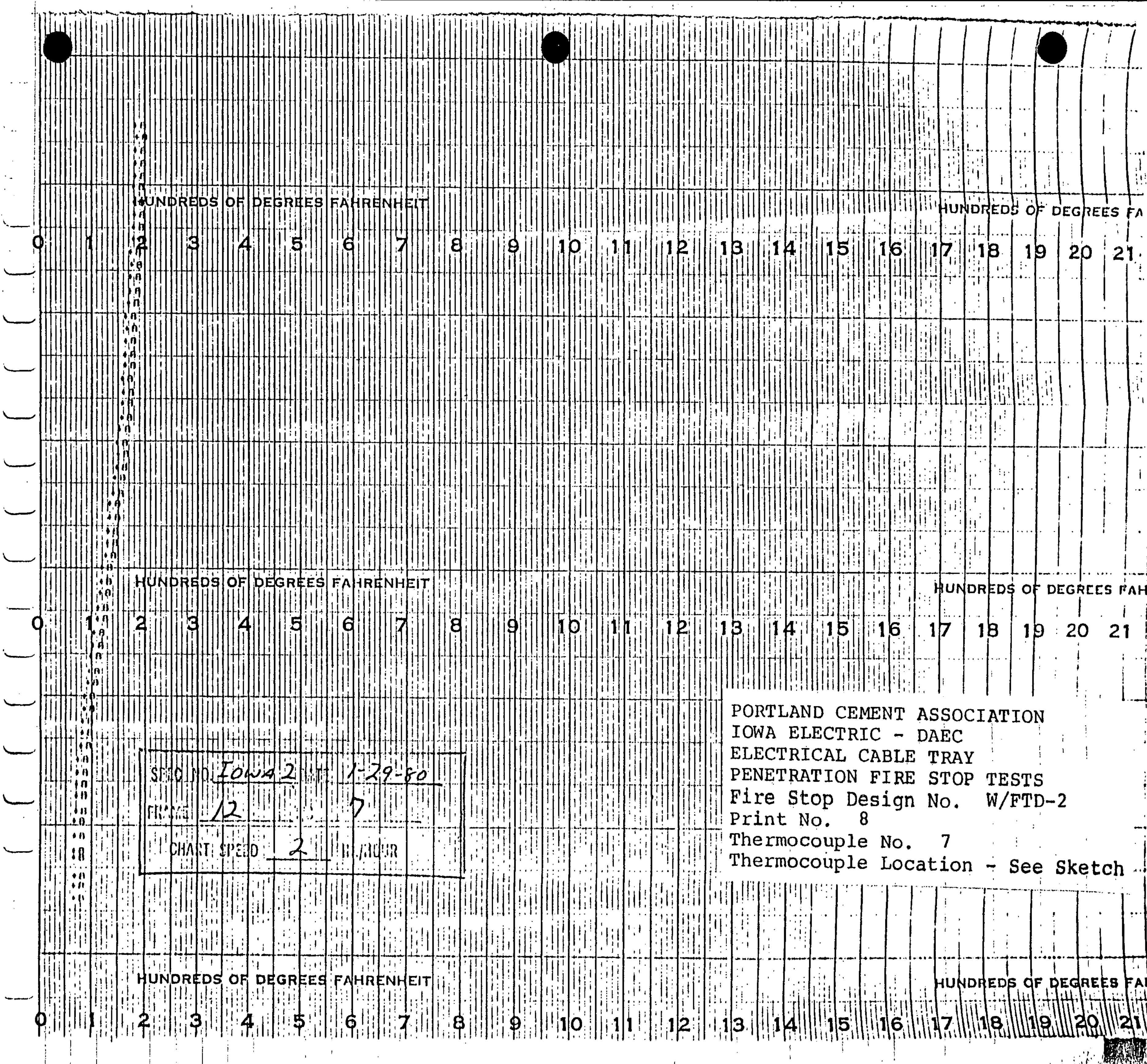
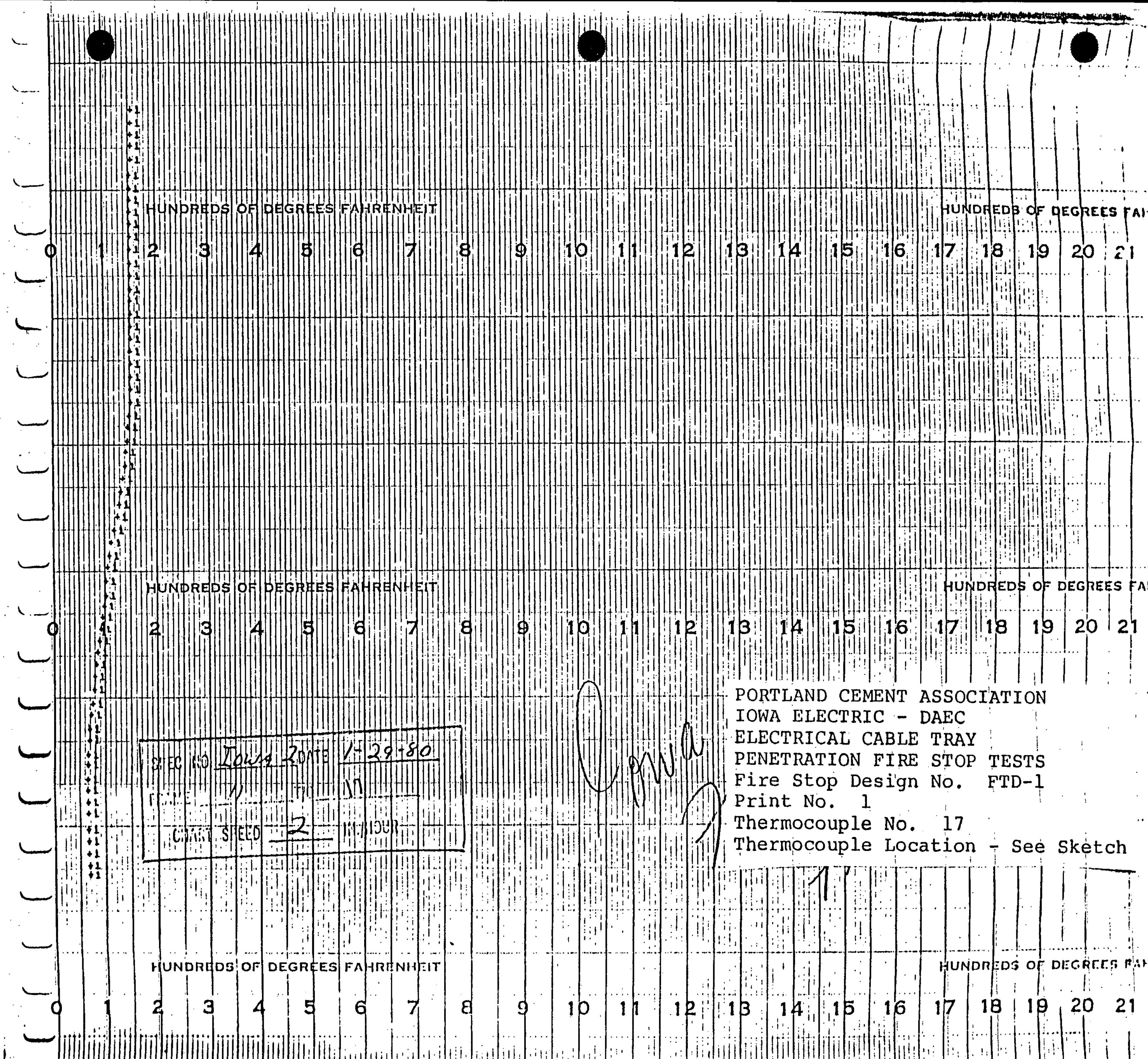
Fire Stop Design No. W/FTD-2
Print No. 7
Thermocouple No. 4
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 8
Thermocouple No. 7
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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Fire Stop Design No. FTD-1
Print No. 1
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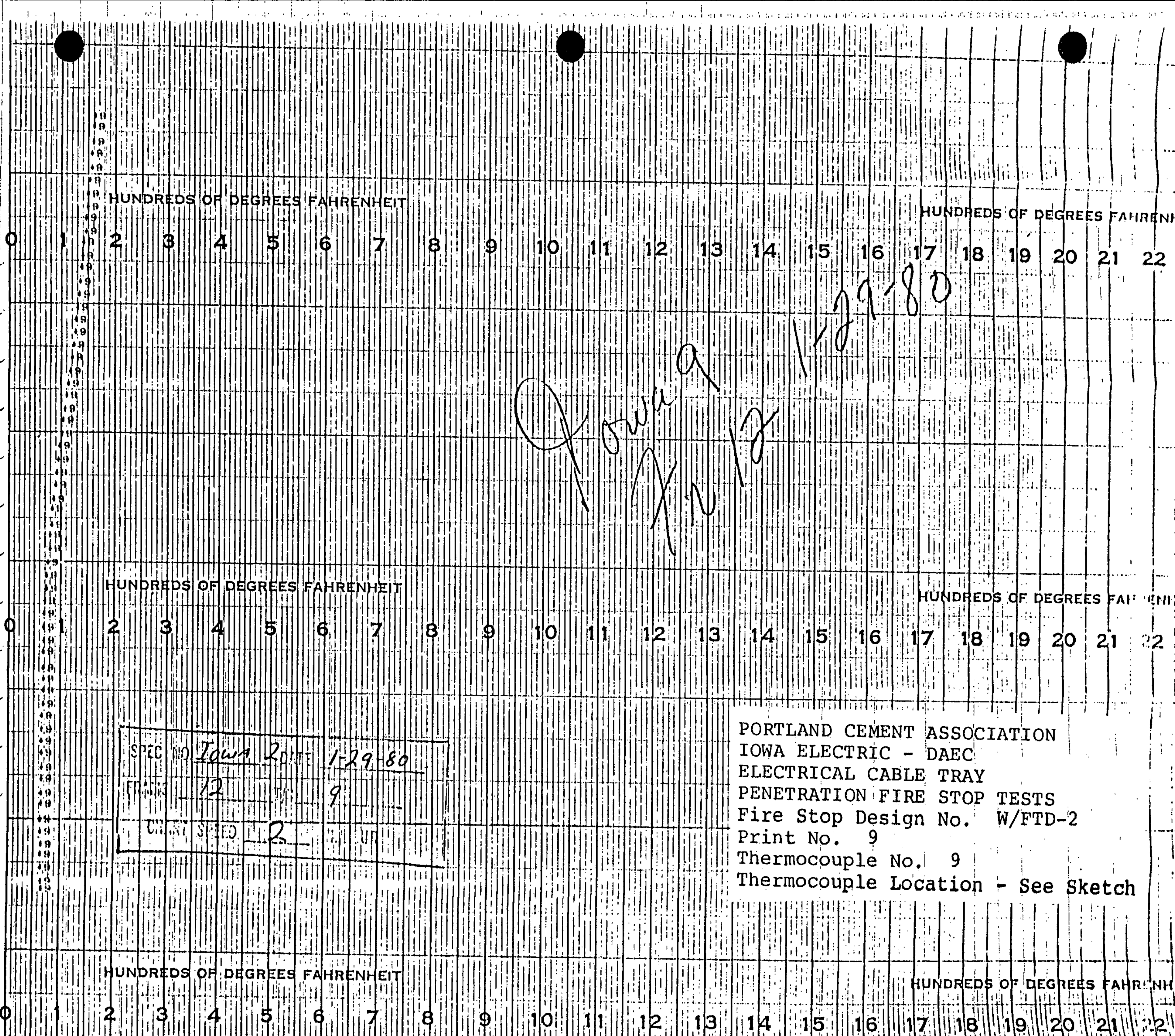
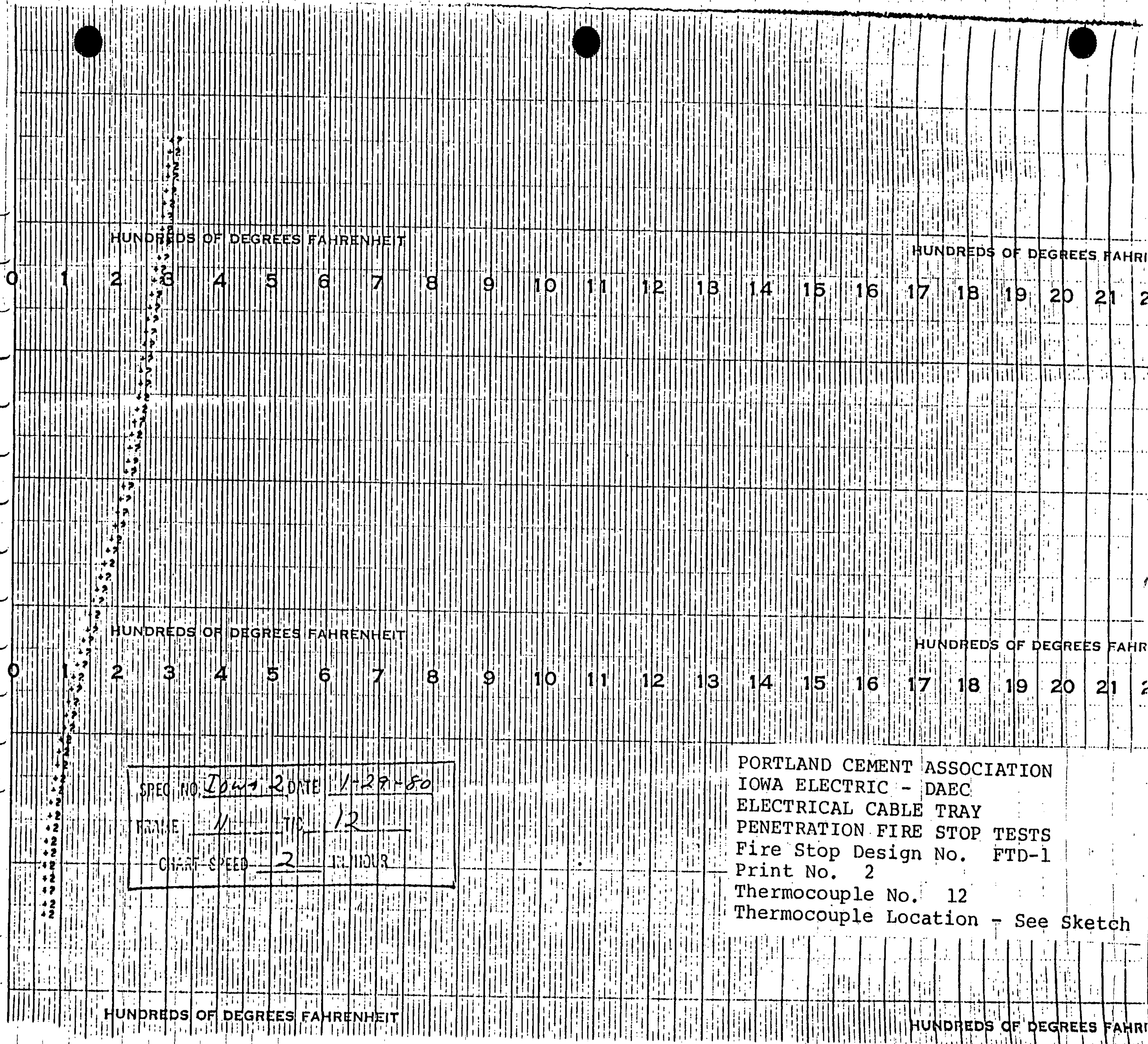
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. W/FTD-2
Print No. 9
Thermocouple No. 9
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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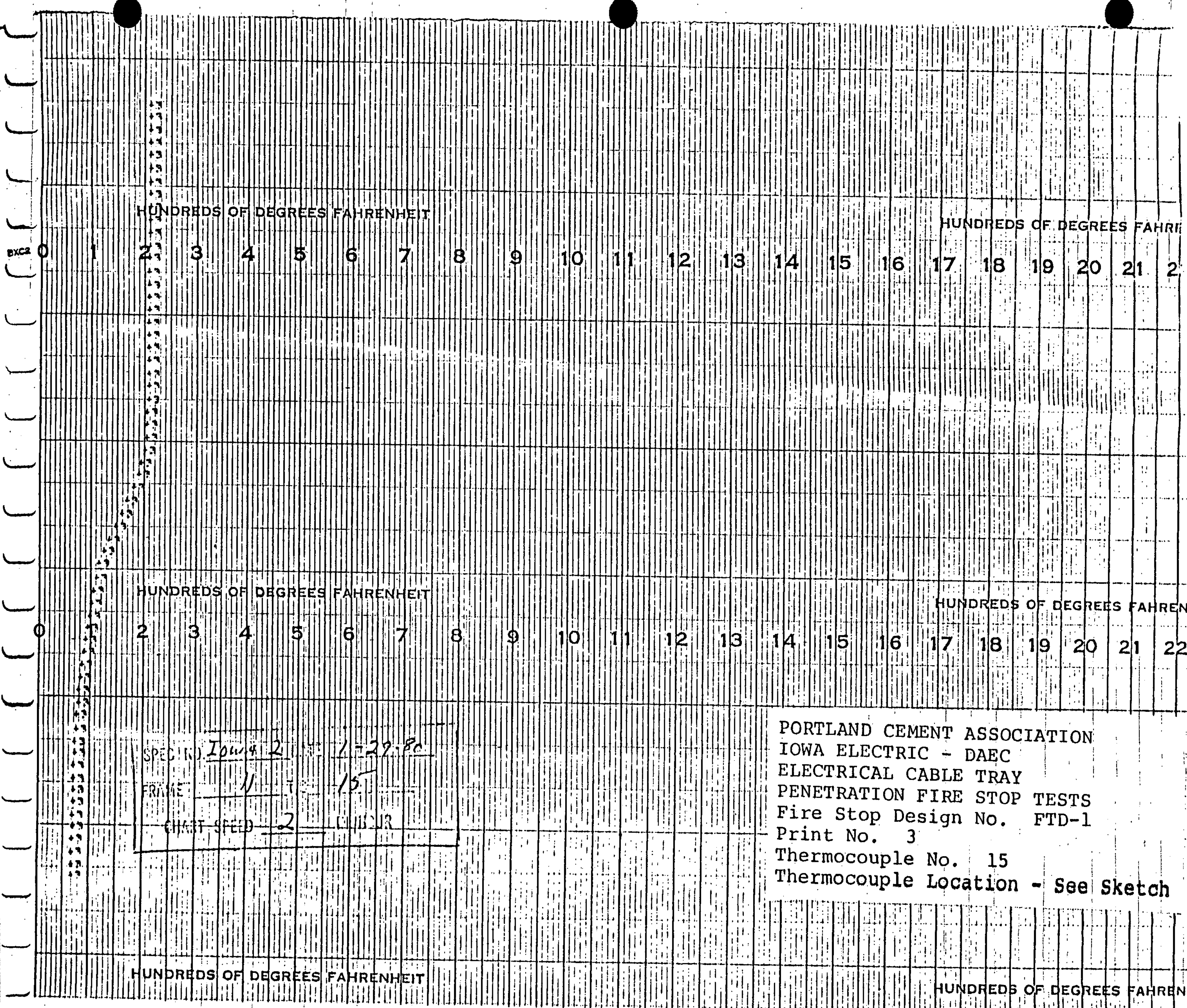
Print No. 2
Thermocouple No. 12
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
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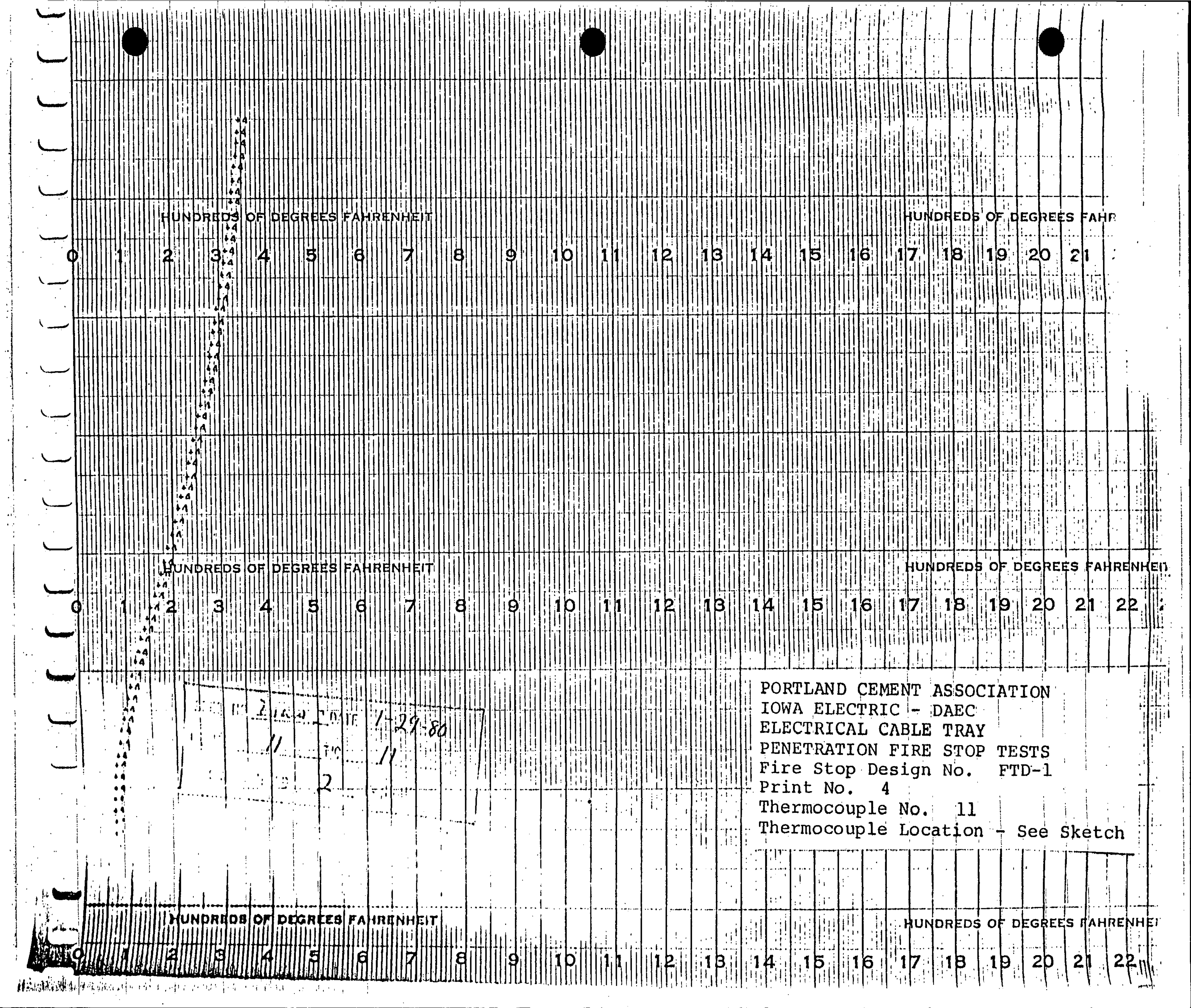
Print No. 3
Thermocouple No. 15
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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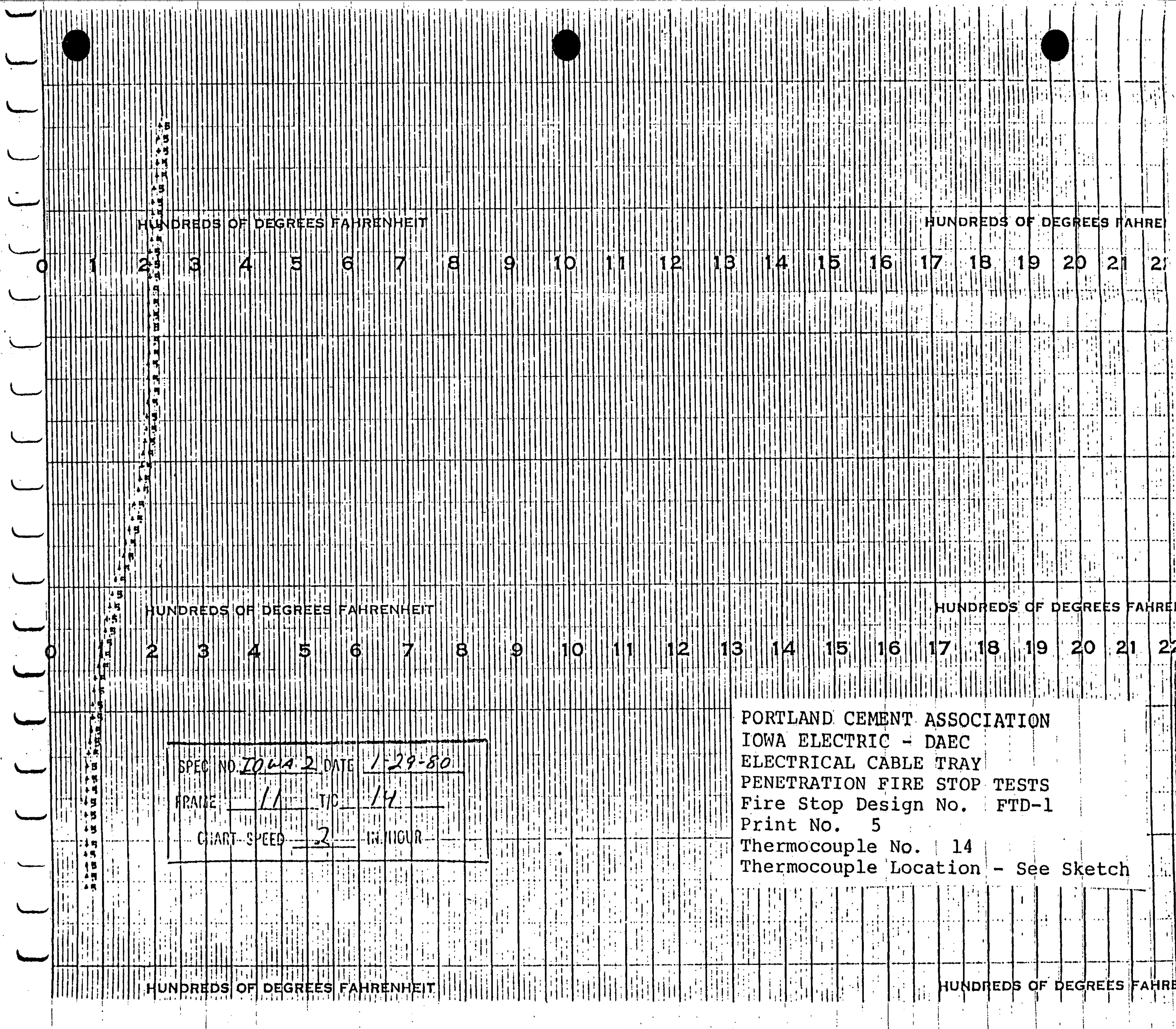
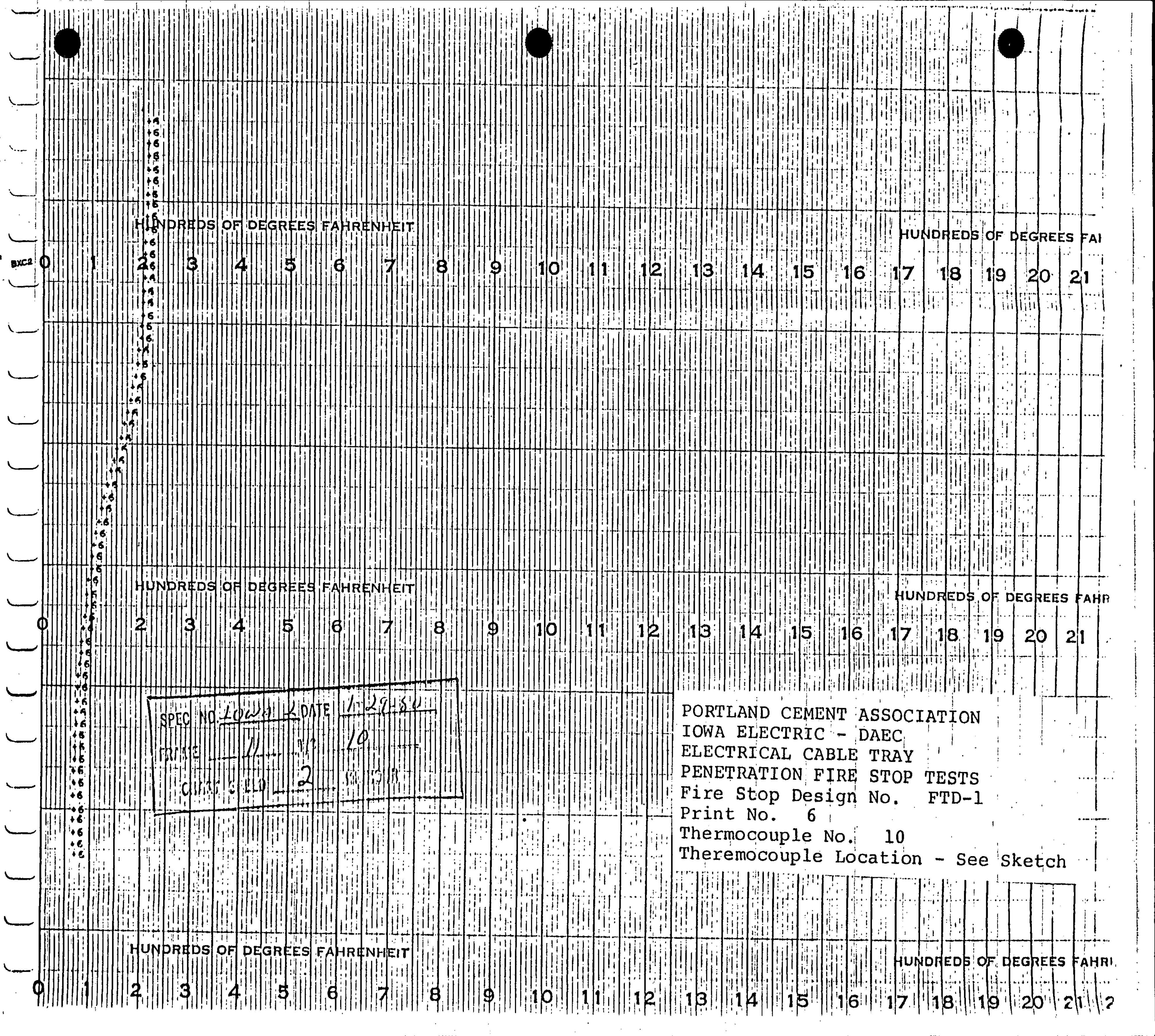
Thermocouple No. 11
Thermocouple Location - See Sketch



SPEC NO. IOWA 2 DATE 1-29-80
FRAME 11 T/C 14
CHART SPEED 2 IN/HOUR

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FTD-1
Print No. 5
Thermocouple No. 14
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
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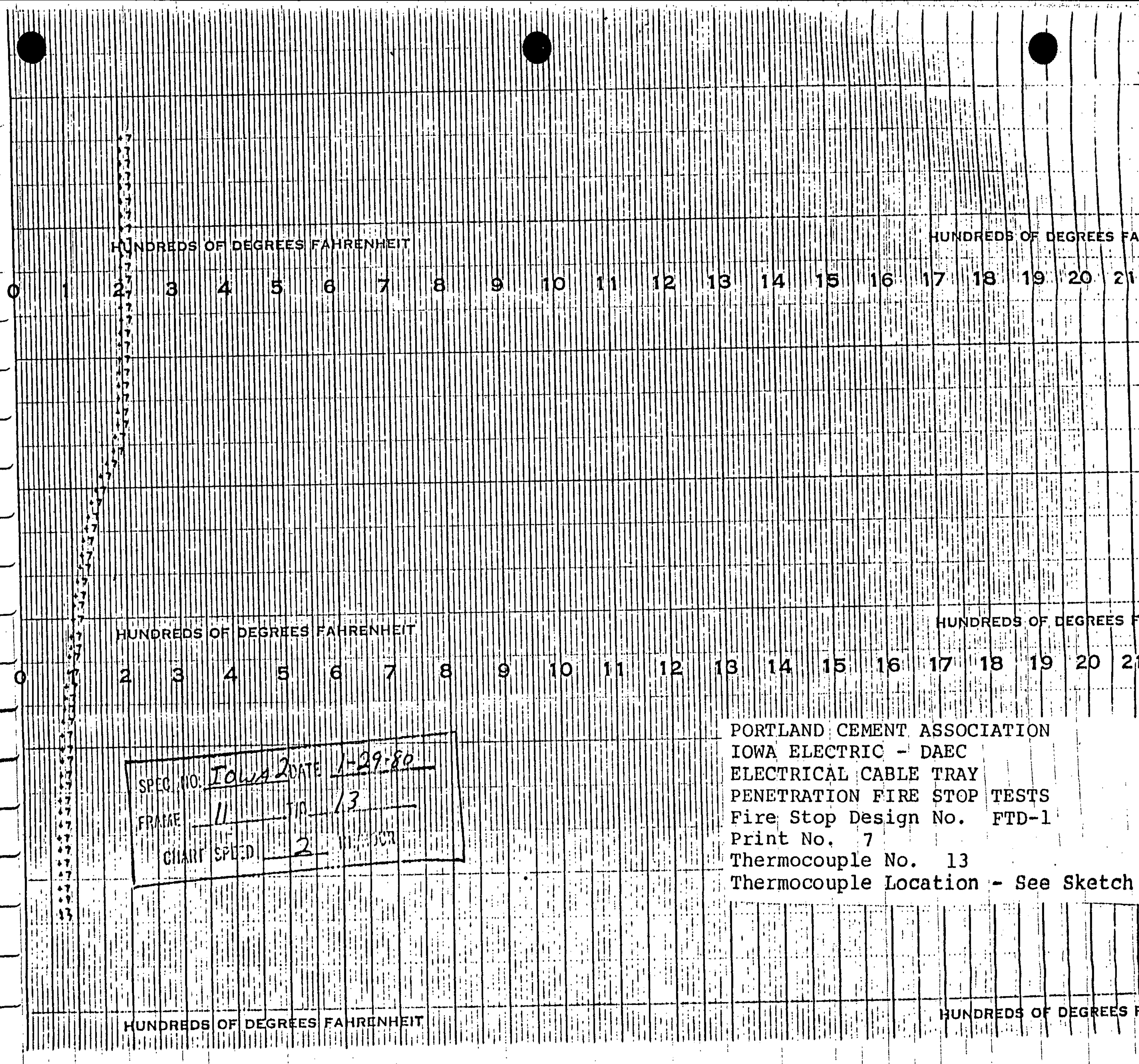
Thermocouple No. 10
Theremocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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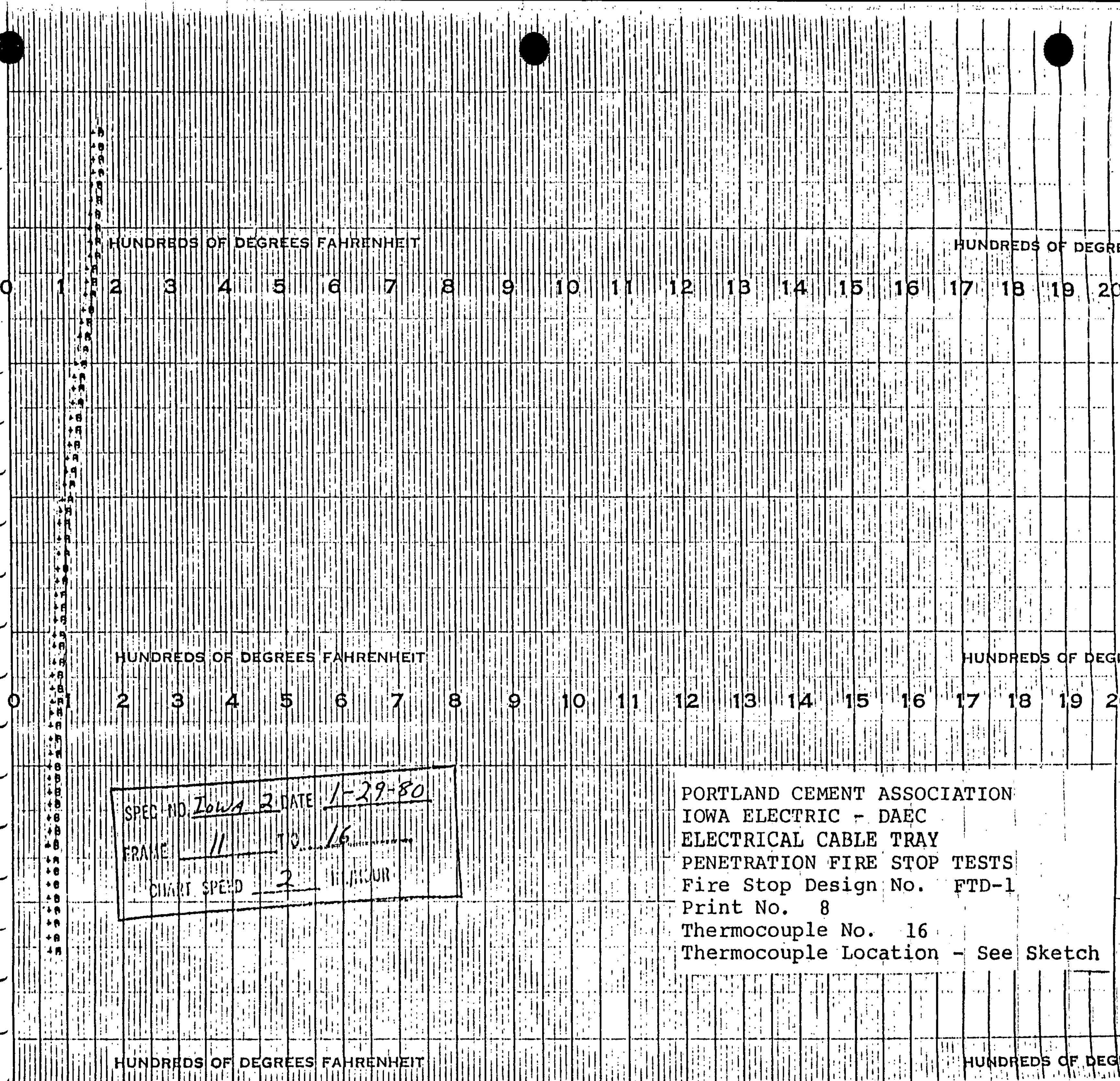
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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ELECTRICAL CABLE TRAY
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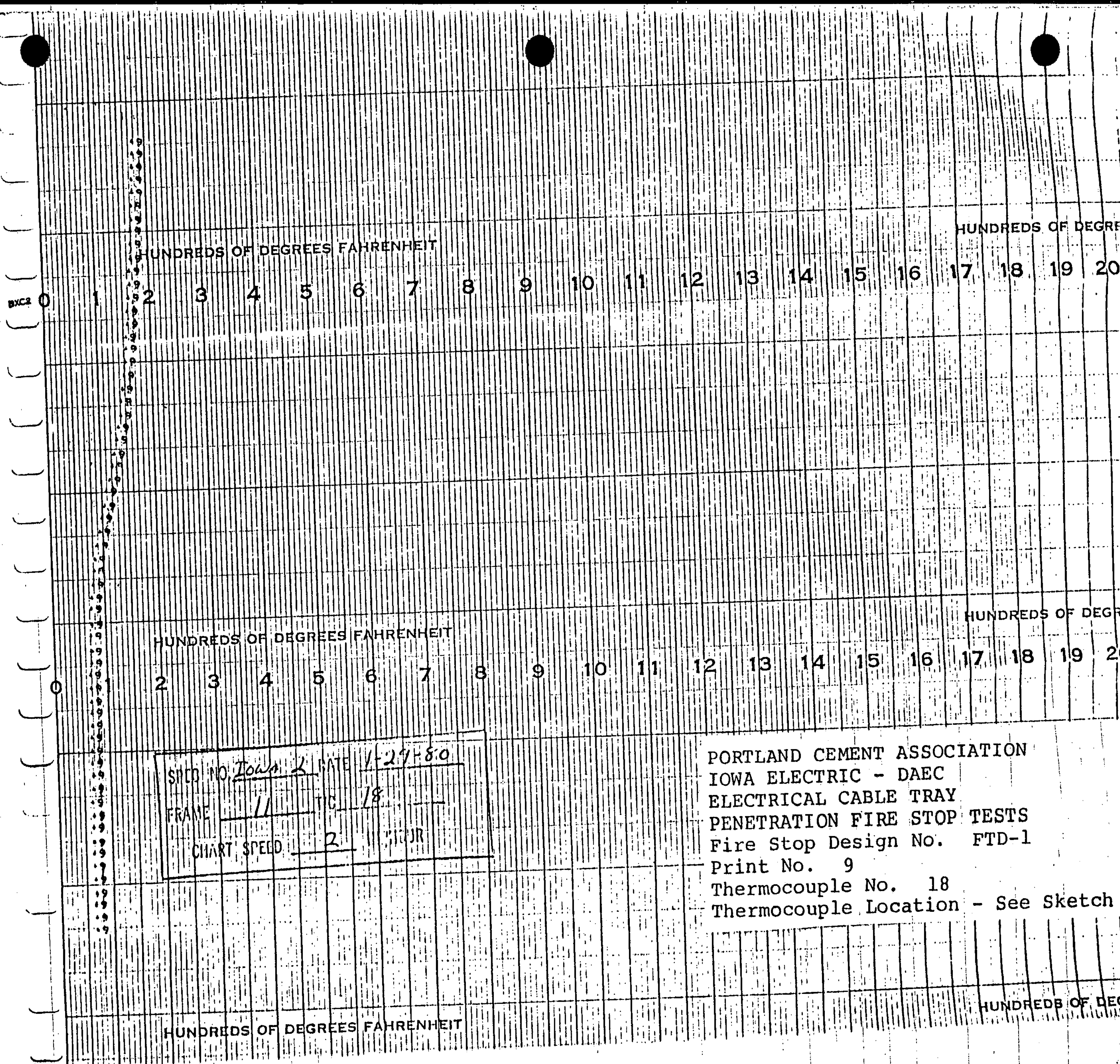
Thermocouple No. 16
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FTD-1
Print No. 9
Thermocouple No. 18
Thermocouple Location - See Sketch

HUNDREDS OF DEGREES FAHRENHEIT

0 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

HUNDREDS OF DEGREES FAHRENHEIT

0 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

IOWA 2

11 CONCRETE SURFACE

2

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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Fire Stop Design No. N/A
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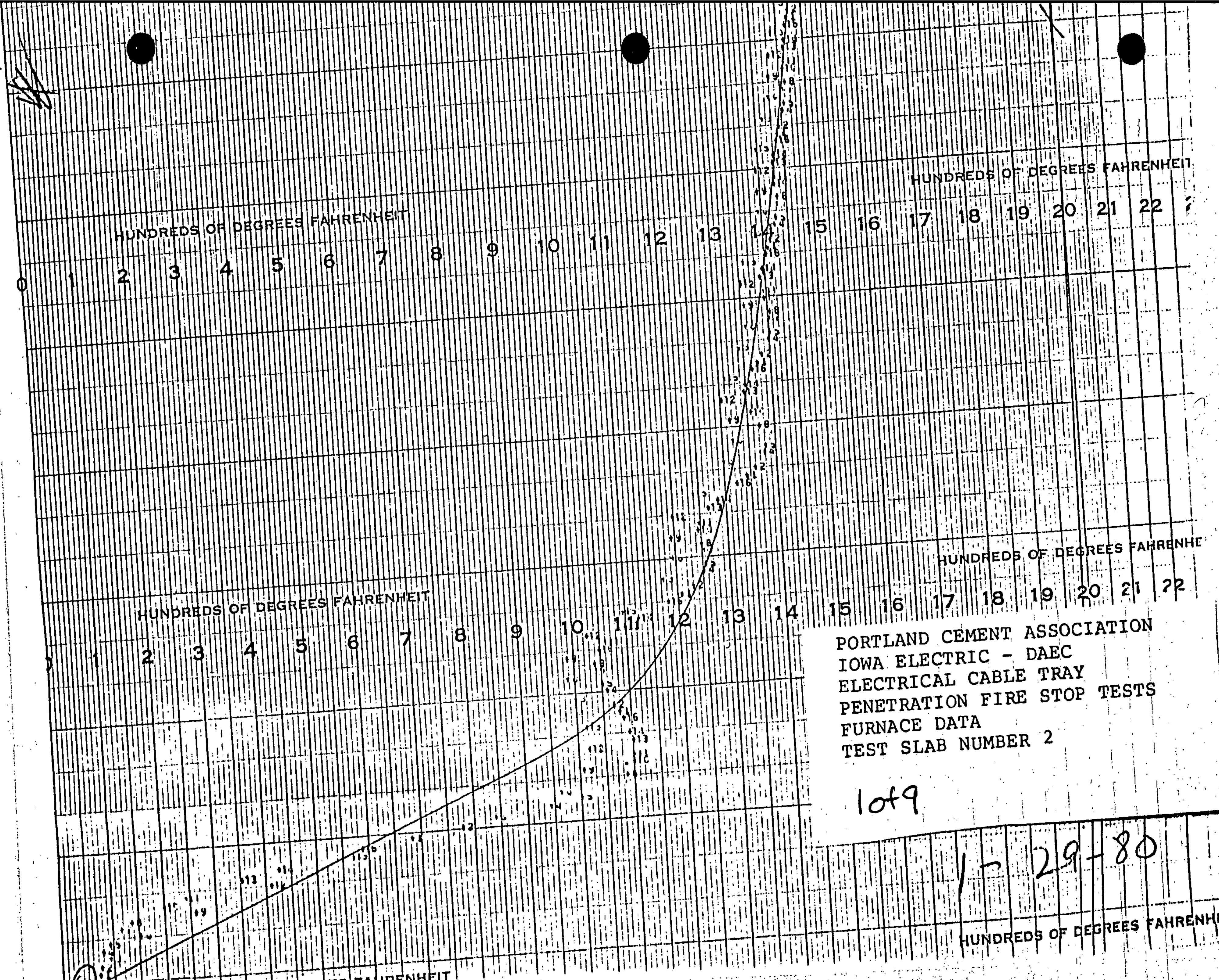
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
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PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 2

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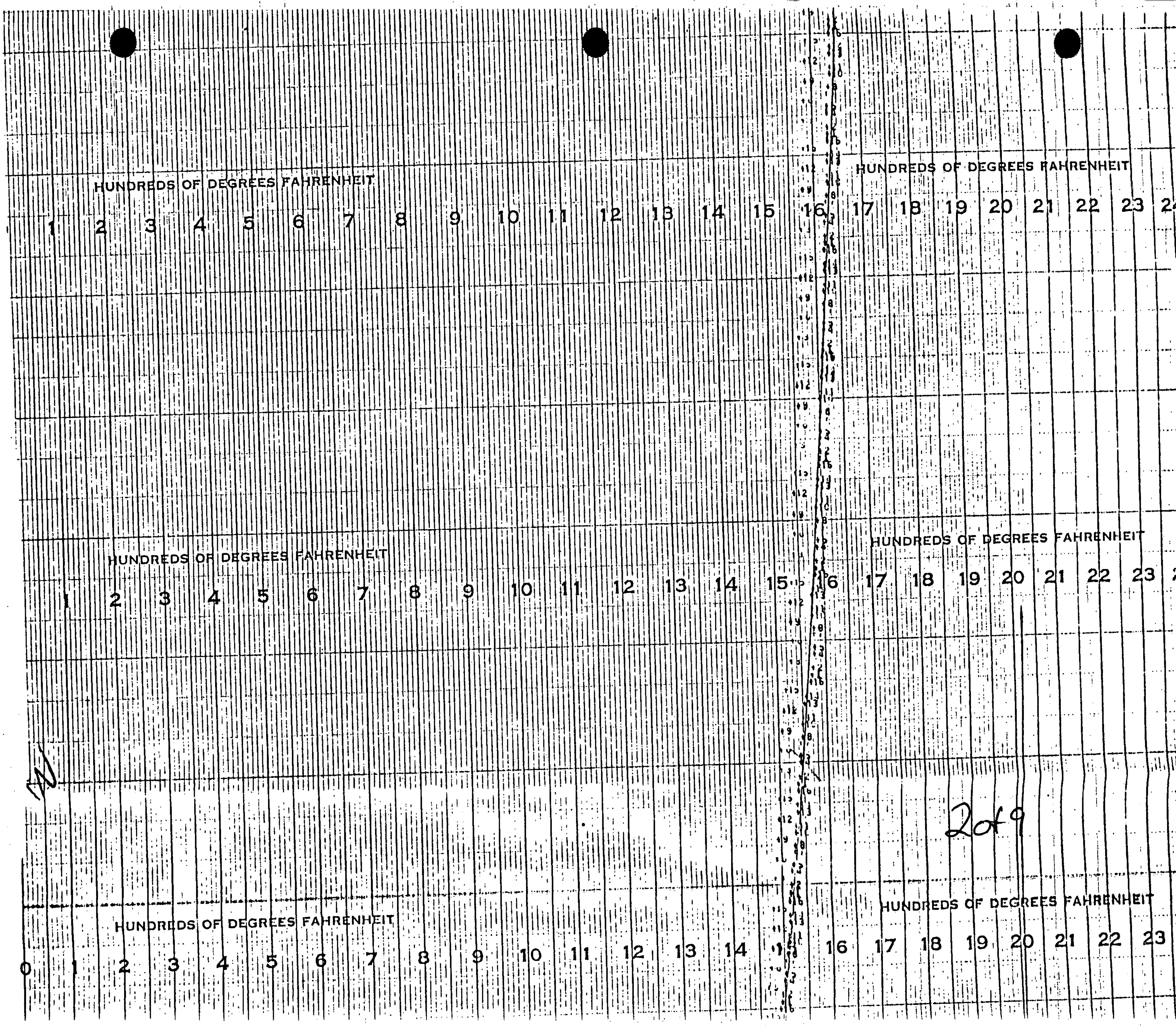
1-29-80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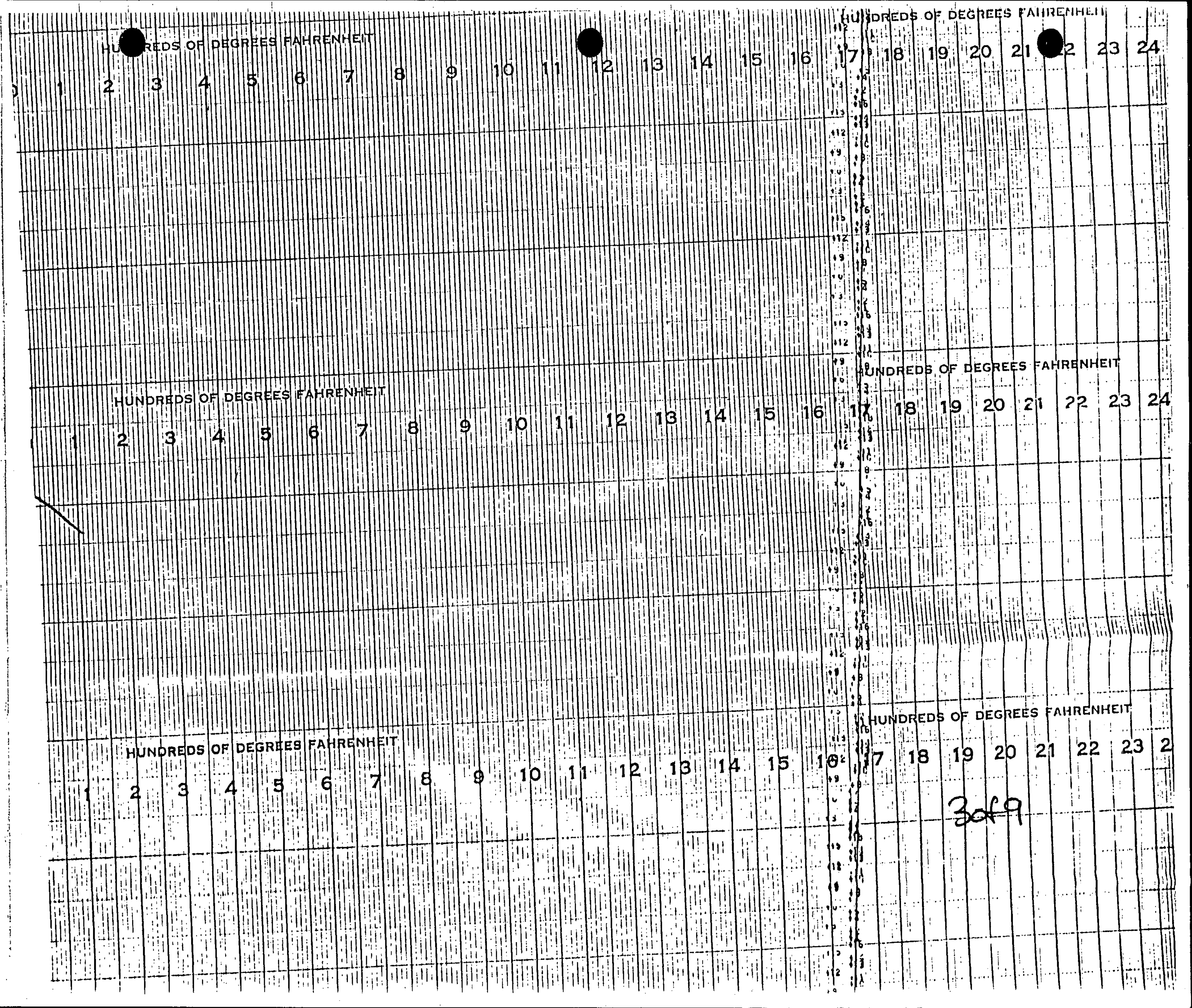
HUNDREDS OF DEGREES FAHRENHEIT
2 of 9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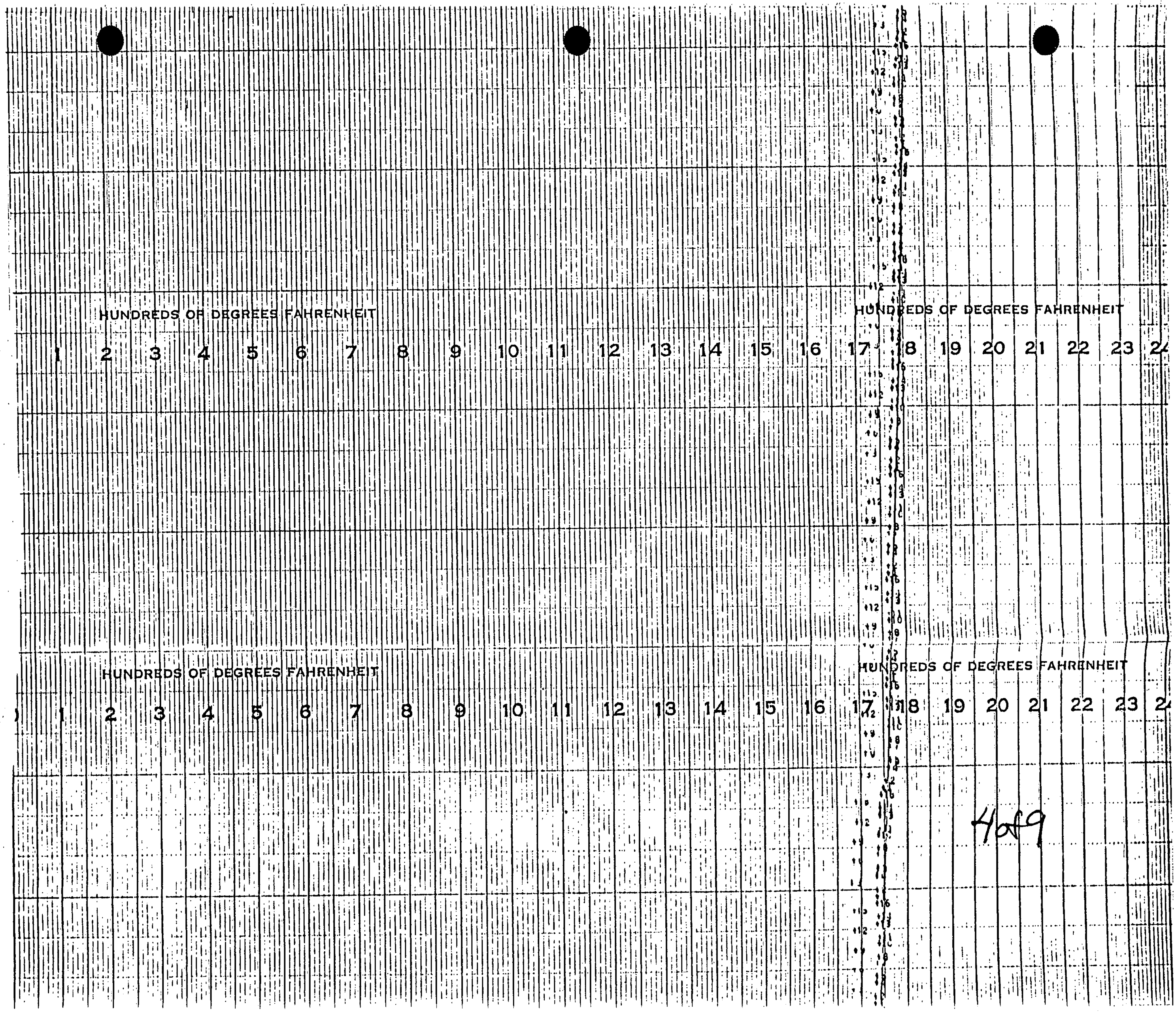
3 of 9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HUNDREDS OF DEGREES FAHRENHEIT

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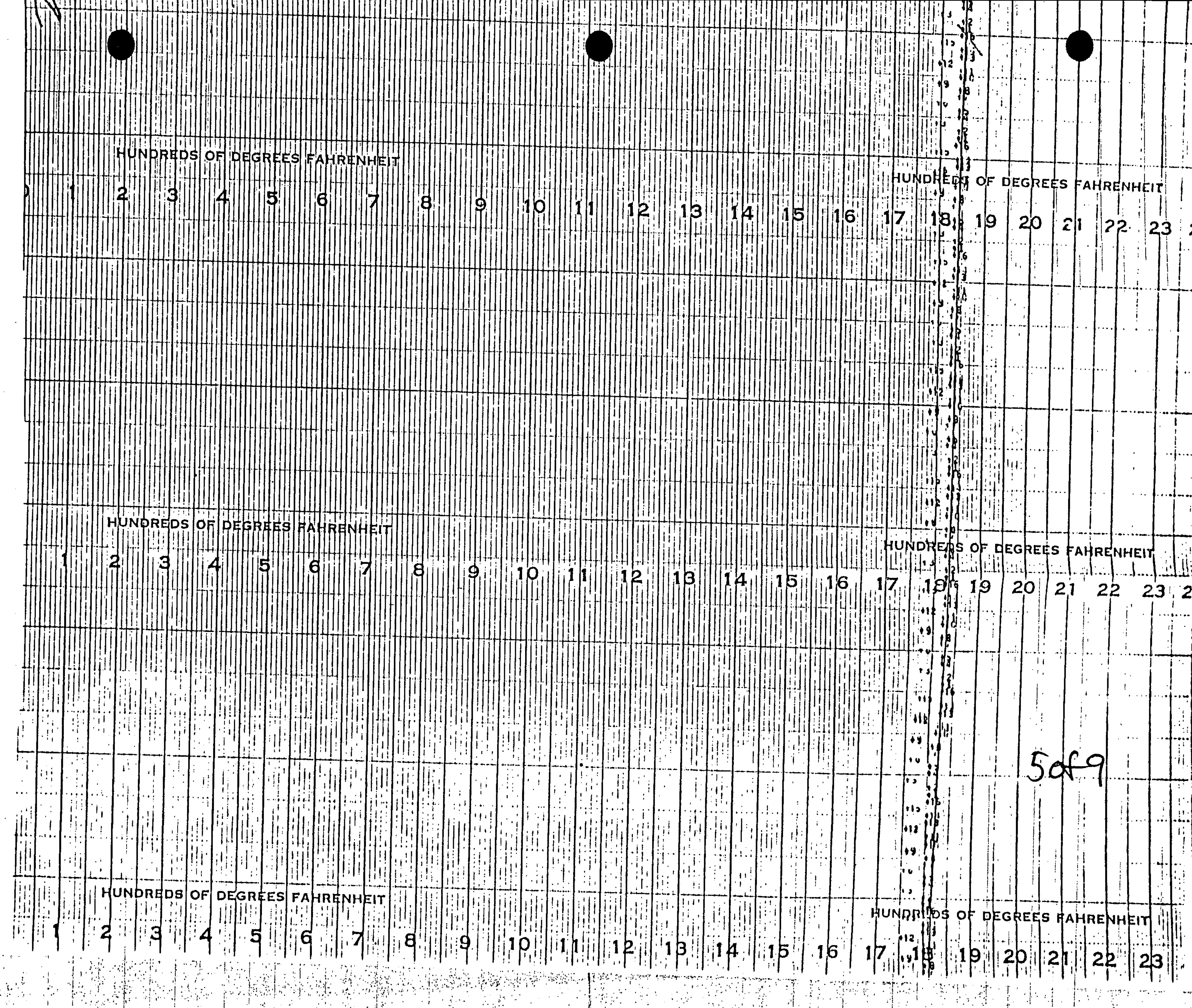
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
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19 20 21 22 23
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
HUNDREDS OF DEGREES FAHRENHEIT
19 20 21 22 23

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HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

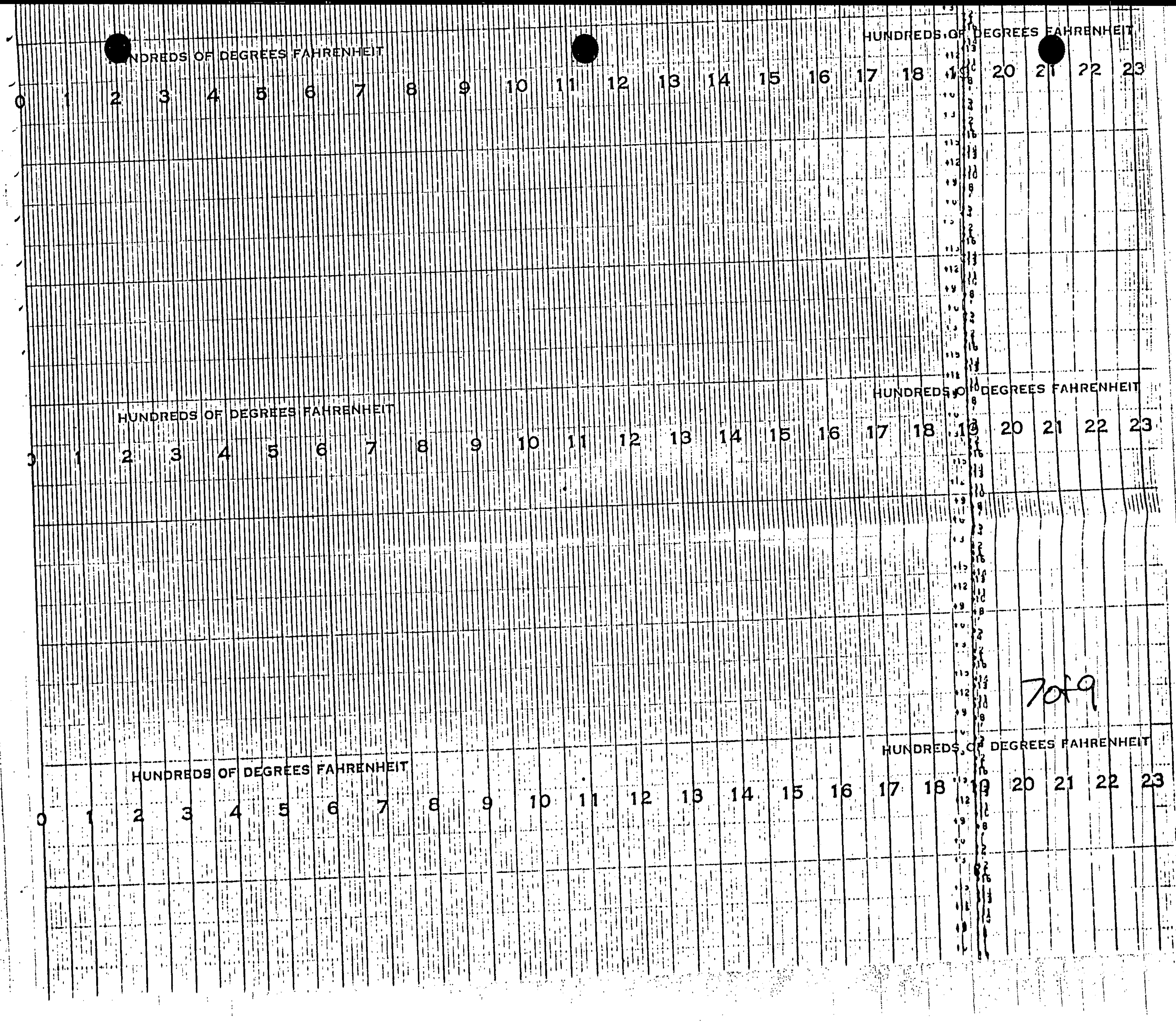
HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

6 of 9

HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23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7of9

M

HUNDREDS OF DEGREES FAHRENHEIT

HUNDREDS OF DEGREES FAHRENHEIT

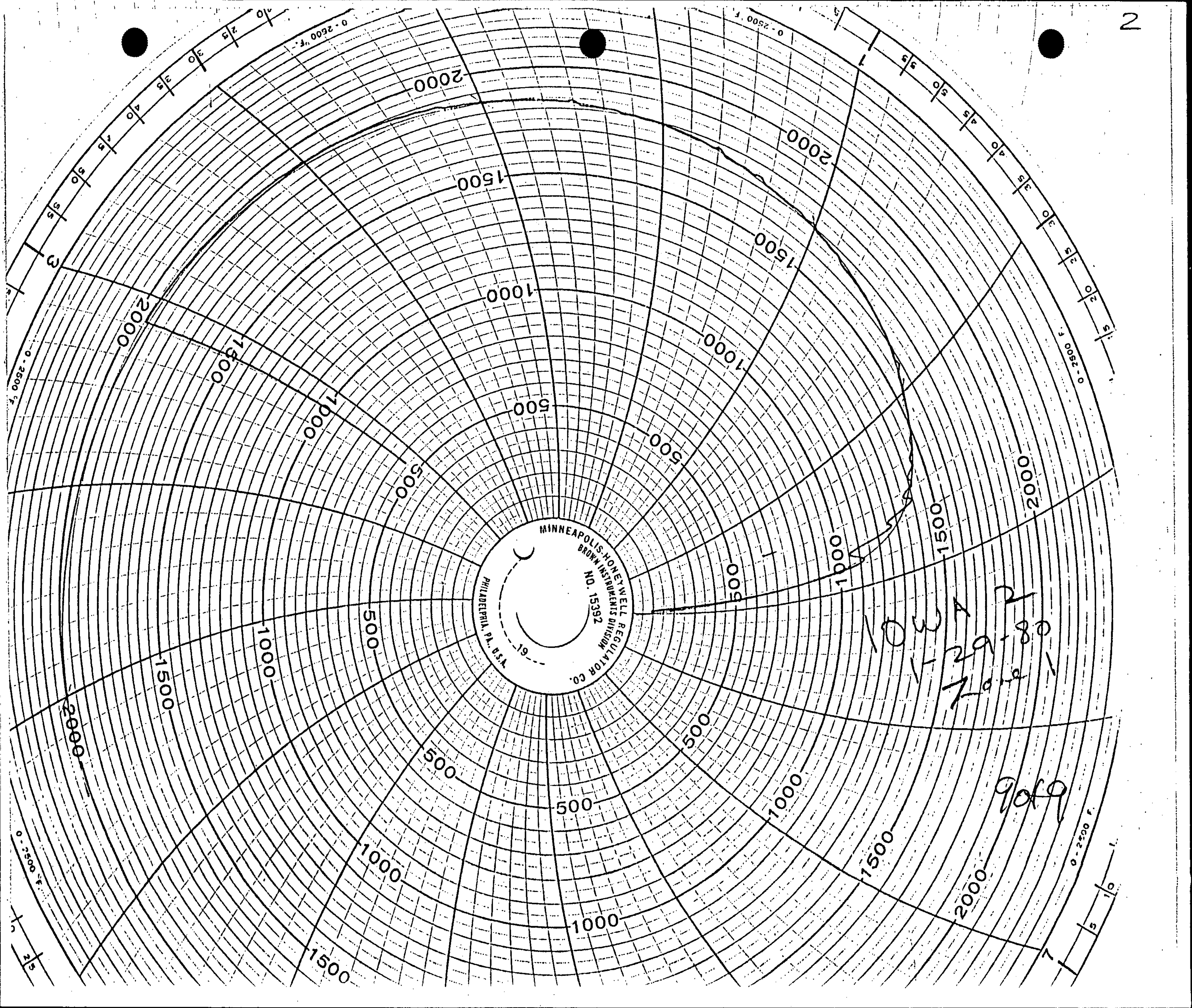
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

HUNDREDS OF DEGREES FAHRENHEIT

HUNDREDS OF DEGREES FAHRENHEIT

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

8 of 9


MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA. U.S.A.
IOWA 2
1-29-80
909

TEST SLAB NUMBER 3

DATE: 03/10/80

FIRE STOP DESIGNS TESTED: WTD-3
WTD-2

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

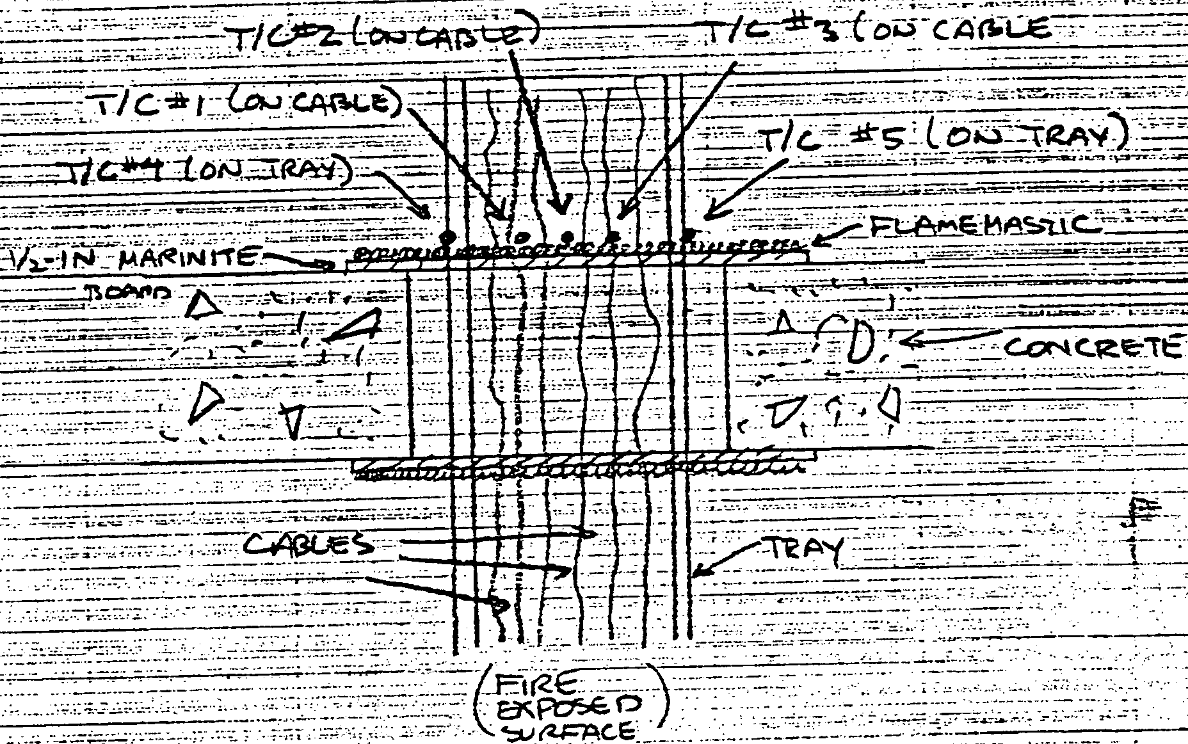
Test Witnessed by:

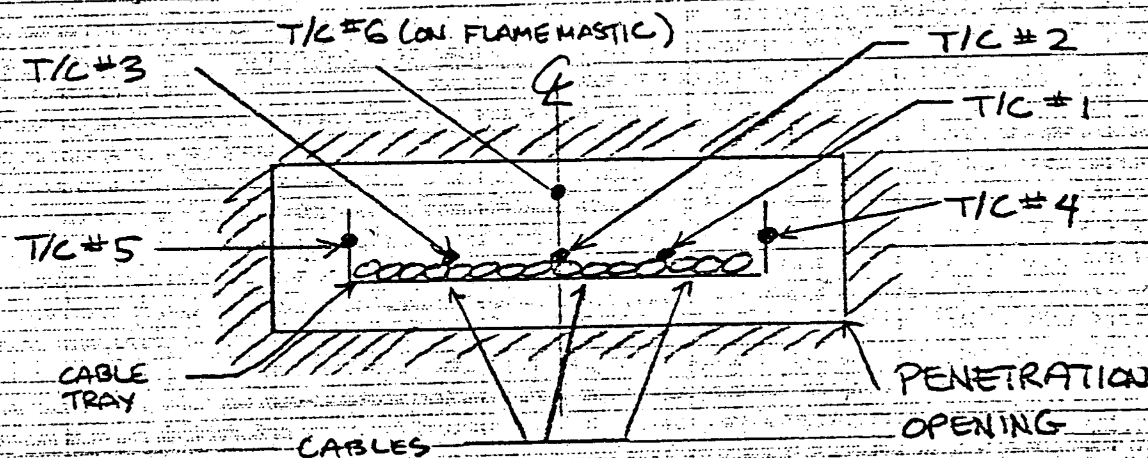
M. S. Abrams, PCA

M. Gillen, PCA

R. H. Hollenbacher, EDS

PENETRATION: T 7 (WTD-3)

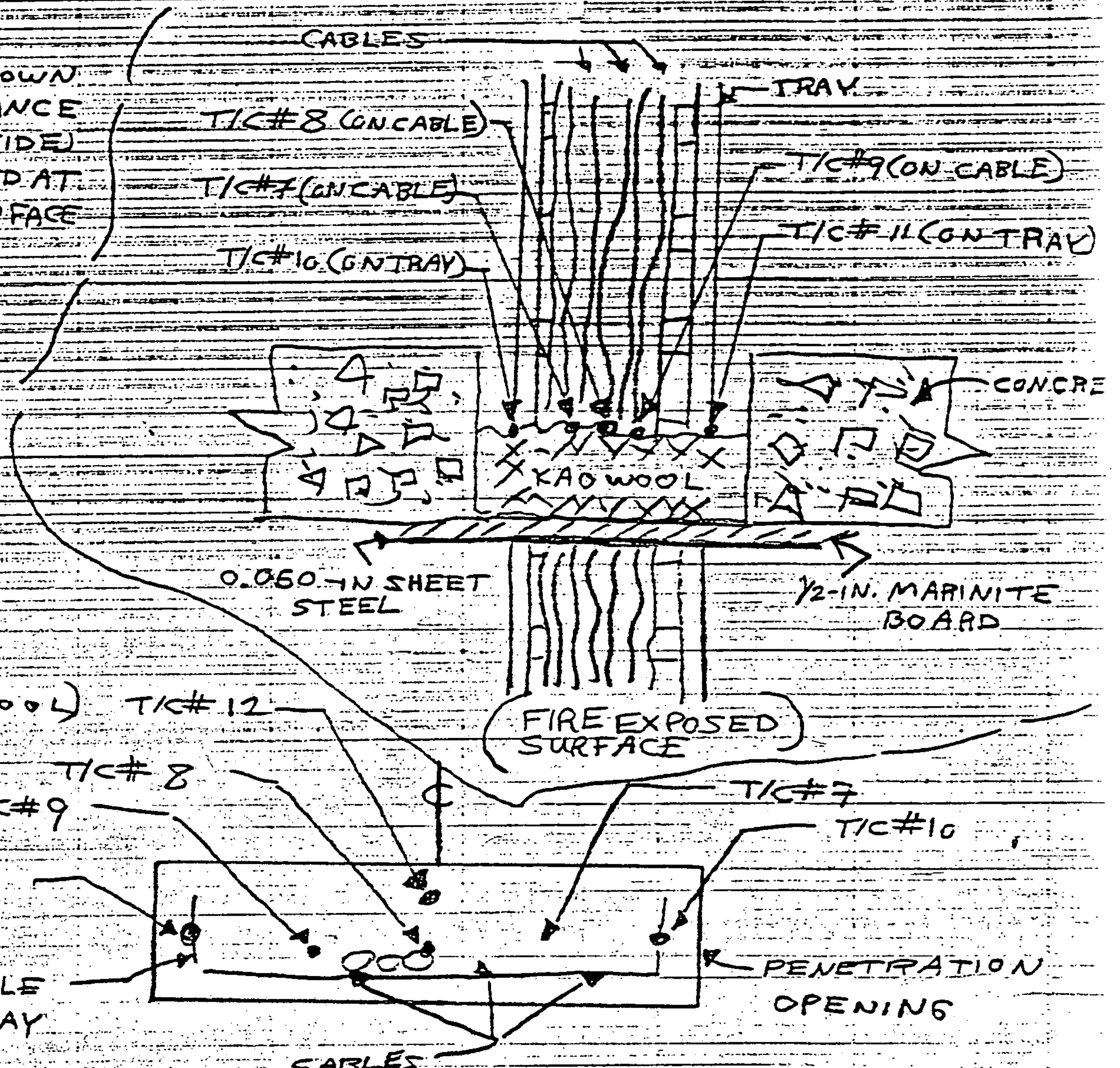




NOTE: ALL THERMOCOUPLES SHOWN ARE TOUCHING FLAMEMASTIC COATING ON THE UNEXPOSED SURFACE OF THE PENETRATION.

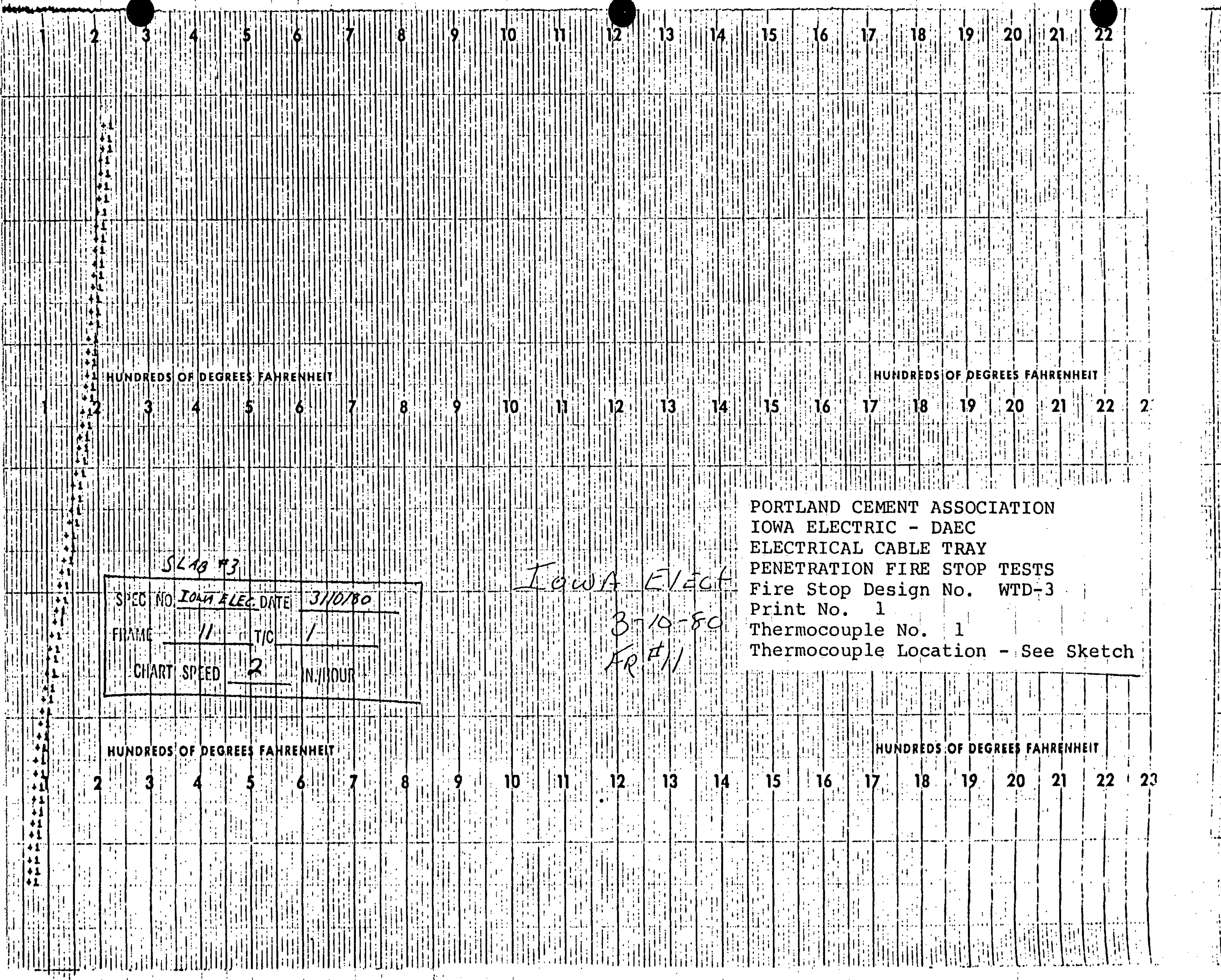
THERMOCOUPLE LOCATIONS - TEST 3

ALL THERMOCOUPLES SHOWN ARE AT THE SAME DISTANCE FROM THE BOTTOM (HOT SIDE) OF THE SLAB; LOCATED AT THE KAOWOOL/AIR INTERFACE IN THE PENETRATION.

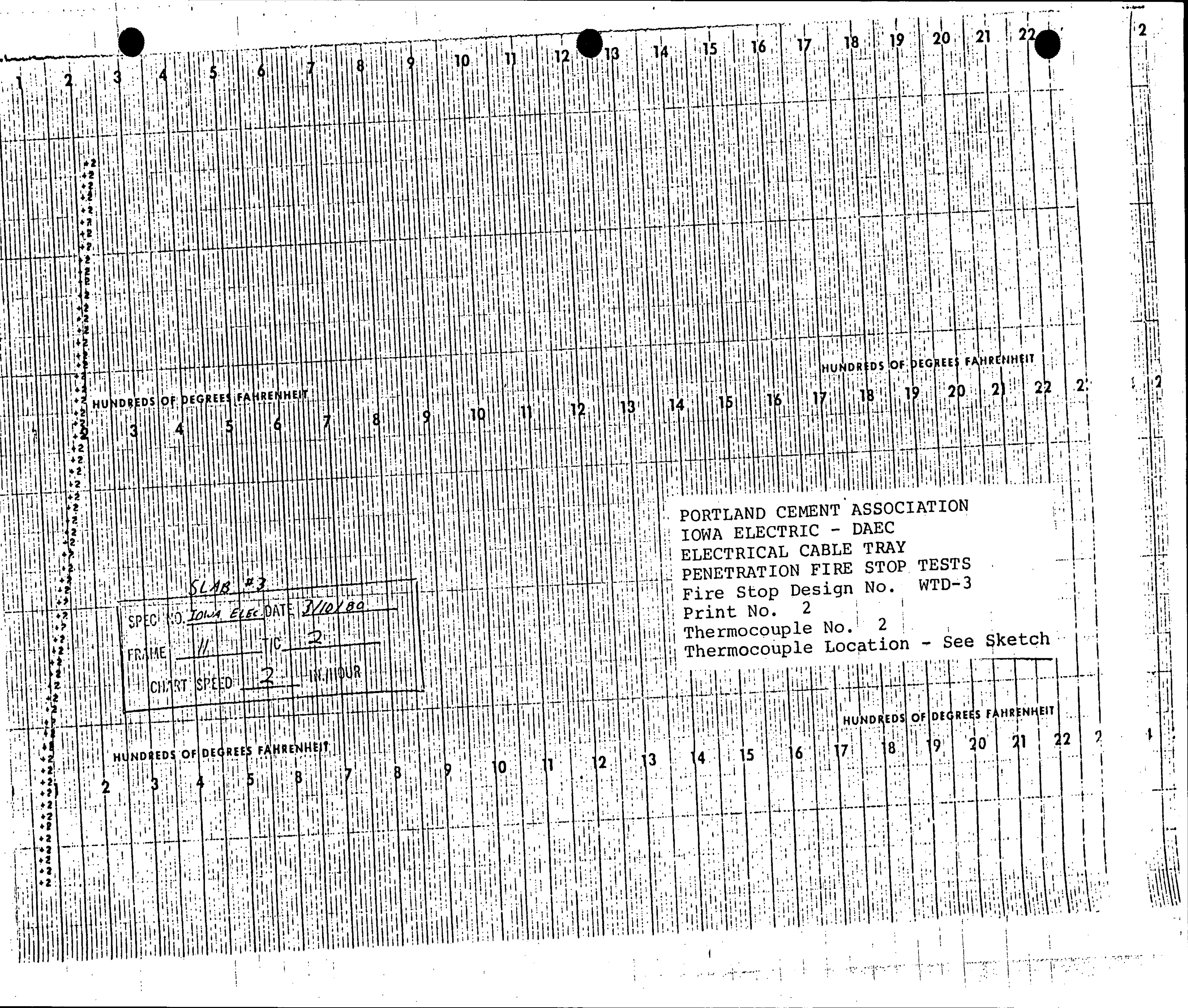


PENETRATION : T4X (WTD-2)

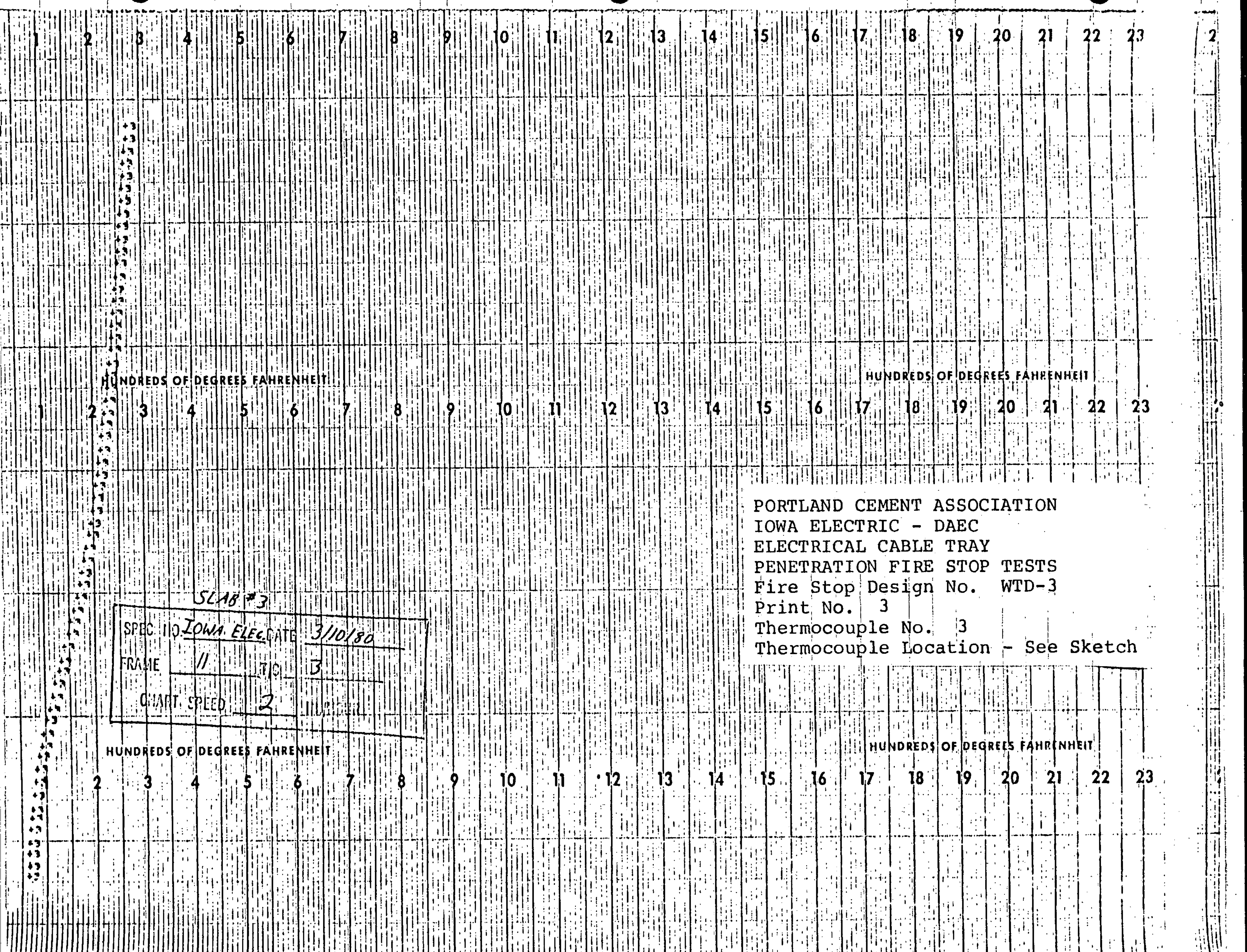
THERMOCOUPLE LOCATIONS - TEST 3



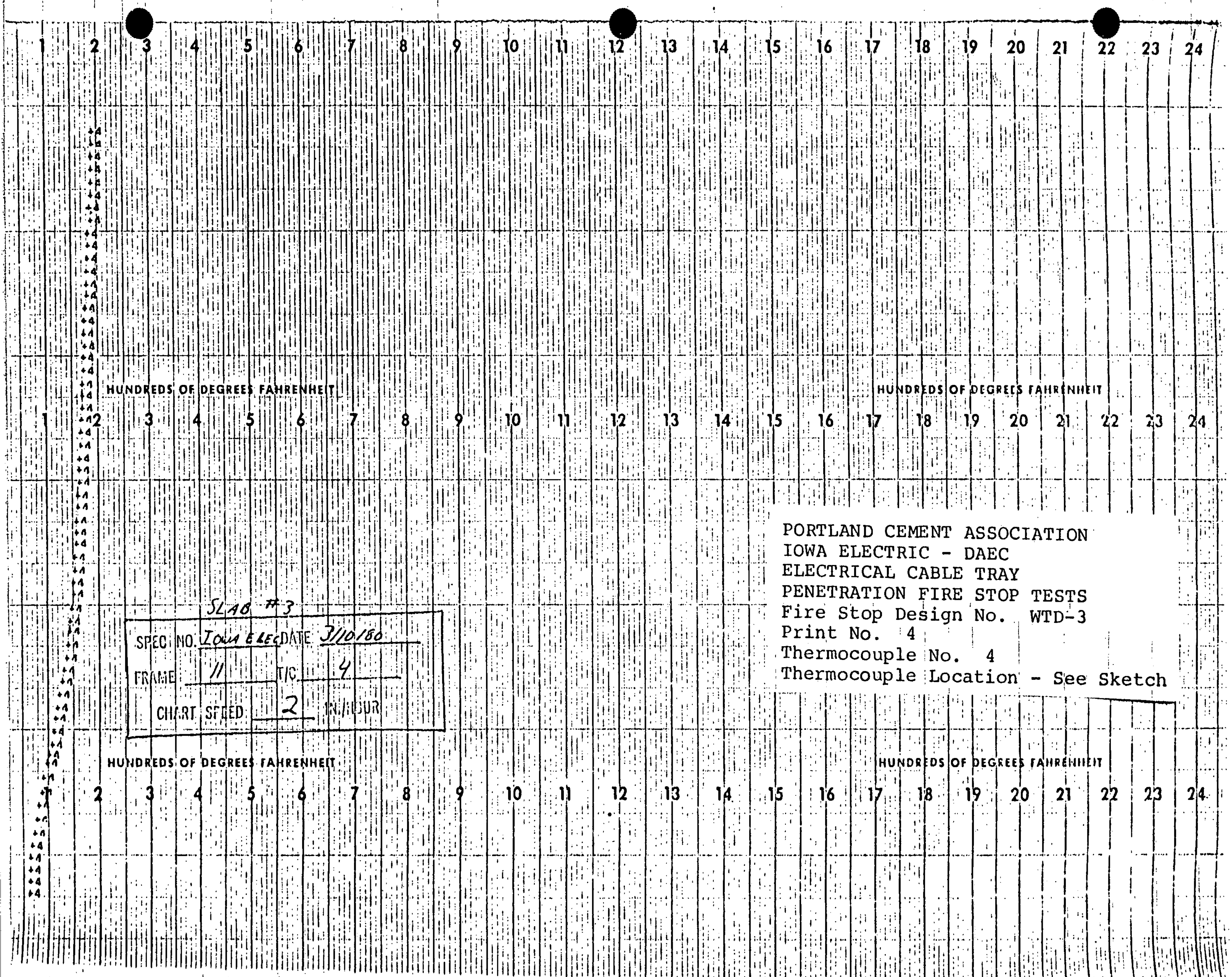
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 1
Thermocouple No. 1
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 2
Thermocouple No. 2
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 3
Thermocouple No. 3
Thermocouple Location - See Sketch



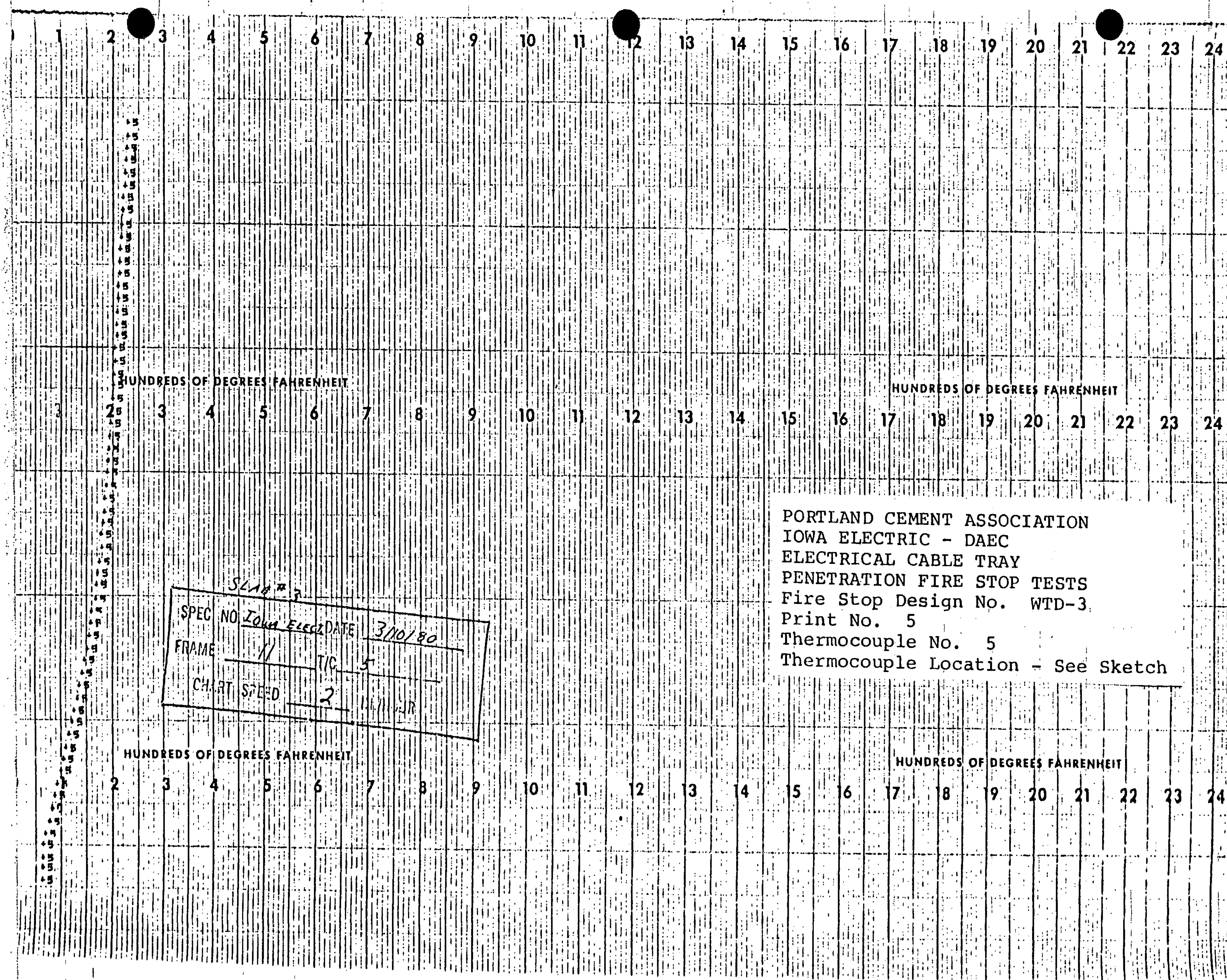
SLAB #3

SPEC NO. Iowa Elec DATE 3/10/80

FRAME 11 T/C 4

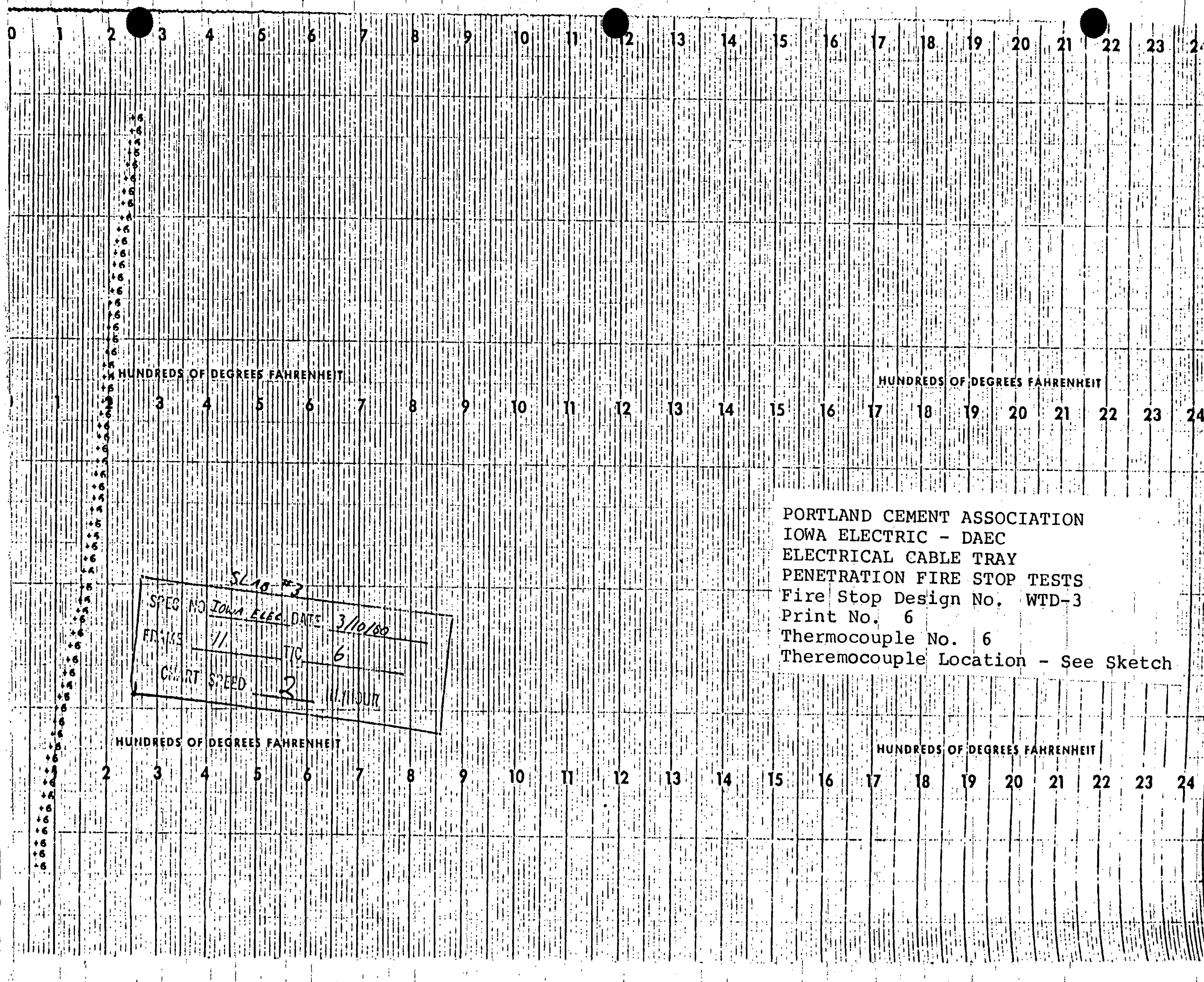
CHART SPEED 2 IN/HOUR

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 4
Thermocouple No. 4
Thermocouple Location - See Sketch



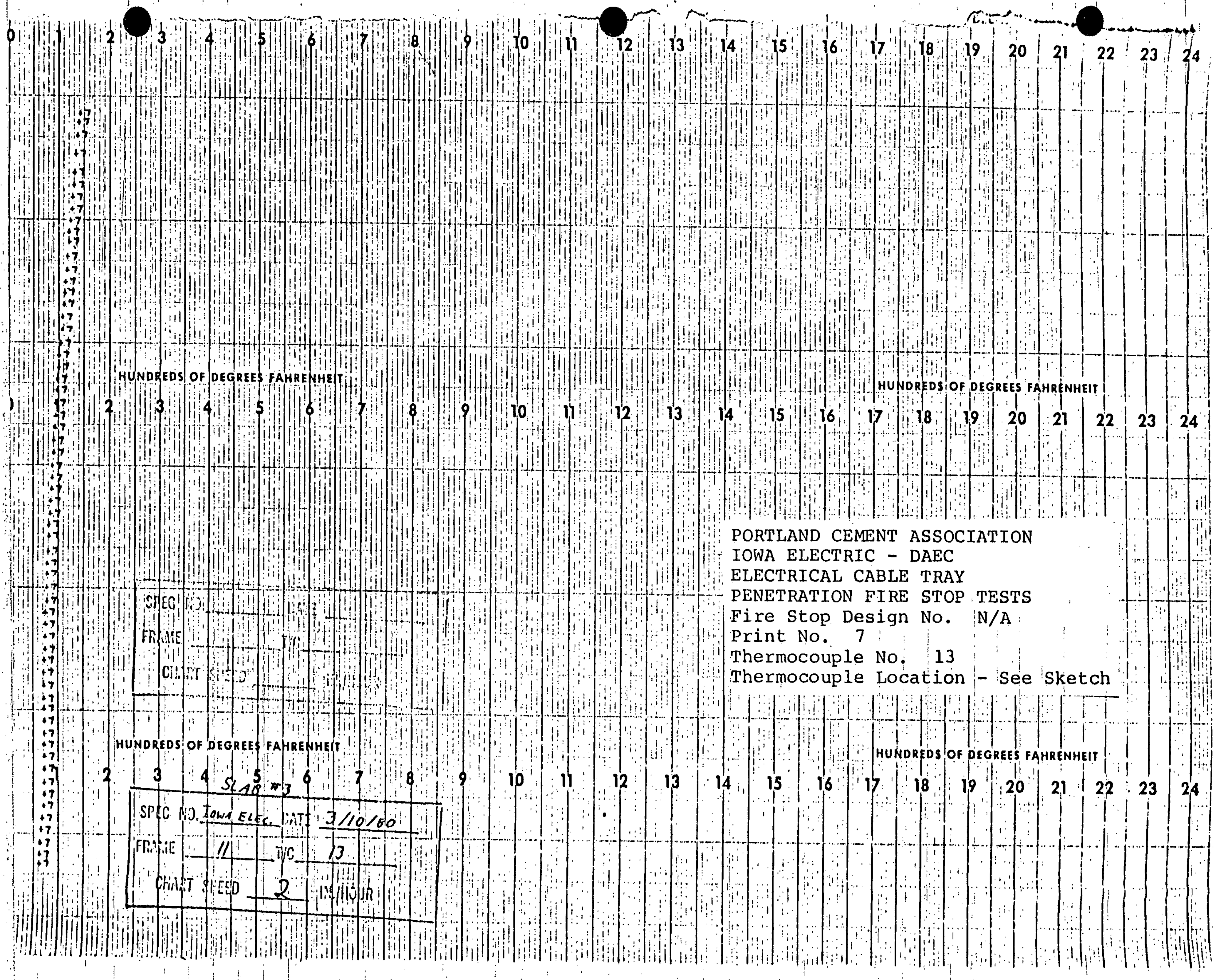
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 5
Thermocouple No. 5
Thermocouple Location - See Sketch

SLAB #3
SPEC NO Iowa Elec DATE 3/10/80
FRAME 11 T/C 5
CHART SPEED 2 IN/HR

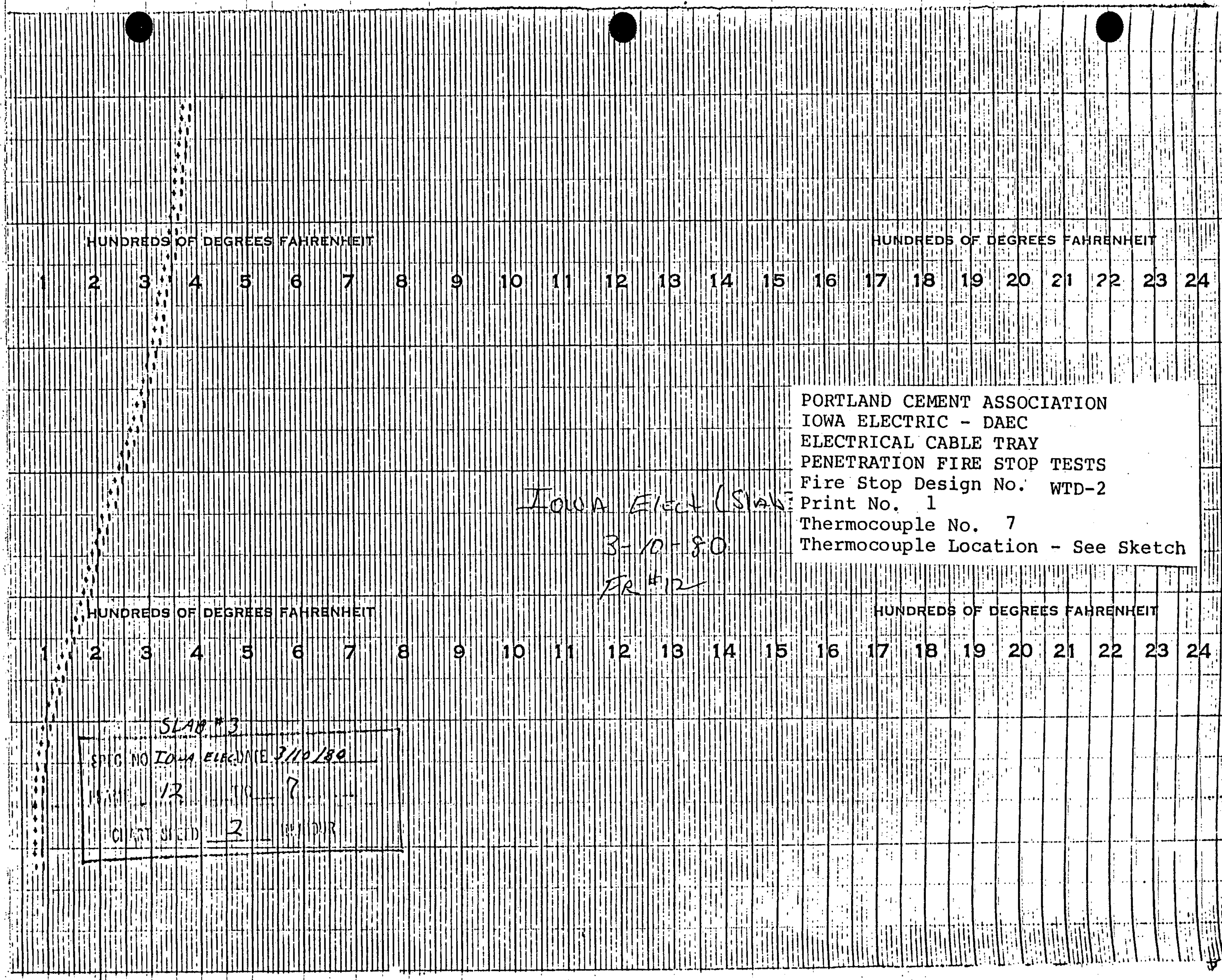


SL18 #3
SPEC NO Iowa Elec DATE 3/10/80
FRAMES 11 T/C 6
CHART SPEED 2 IN/HOUR

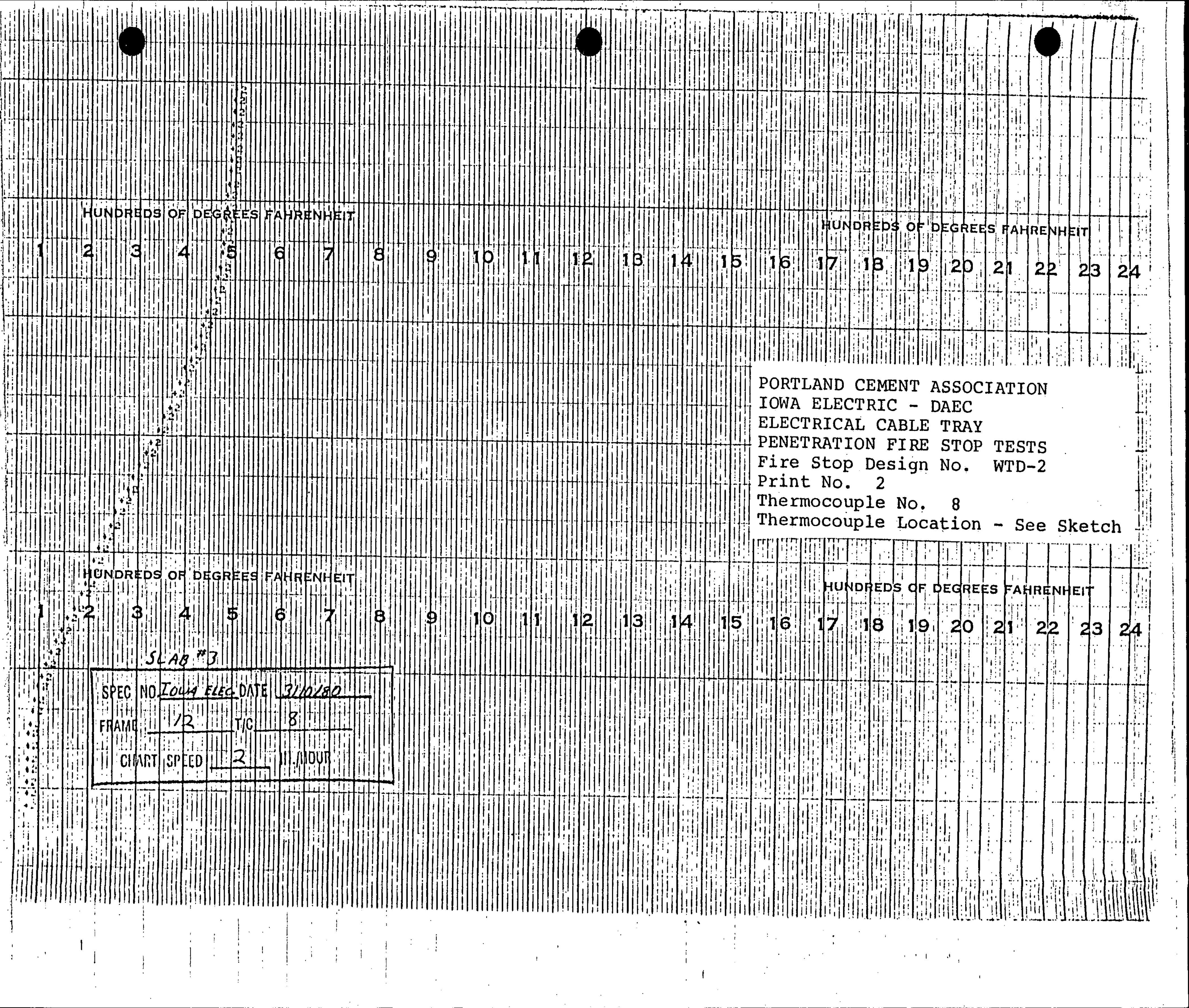
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-3
Print No. 6
Thermocouple No. 6
Theremocouple Location - See Sketch



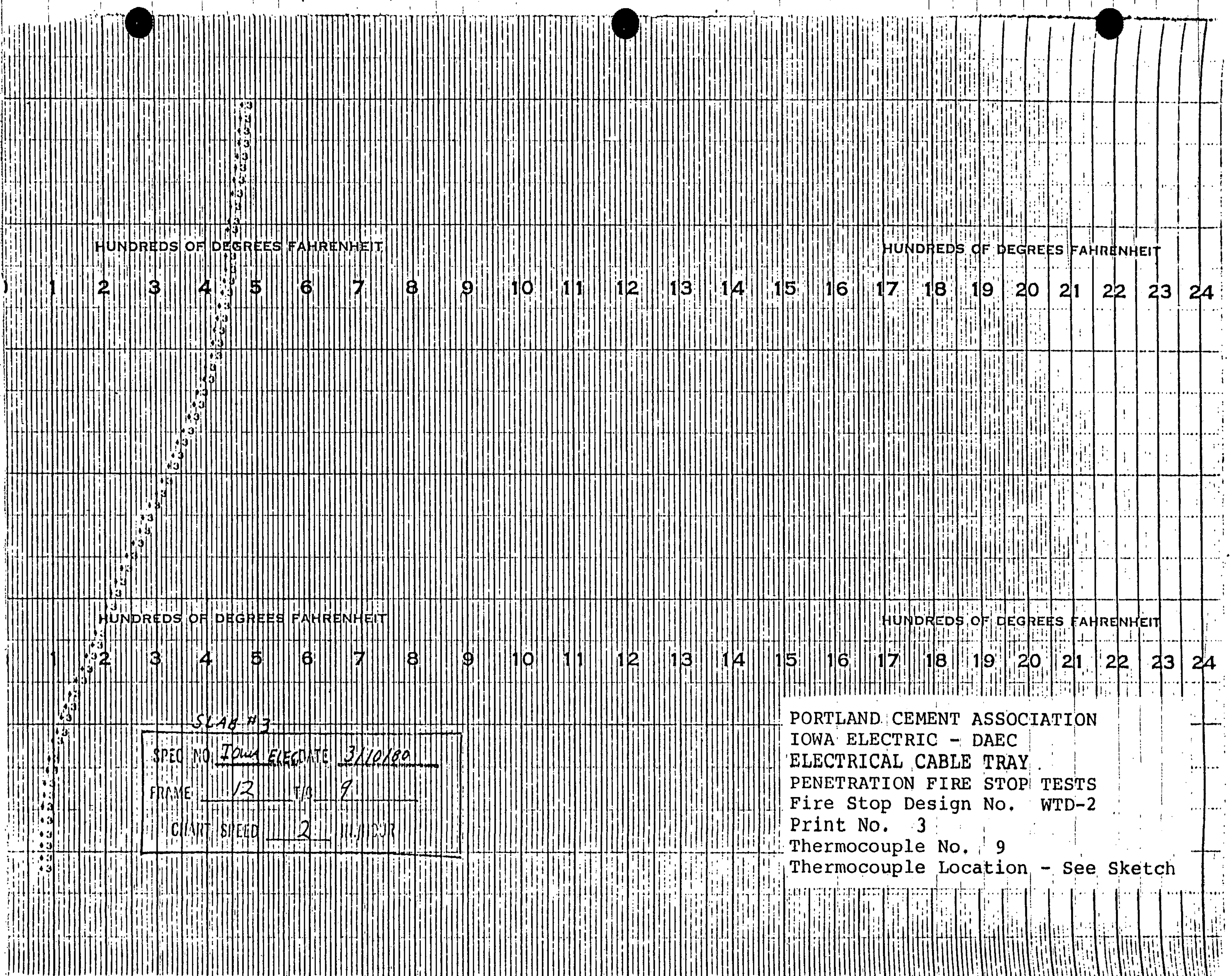
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. N/A
Print No. 7
Thermocouple No. 13
Thermocouple Location - See Sketch



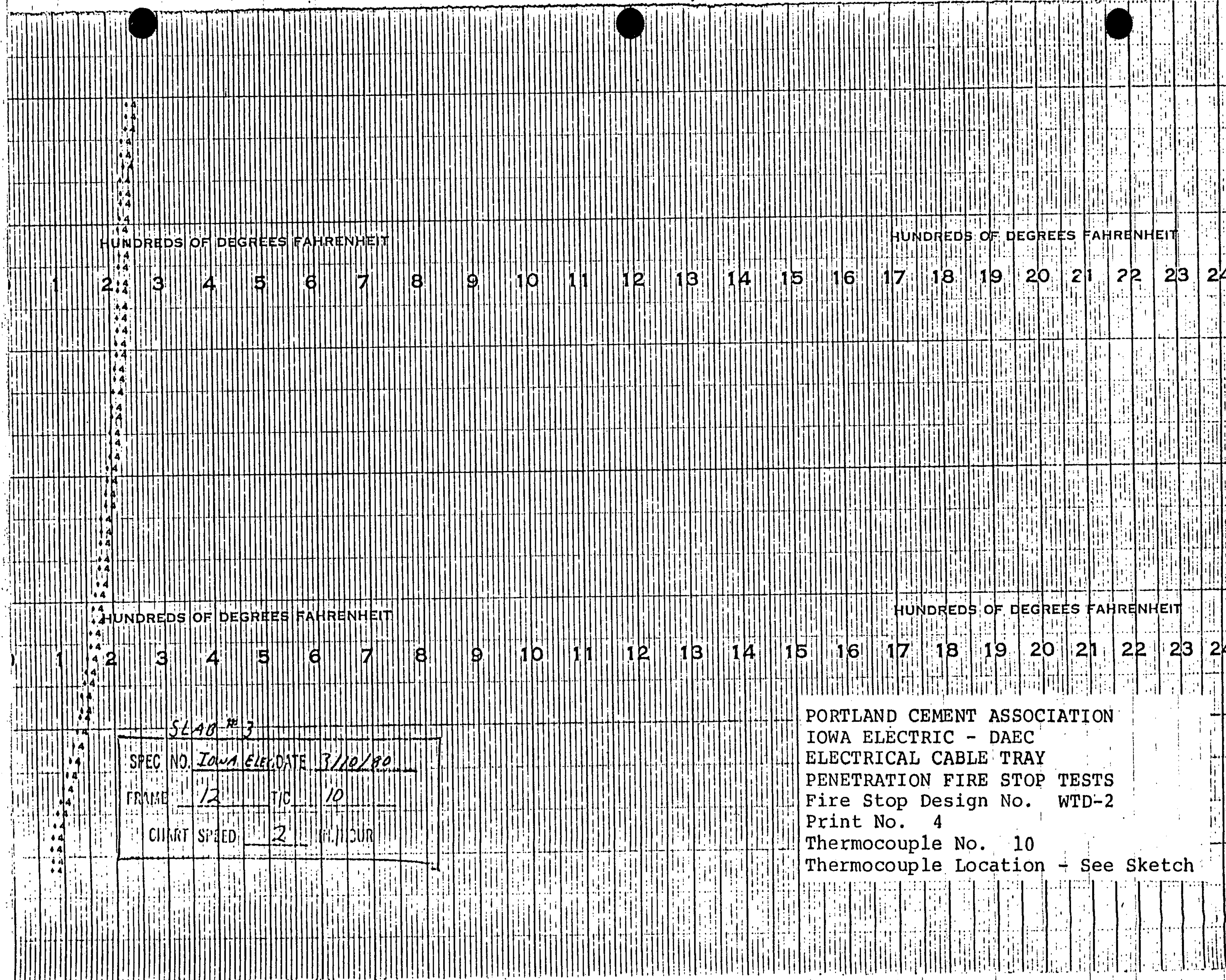
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 1
Thermocouple No. 7
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 2
Thermocouple No. 8
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 3
Thermocouple No. 9
Thermocouple Location - See Sketch



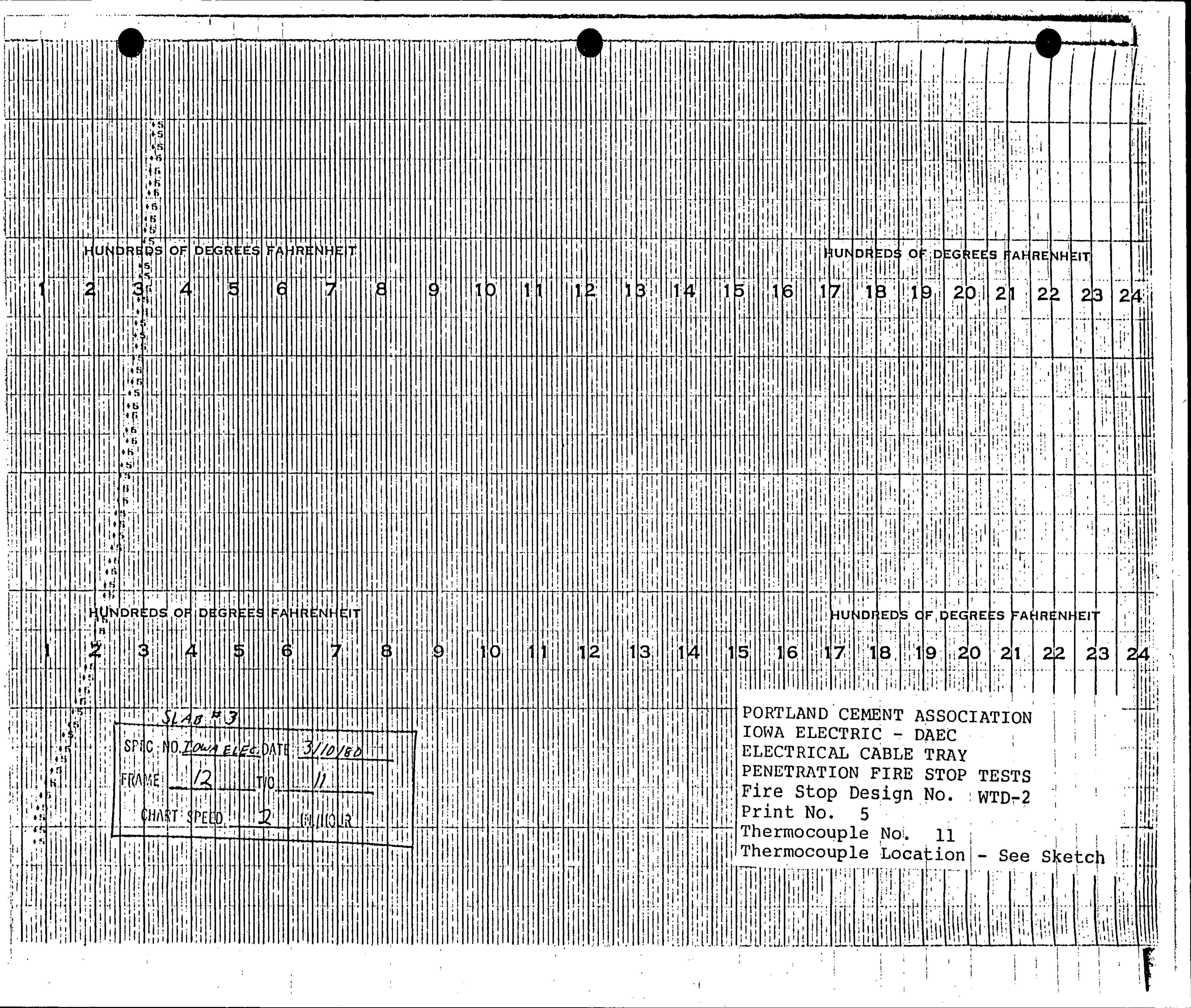
SLAB # 3

SPEC NO. Iowa Elec DATE 3/10/80

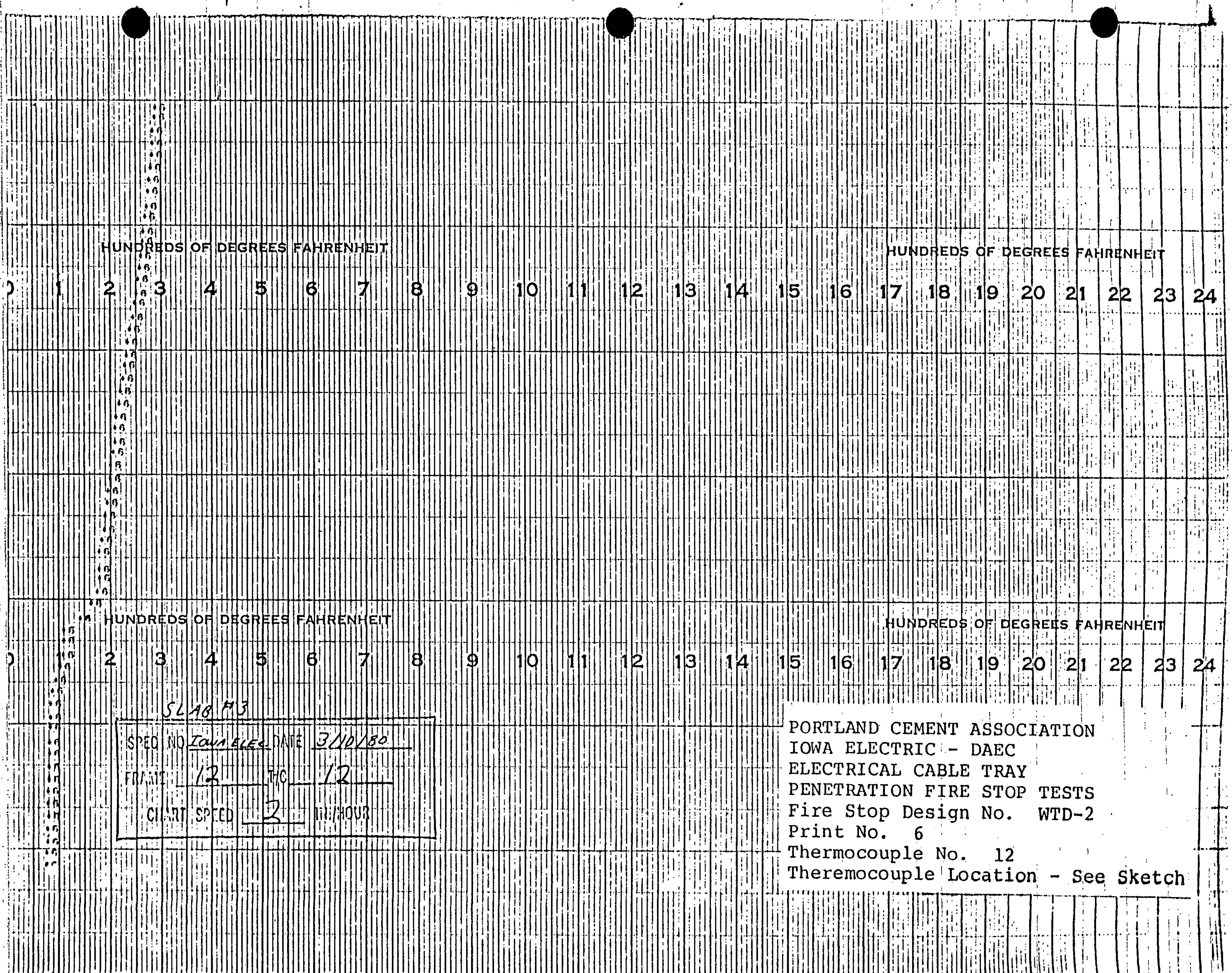
FRAME 12 T/C 10

CHART SPEED 2 IN/HOUR

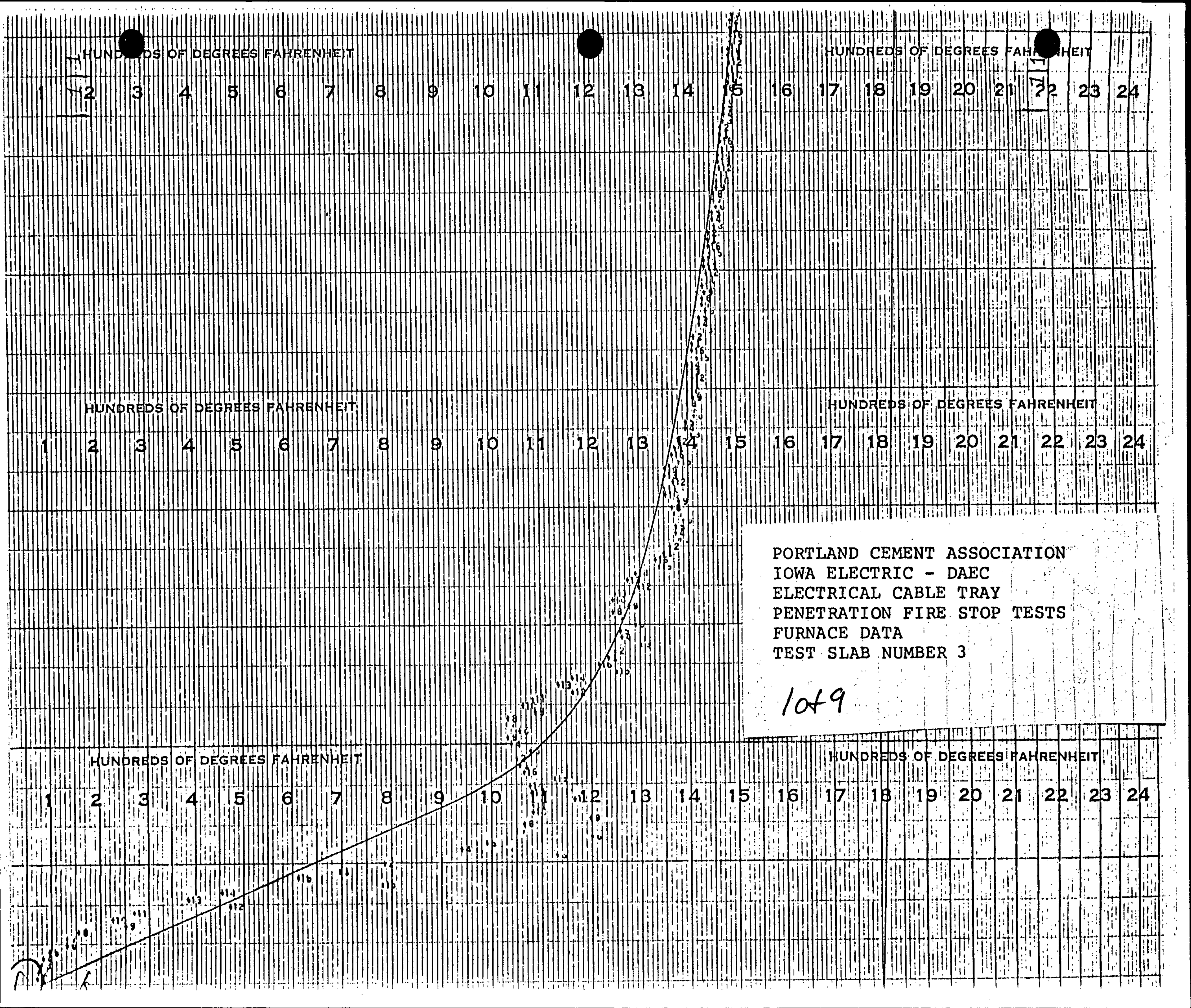
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 4
Thermocouple No. 10
Thermocouple Location - See Sketch



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 5
Thermocouple No. 11
Thermocouple Location - See Sketch

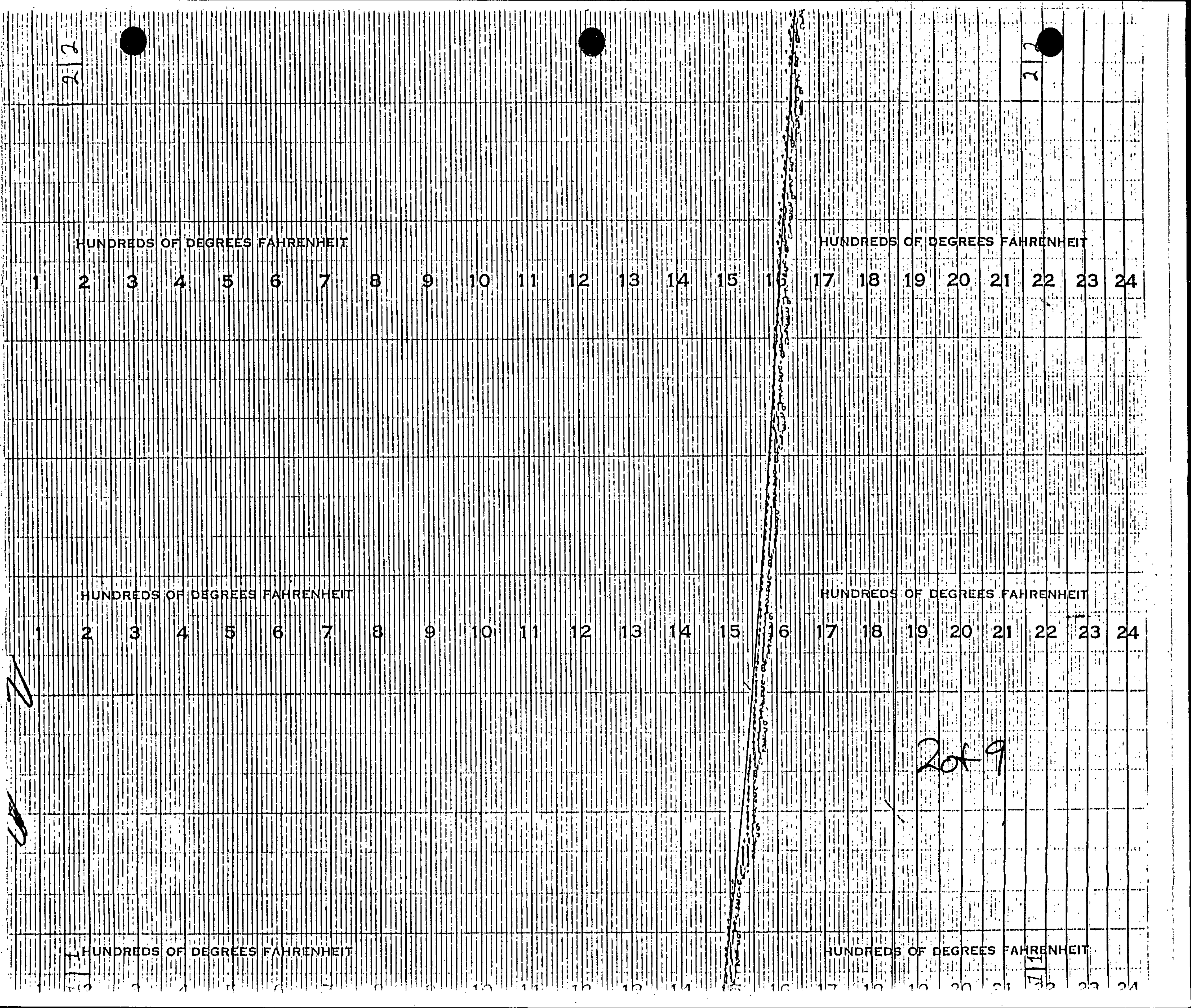


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WTD-2
Print No. 6
Thermocouple No. 12
Theremocouple Location - See Sketch

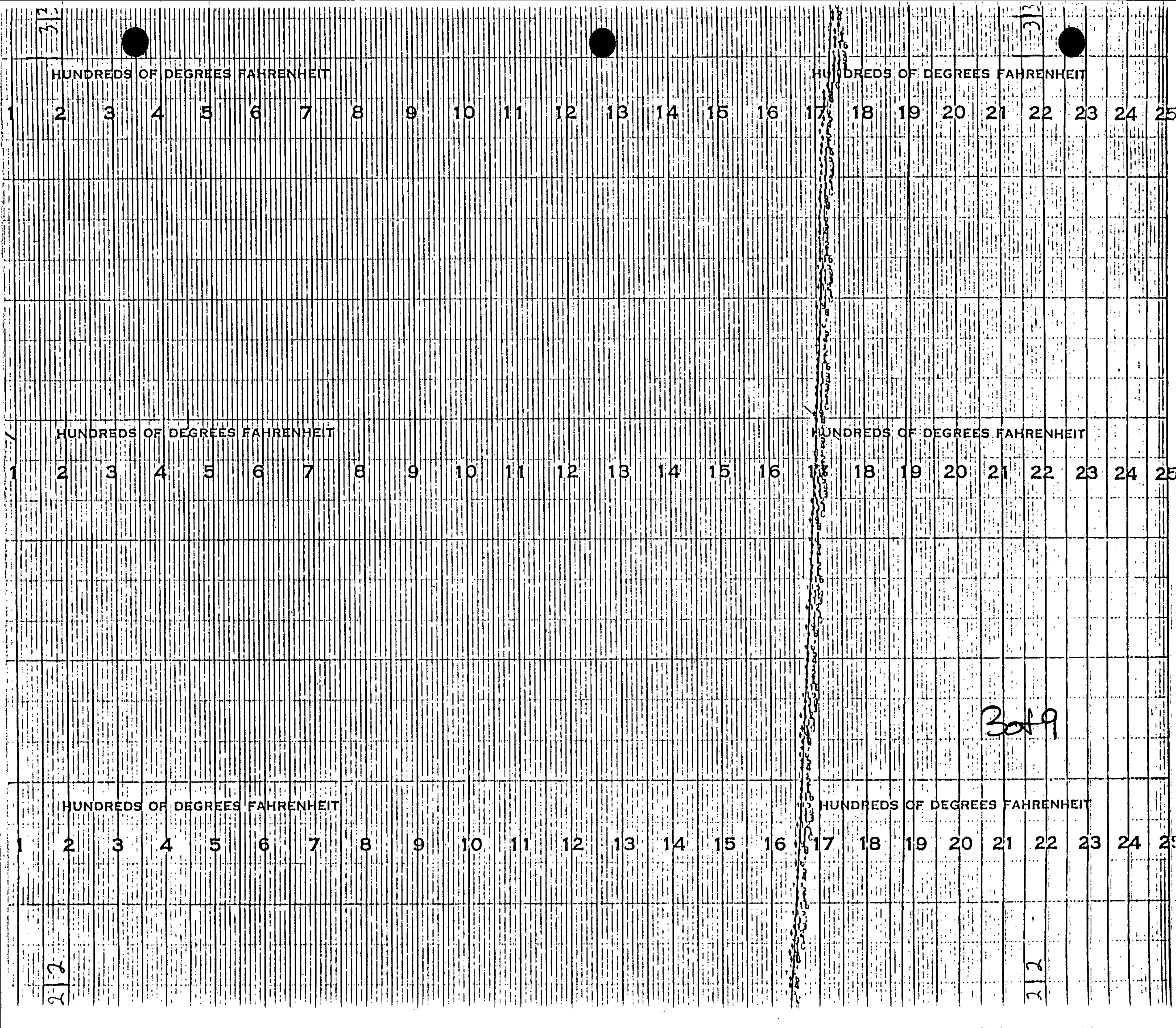


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 3

1 of 9



2|2
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
2 of 9
HUNDREDS OF DEGREES FAHRENHEIT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HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
HUNDREDS OF DEGREES FAHRENHEIT
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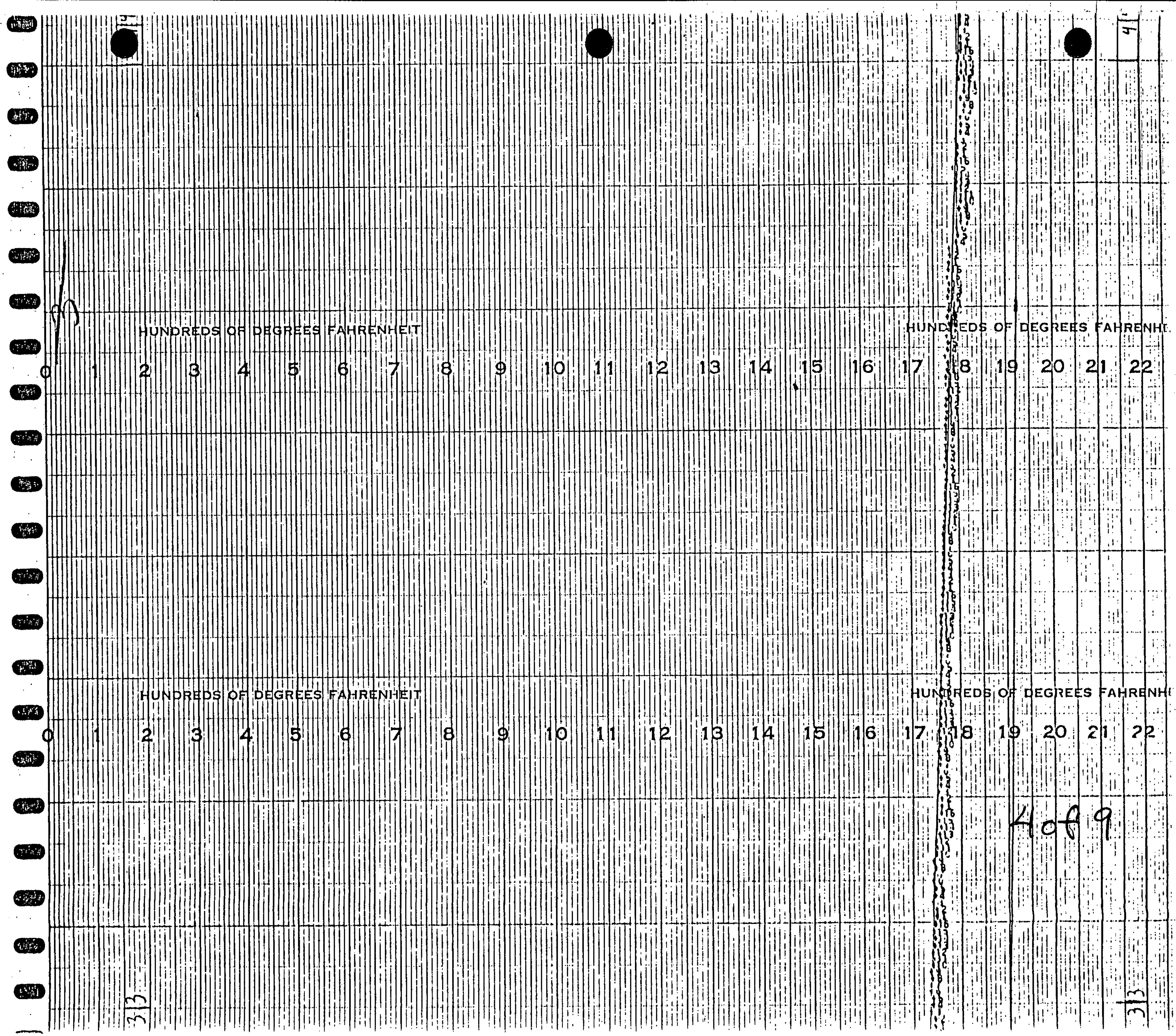
3 of 9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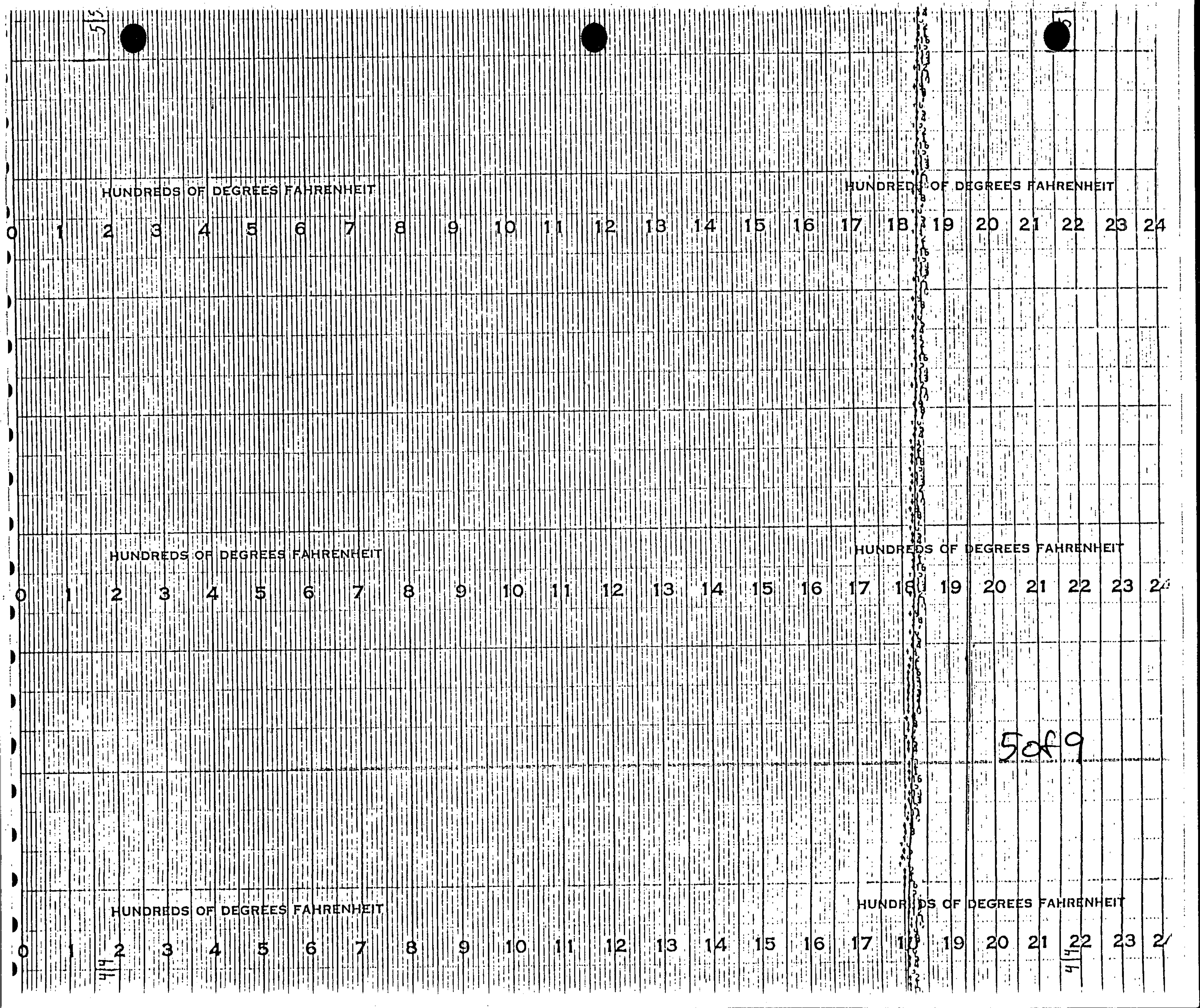
4 of 9
33
33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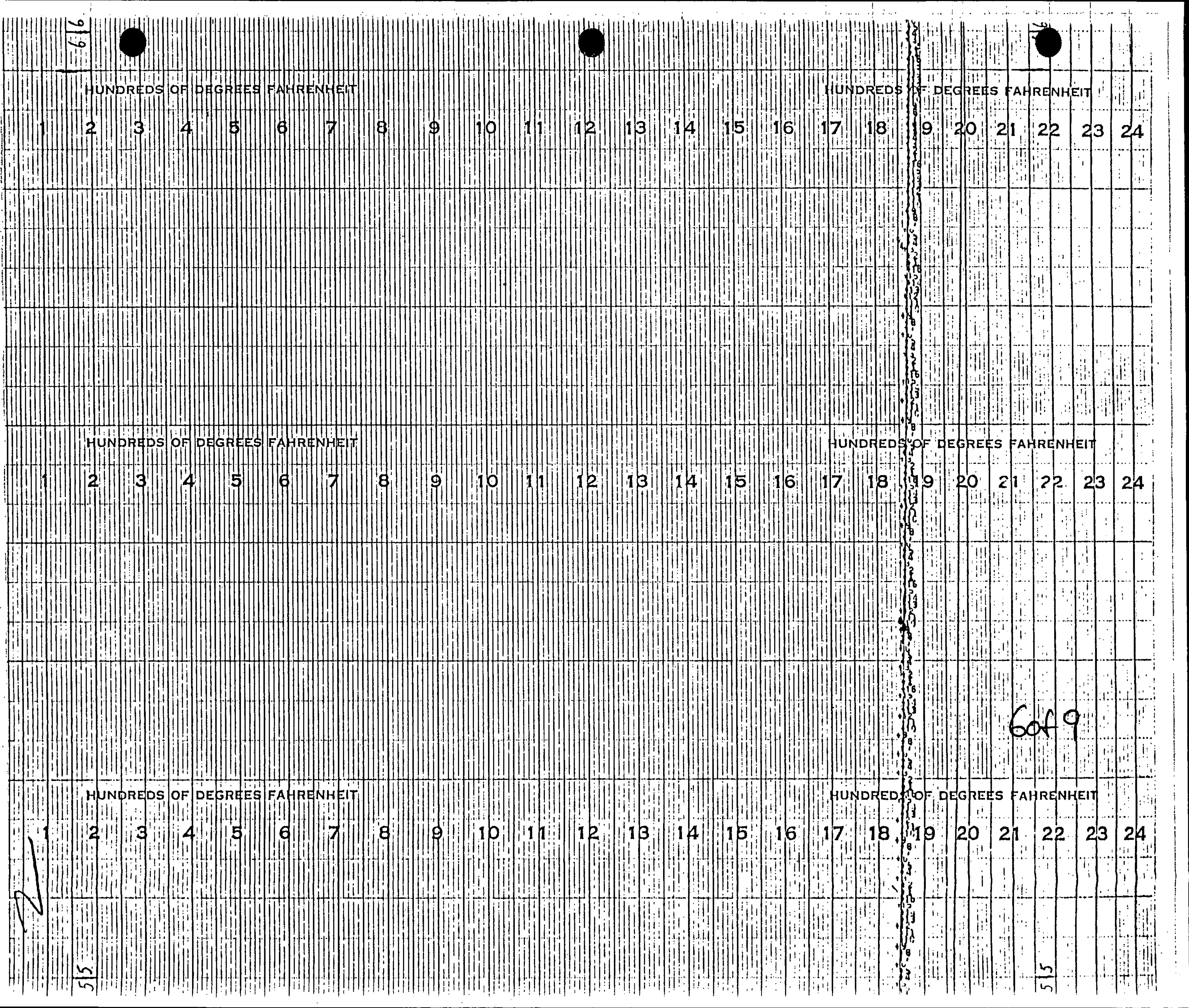
5of9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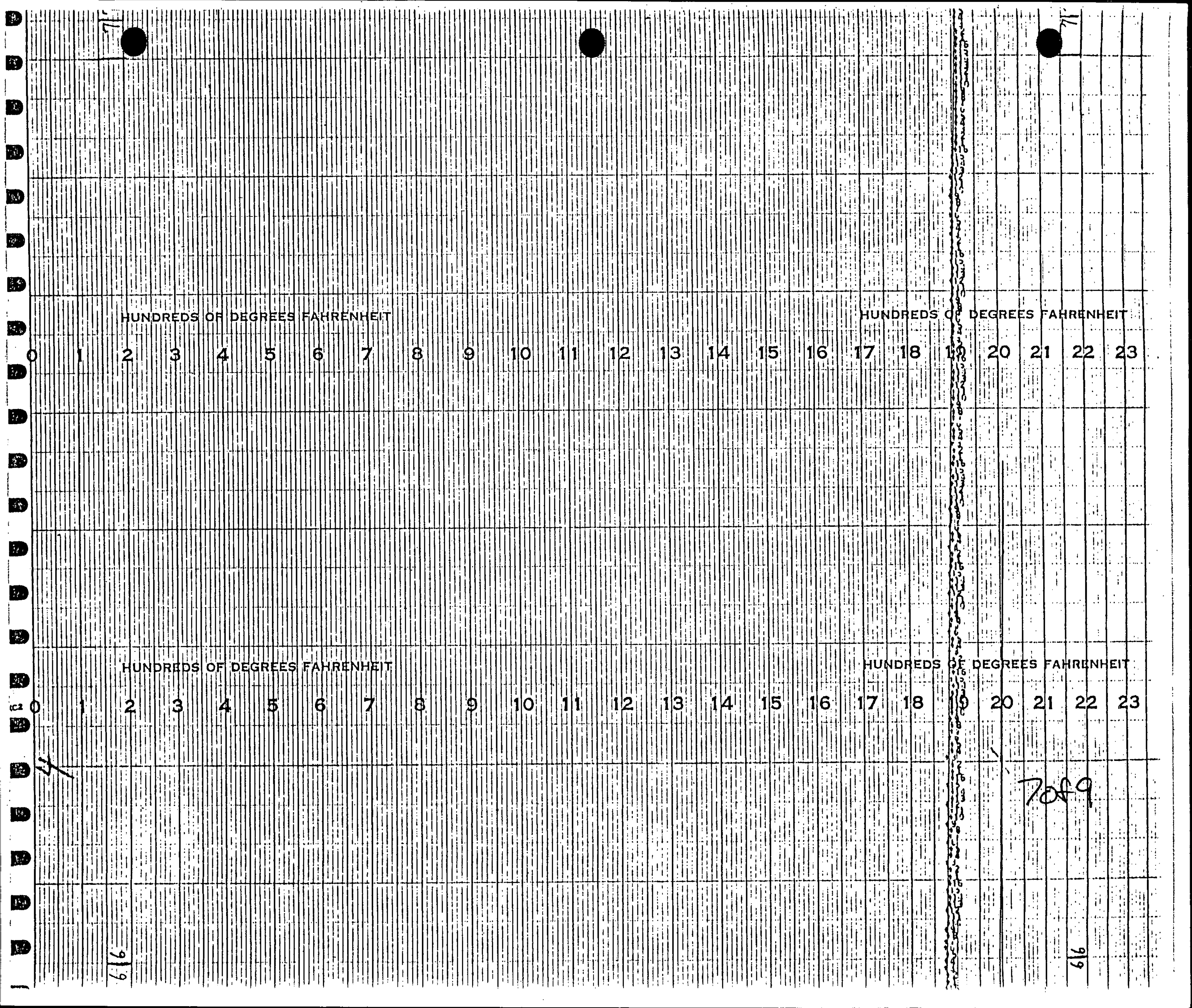
6 of 9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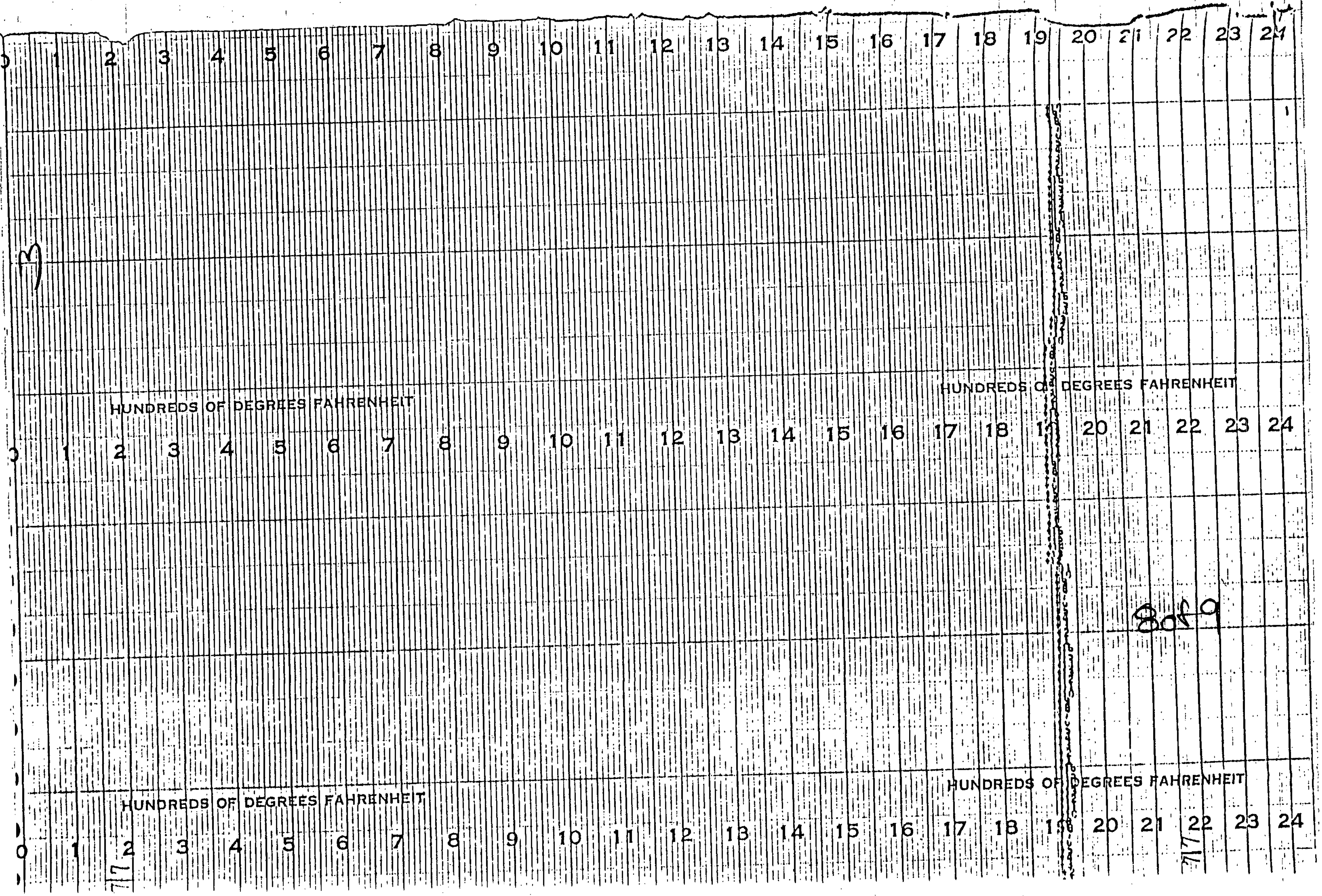
7 of 9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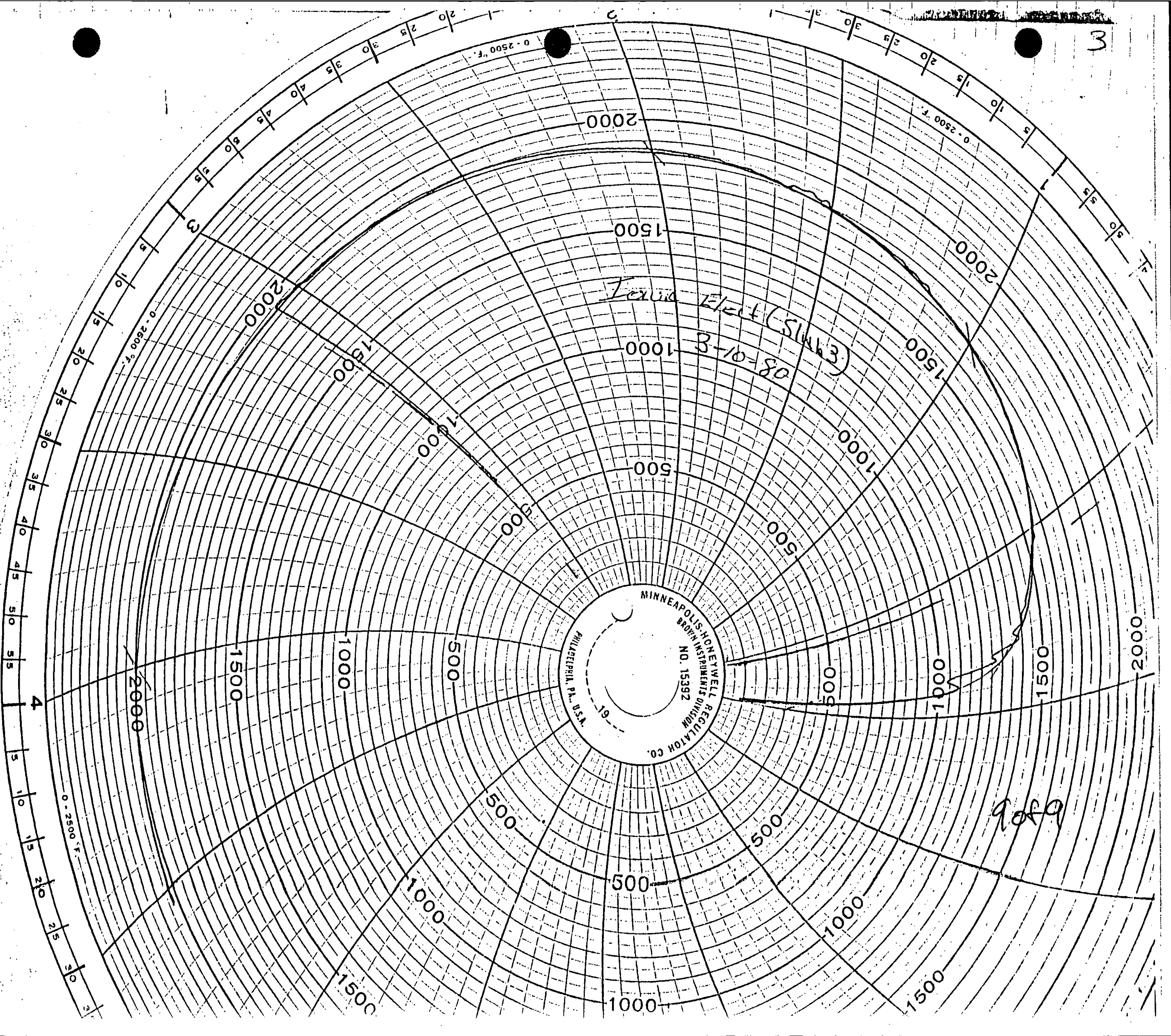
M
8 of 9
717

3


MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA., U.S.A.
19
0 - 2500 °F.
500
1000
1500
2000
Lewis Elect (Slug 3)
3-10-80

TEST SLAB NUMBER 4

DATE: 01/28/80

FIRE STOP DESIGNS TESTED: WPD-1
WPD-2
WPD-4
WPD-5
WPD-6
WPD-RP-1, SHT 1
WPD-RP-2, SHT 1
WPD-RP-2, SHT 2

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

Test Witnessed by:

M. Gillen, PCA

R. H. Hollenbacher, EDS

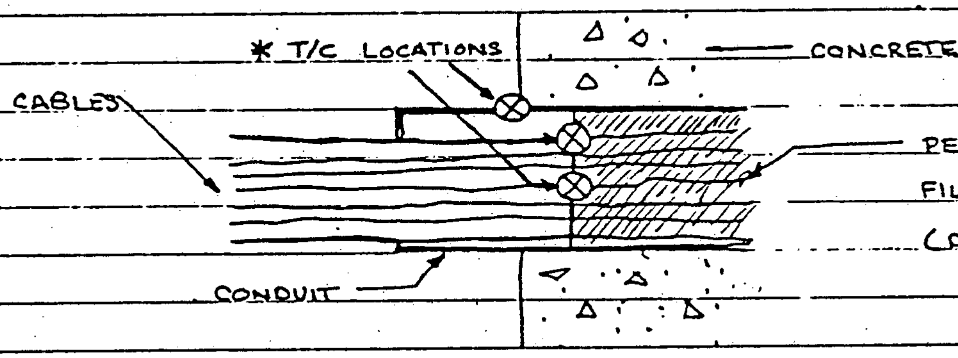
T. A. Gucciardo, IEL&P

CR 4557

IELP/EDS SPECIMEN NO. 4 - NINE 6 IN. CONDUIT SLAB

THERMOCOUPLE LOCATIONS

General: Three thermocouples were placed on each penetration assembly. As shown in the sketch, these were placed in the interior of each cable bundle and on the surface of each cable bundle where the penetration materials ended on the unexposed side of the slab. The third thermocouple was placed on the conduit at the point where it intersects the concrete on the unexposed surface



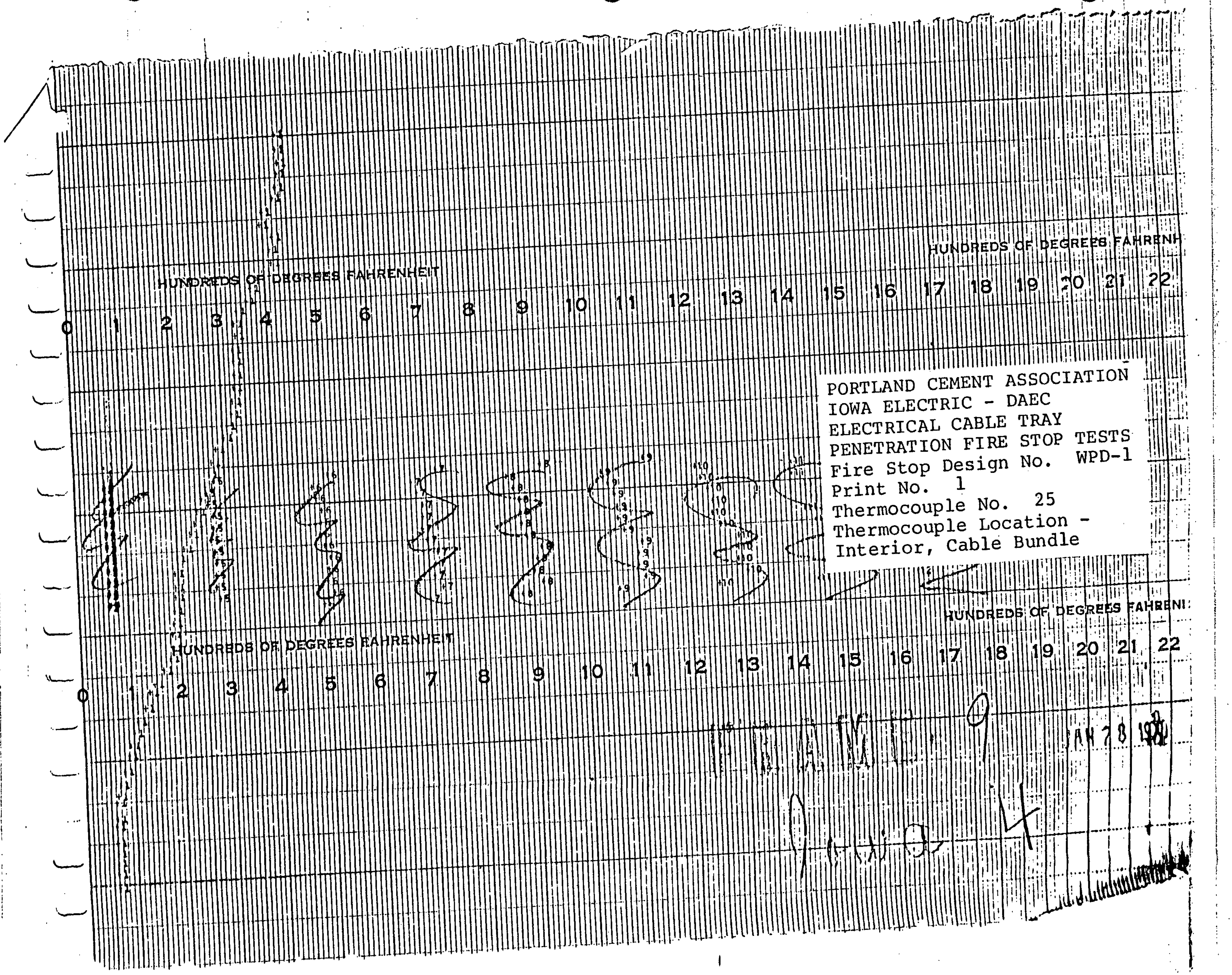
PENETRATION ID	THERMOCOUPLE NO.		
	BUNDLE INTERIOR	BUNDLE SURFACE	ON CONDUIT
C1	T/C NO. 25	T/C NO. 26	T/C NO. 27
C2	4	5	6
C3	7	8	9
C4	10	11	12
C5	1	2	3
C7	22	23	24
C10	18	19	20
C13	16	17	18
C16	13	14	15

m.g.

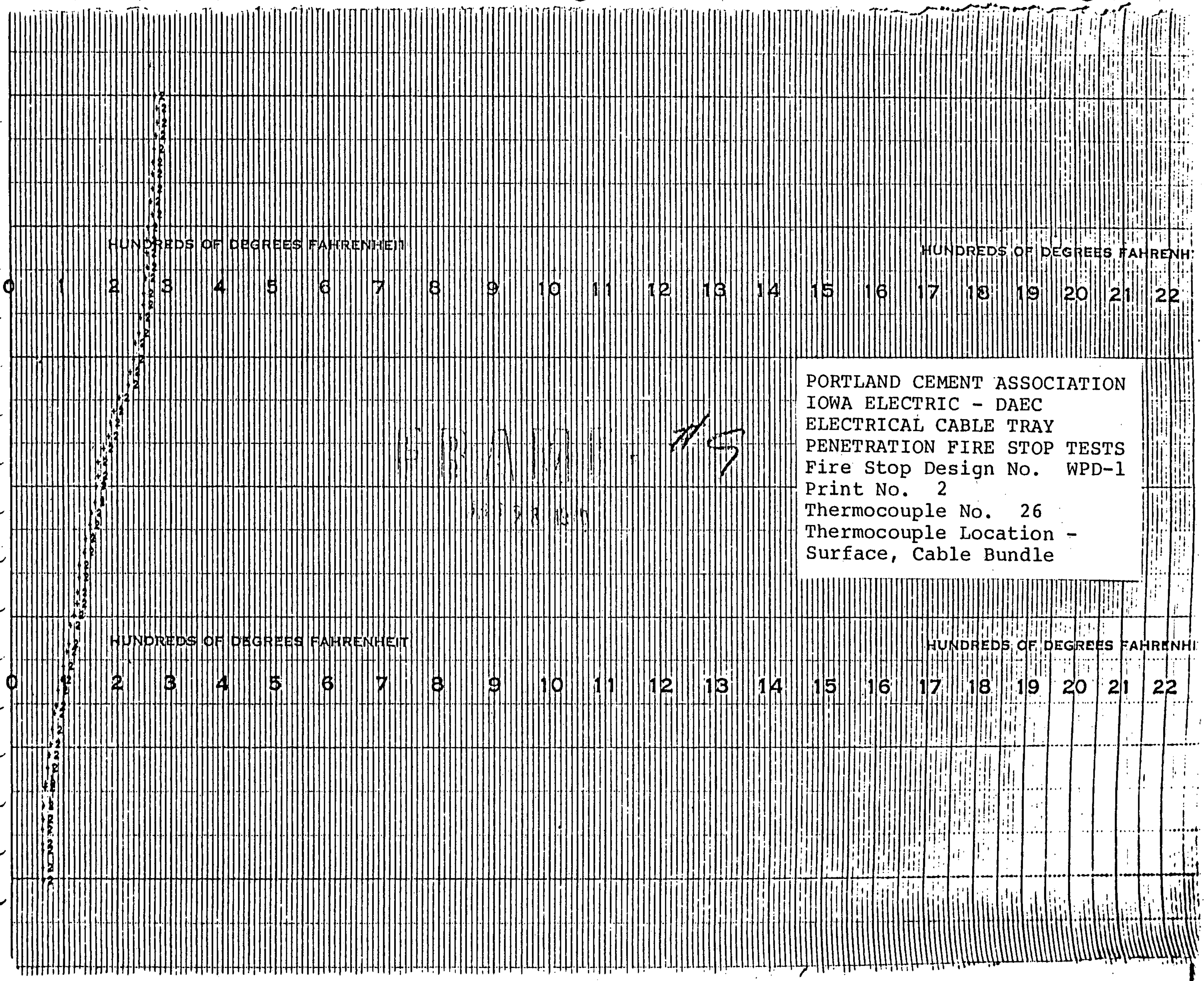
THERMOCOUPLE LOCATIONS - TEST 4

SLAB 4

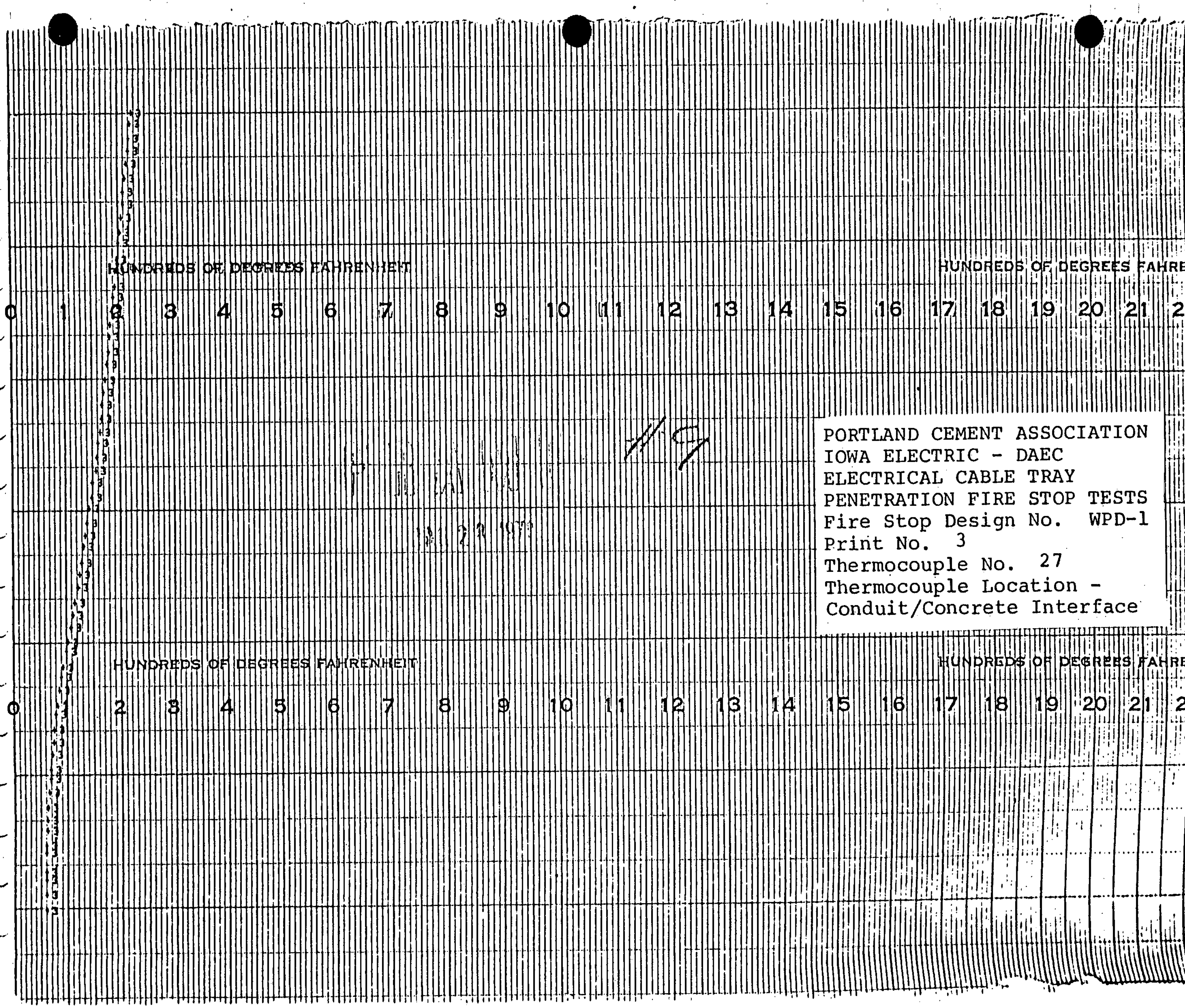
CONSTRUCTION DESIGN Nº	FIRE STOP DESIGN Nº
C1	WPD-1
C2	WPD-RP-1, SHT 1
C3	WPD-RP-2, SHT 1
C4	WPD-2
C5	WPD-RP-1, SHT. 2
C7	WPD-3
C10	WPD-5
C13	WPD-6
C16	WPD-4



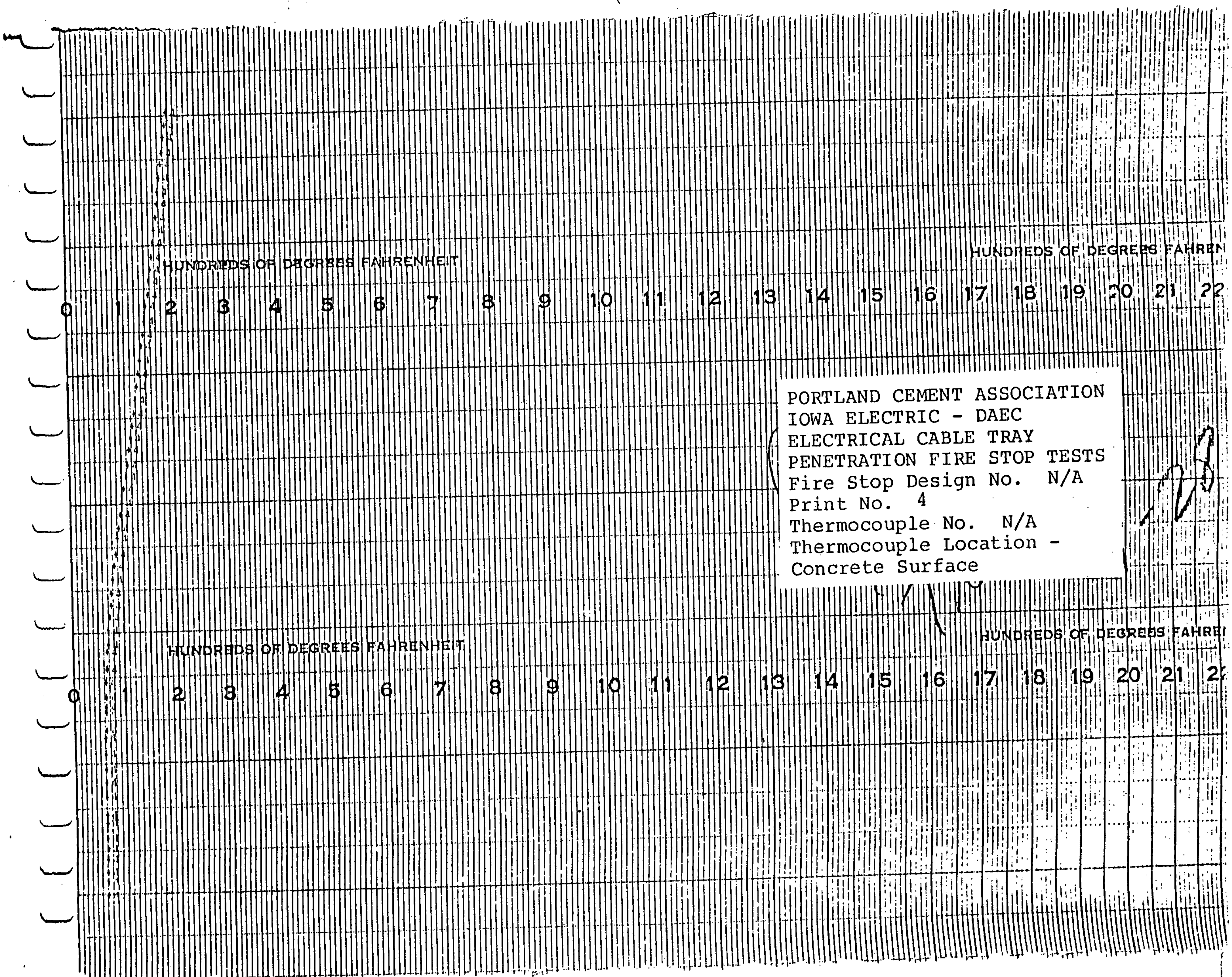
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-1
Print No. 1
Thermocouple No. 25
Thermocouple Location -
Interior, Cable Bundle



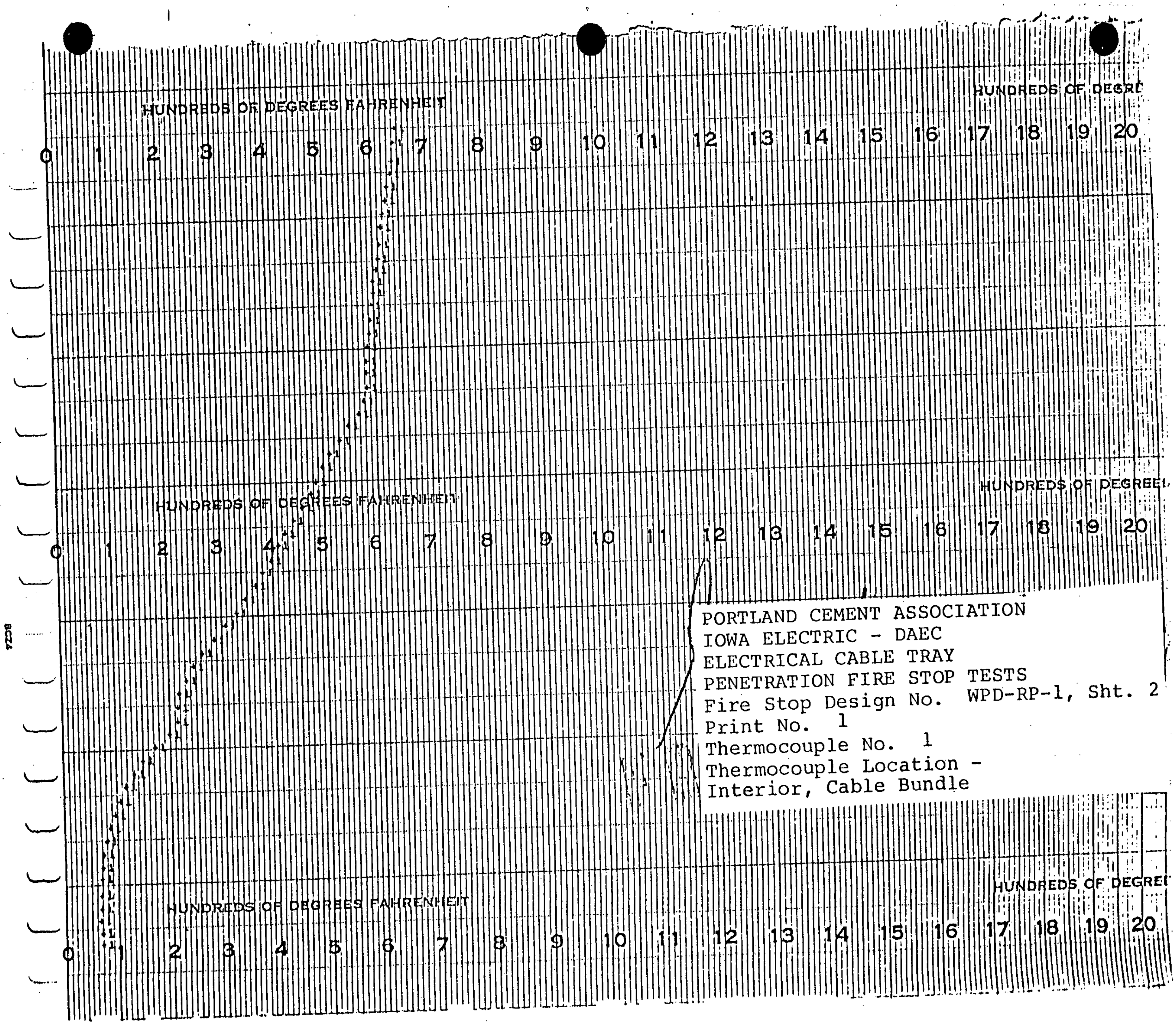
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-1
Print No. 2
Thermocouple No. 26
Thermocouple Location -
Surface, Cable Bundle

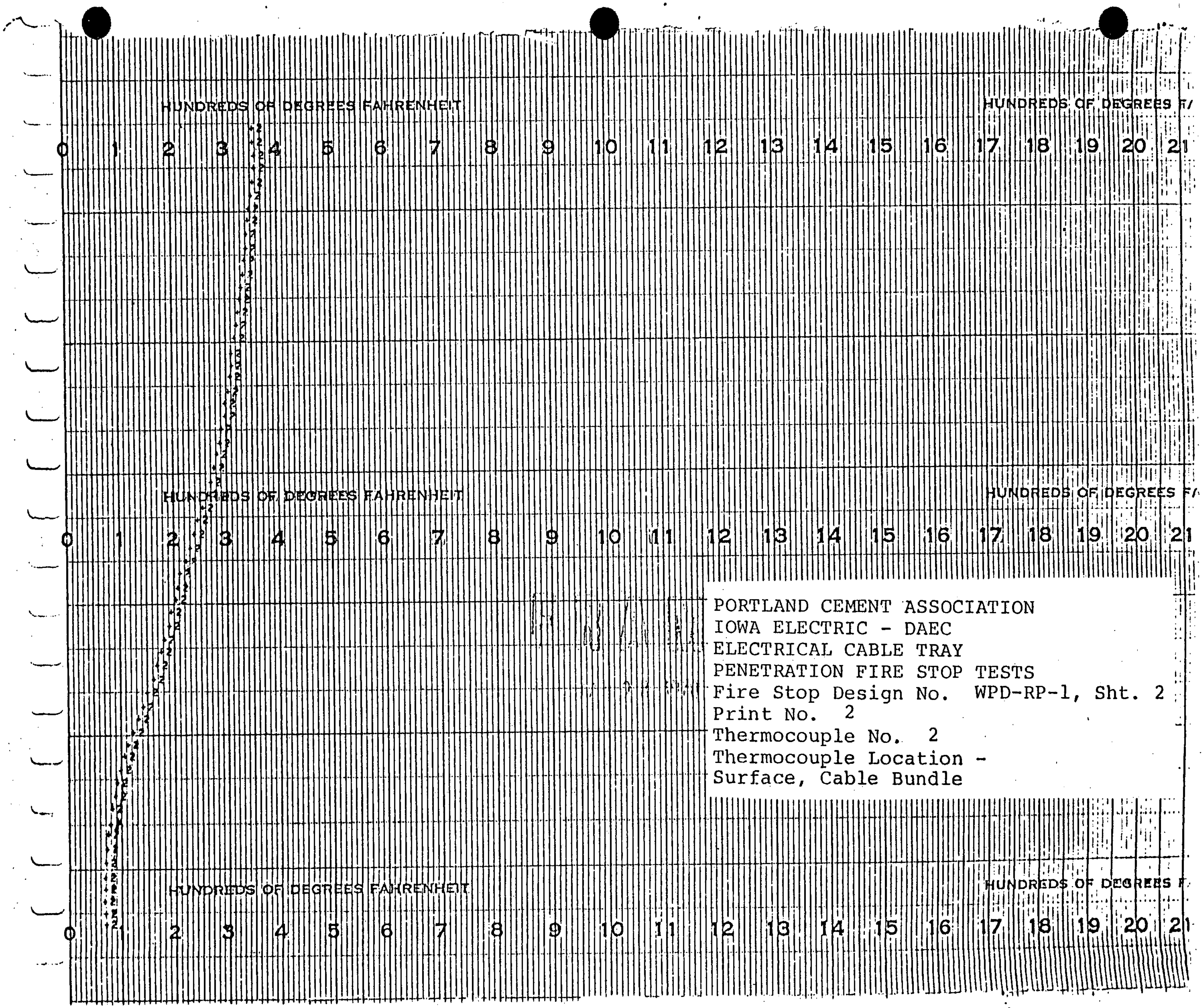


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-1
Print No. 3
Thermocouple No. 27
Thermocouple Location -
Conduit/Concrete Interface

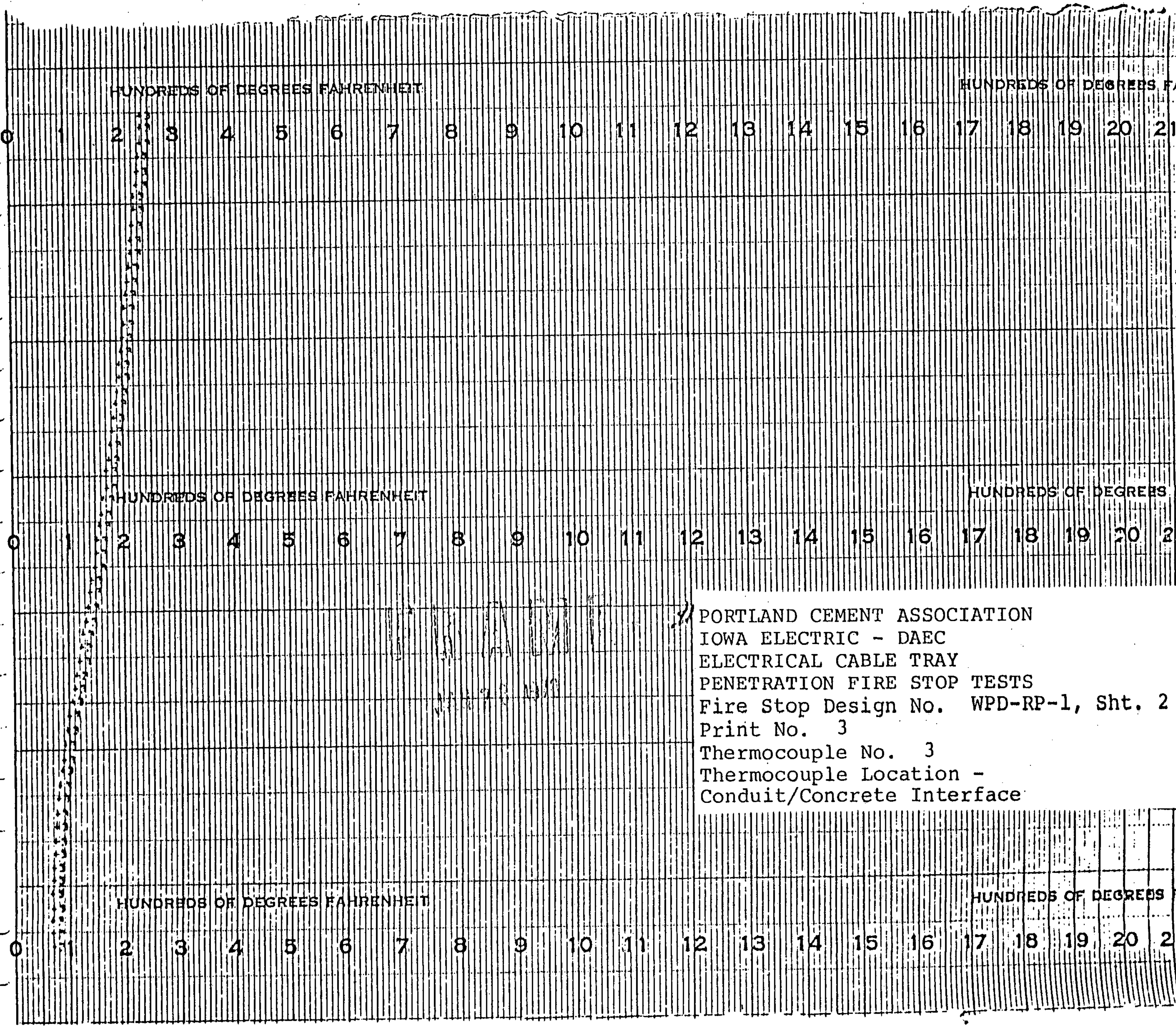


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. N/A
Print No. 4
Thermocouple No. N/A
Thermocouple Location -
Concrete Surface

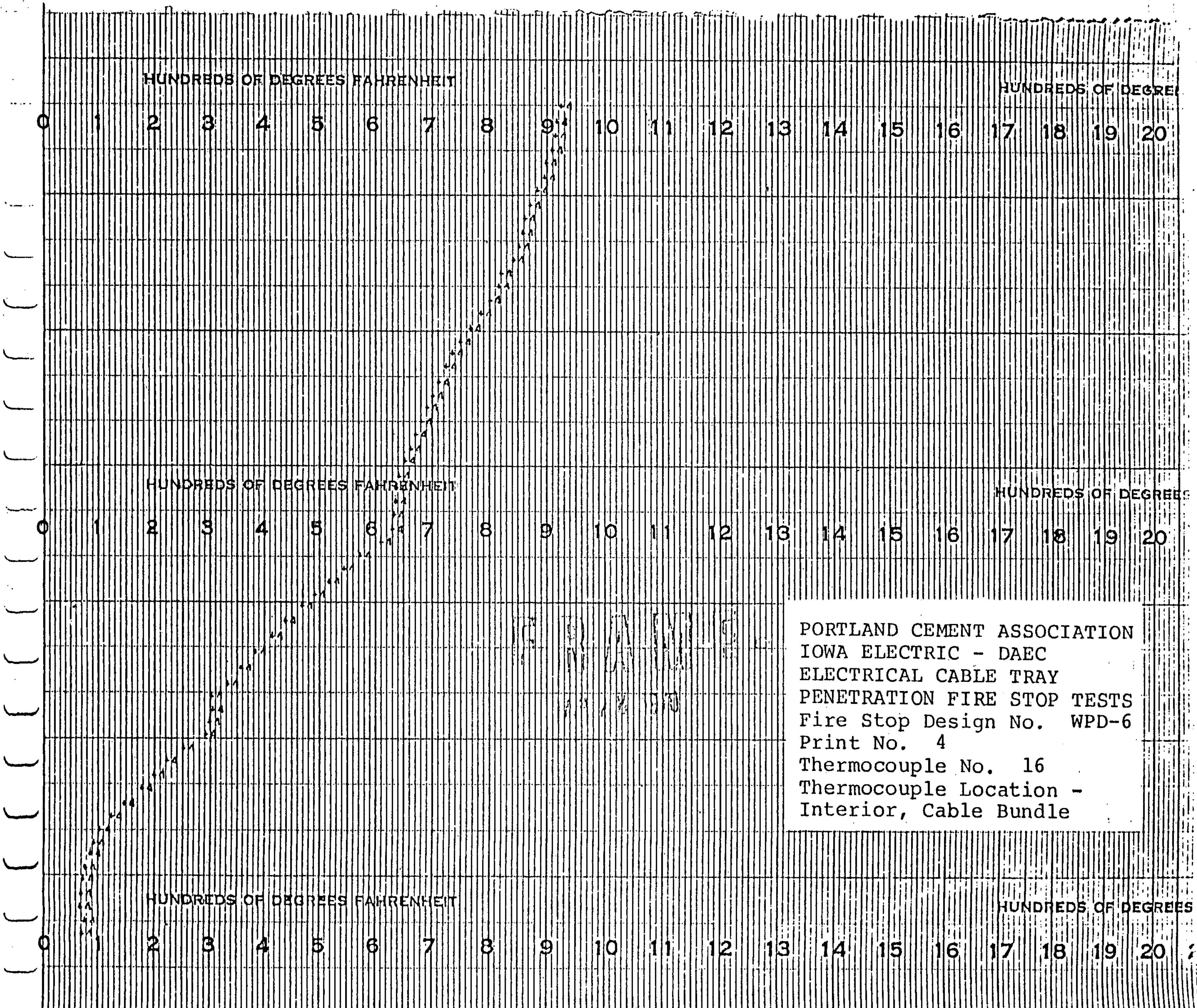

HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 2
Print No. 1
Thermocouple No. 1
Thermocouple Location -
Interior, Cable Bundle



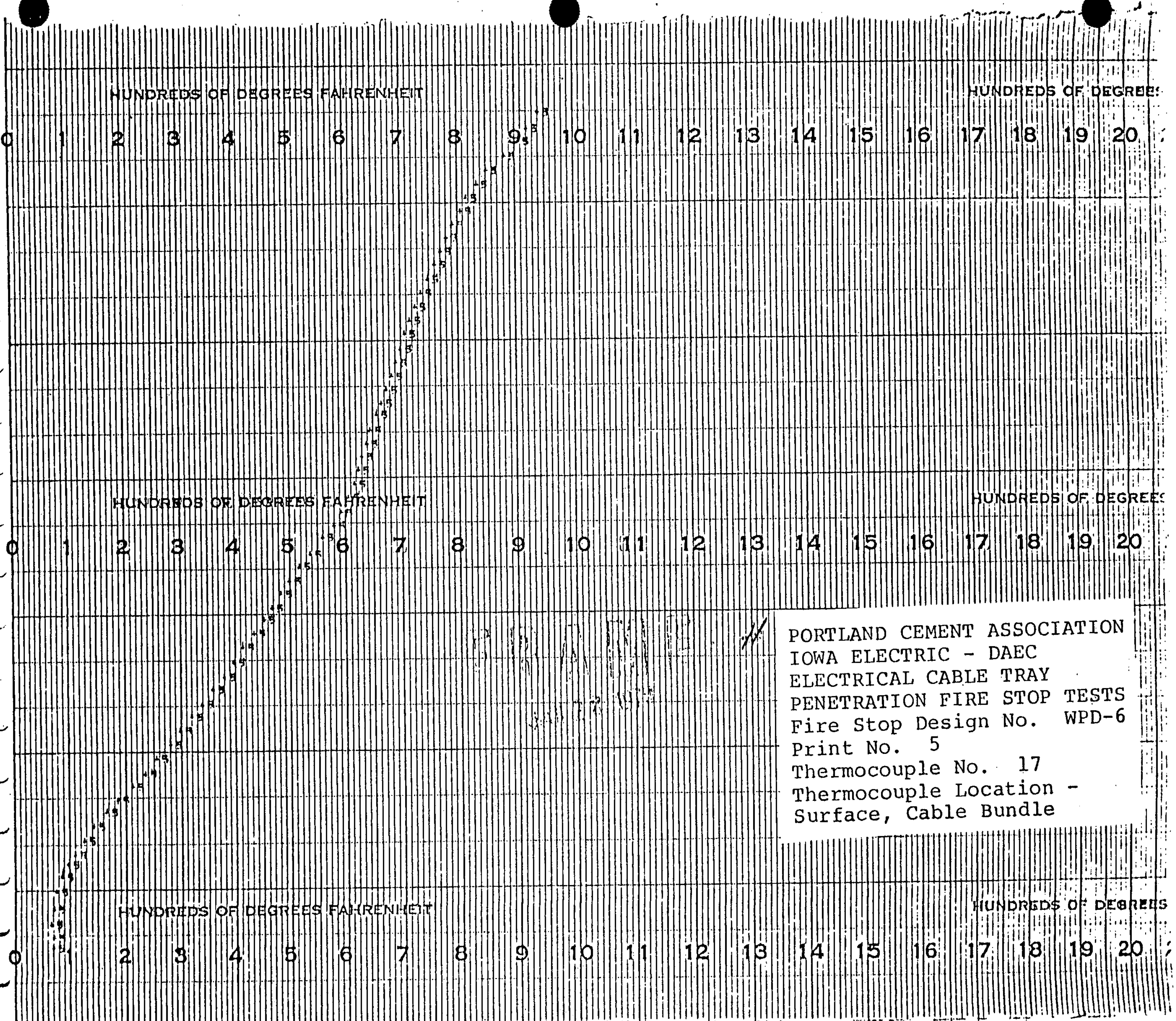
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 2
Print No. 2
Thermocouple No. 2
Thermocouple Location -
Surface, Cable Bundle



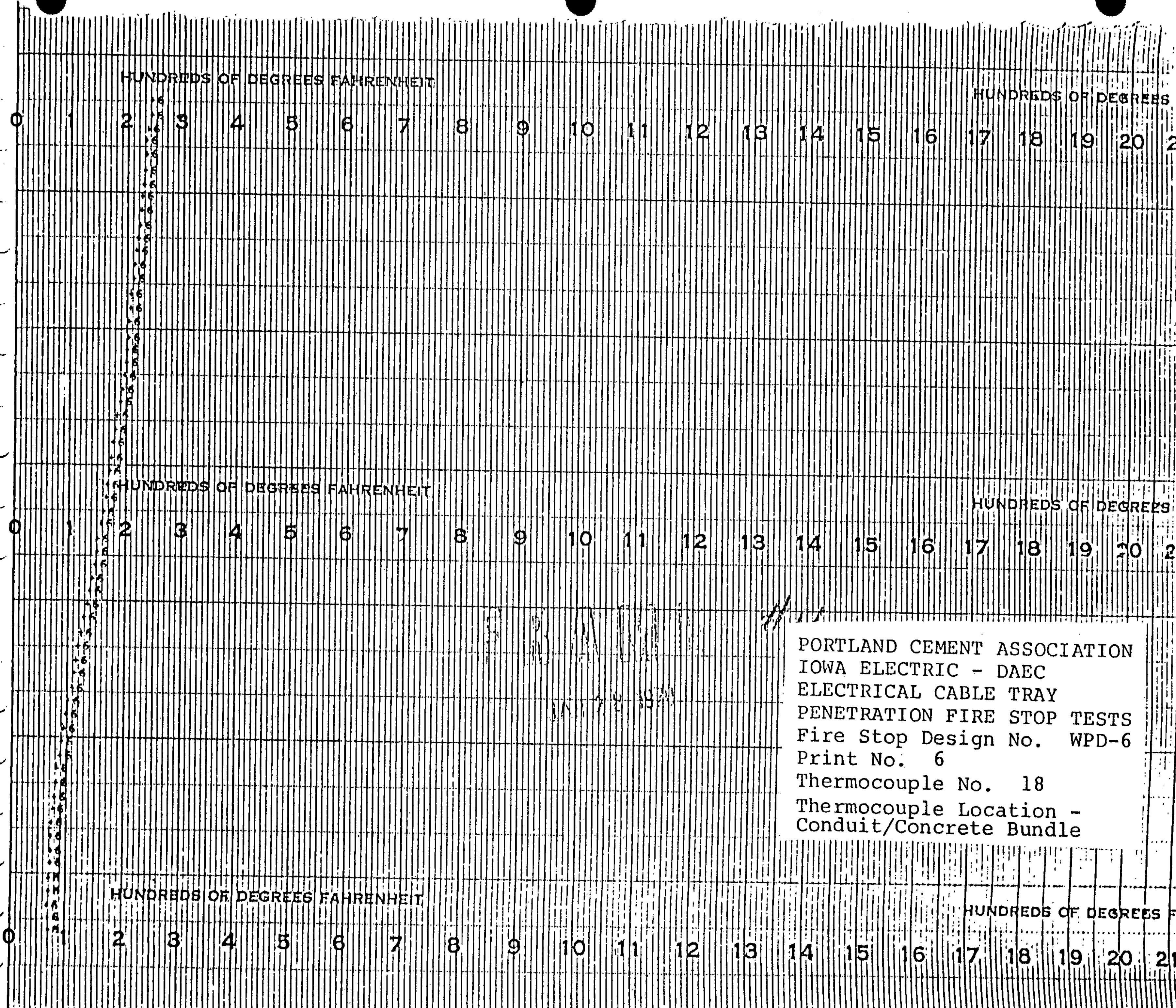
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 2
Print No. 3
Thermocouple No. 3
Thermocouple Location -
Conduit/Concrete Interface



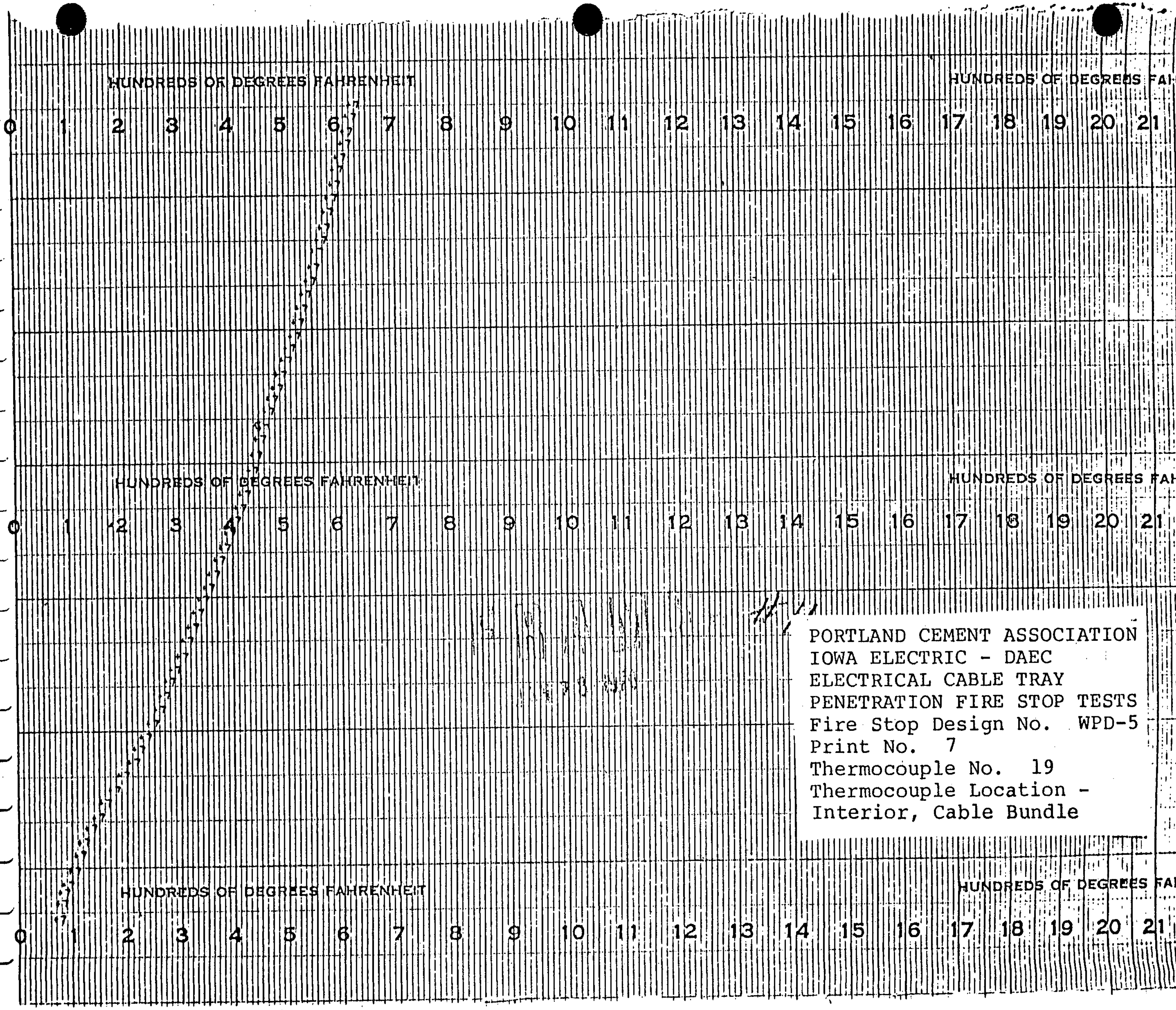
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 4
Thermocouple No. 16
Thermocouple Location -
Interior, Cable Bundle



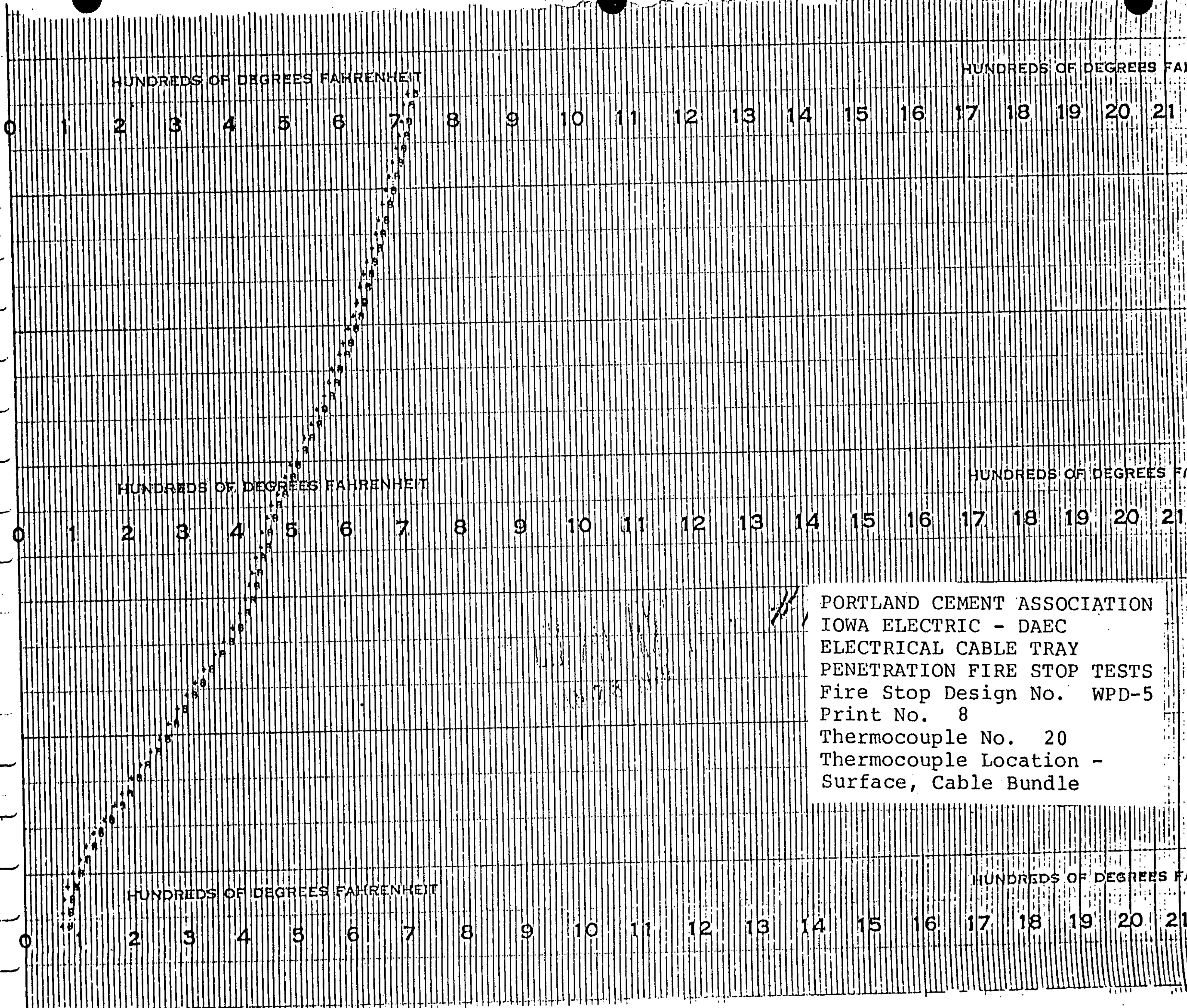
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 5
Thermocouple No. 17
Thermocouple Location -
Surface, Cable Bundle



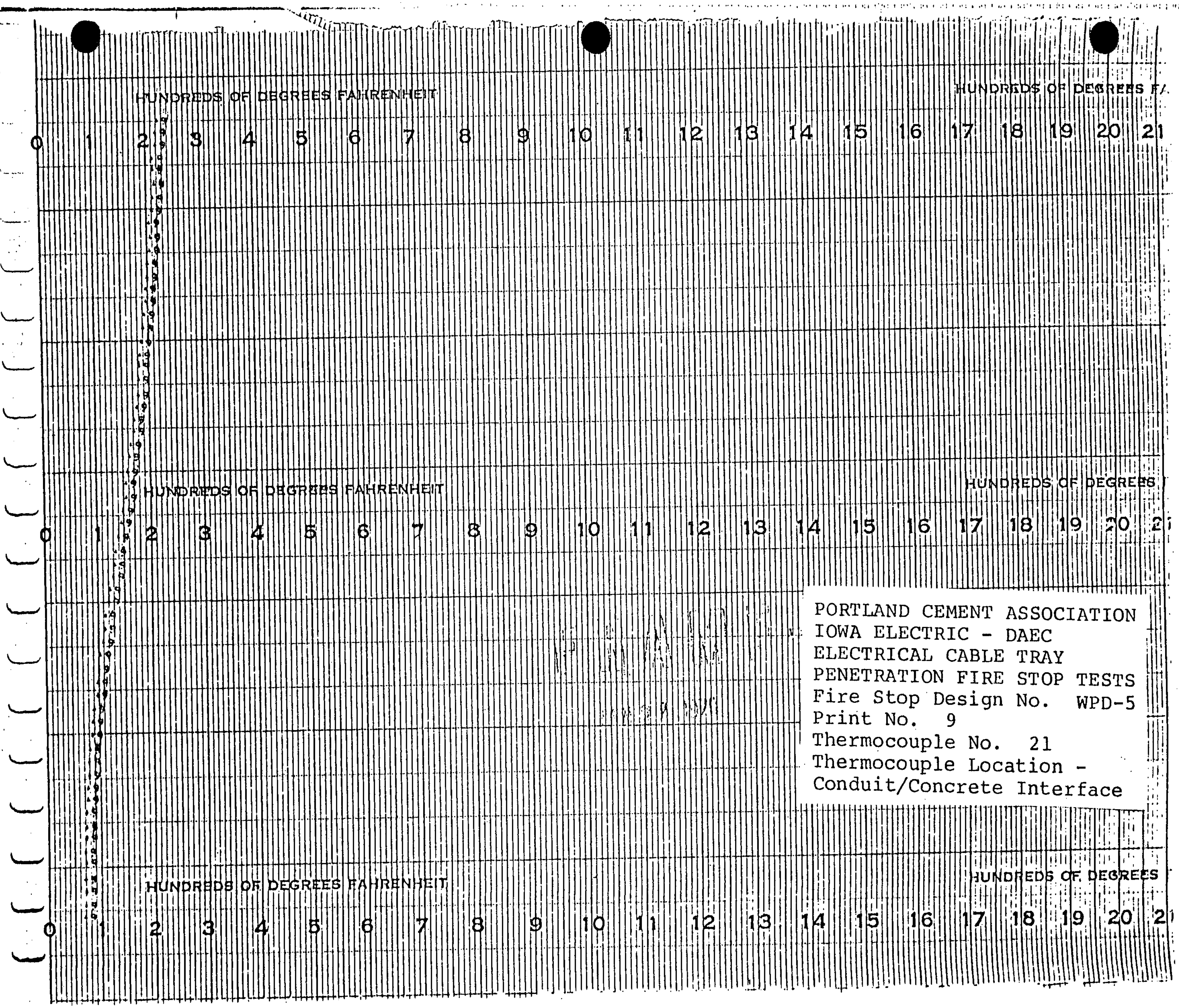
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 6
Thermocouple No. 18
Thermocouple Location -
Conduit/Concrete Bundle



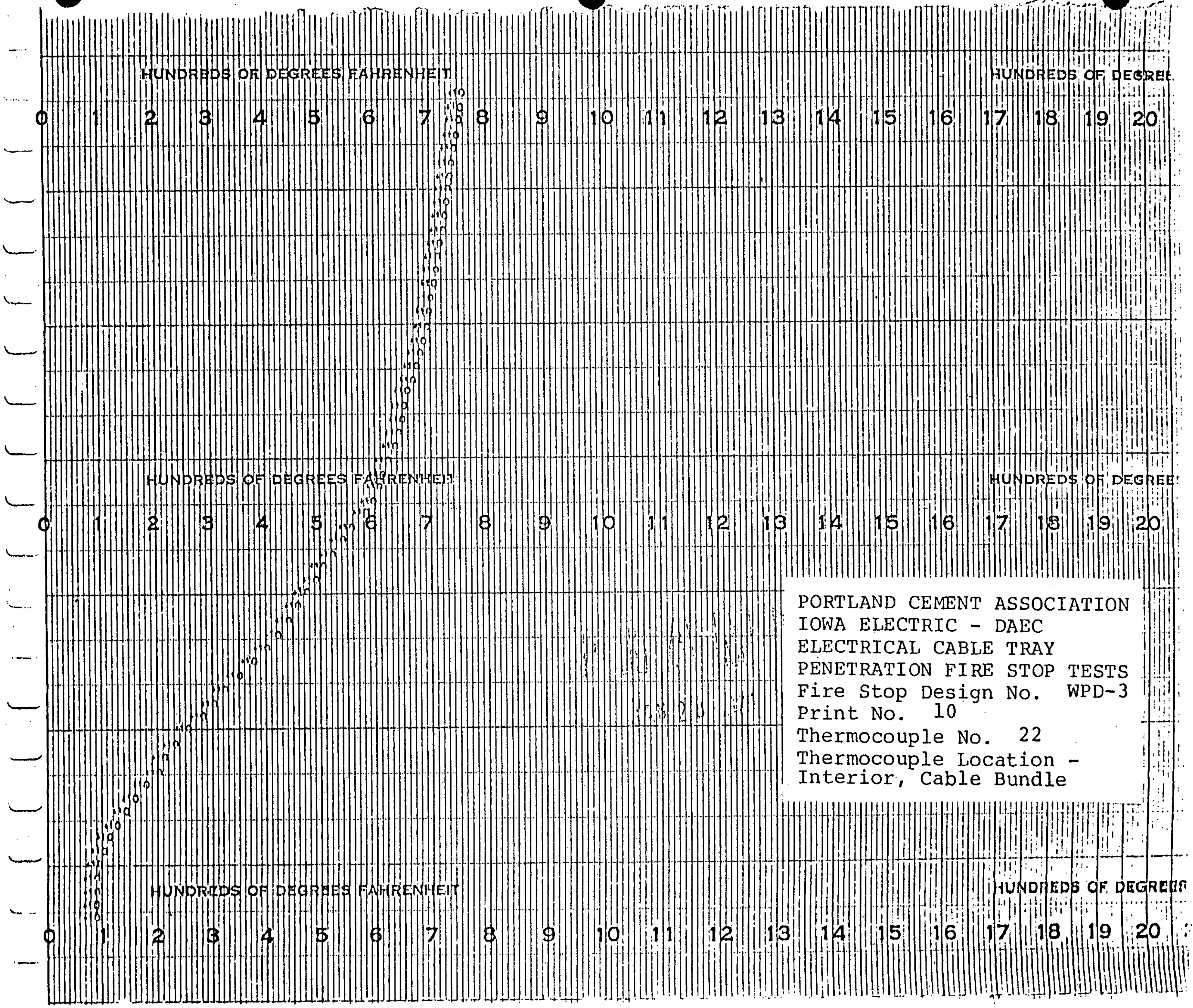
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 7
Thermocouple No. 19
Thermocouple Location -
Interior, Cable Bundle



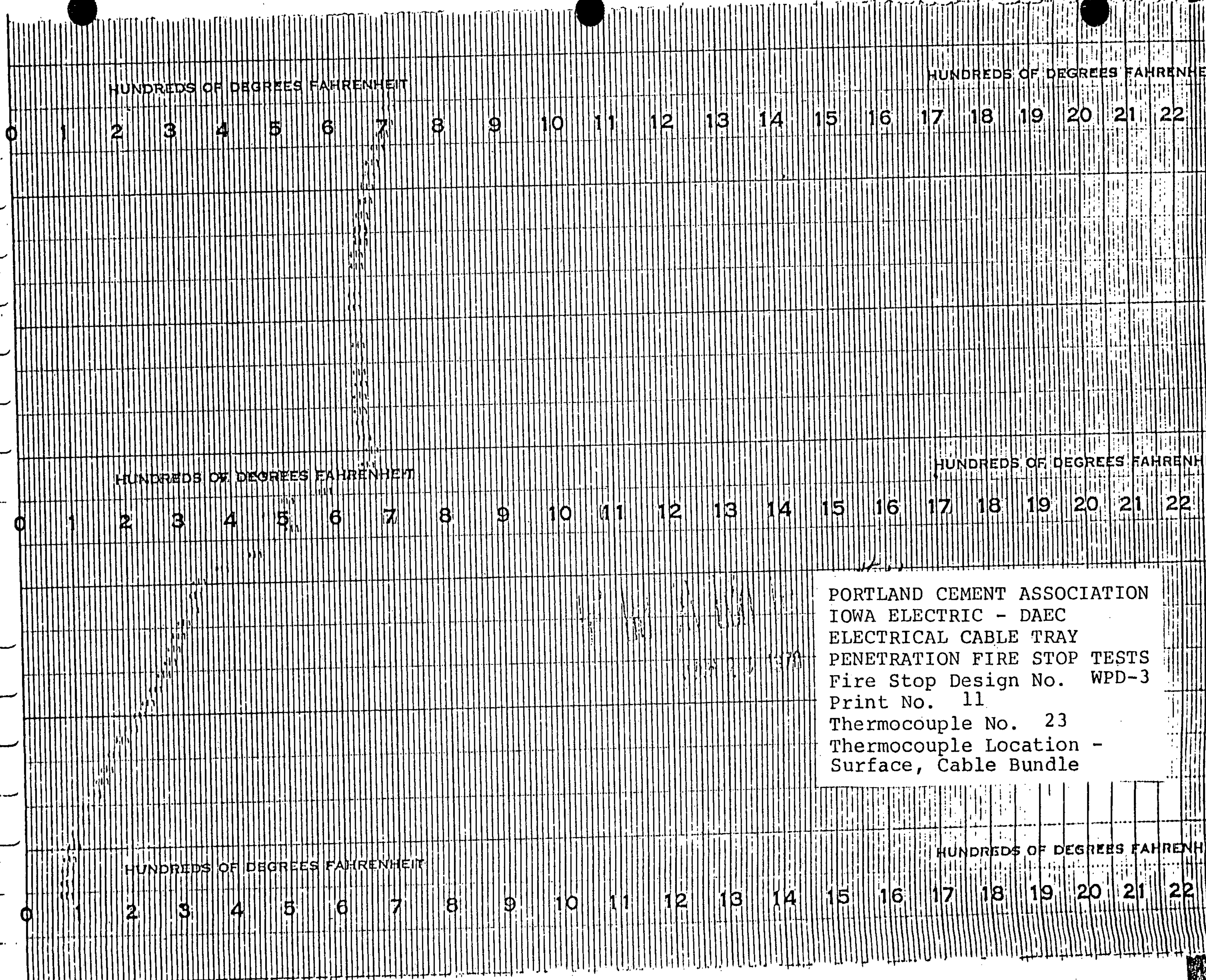
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 8
Thermocouple No. 20
Thermocouple Location -
Surface, Cable Bundle



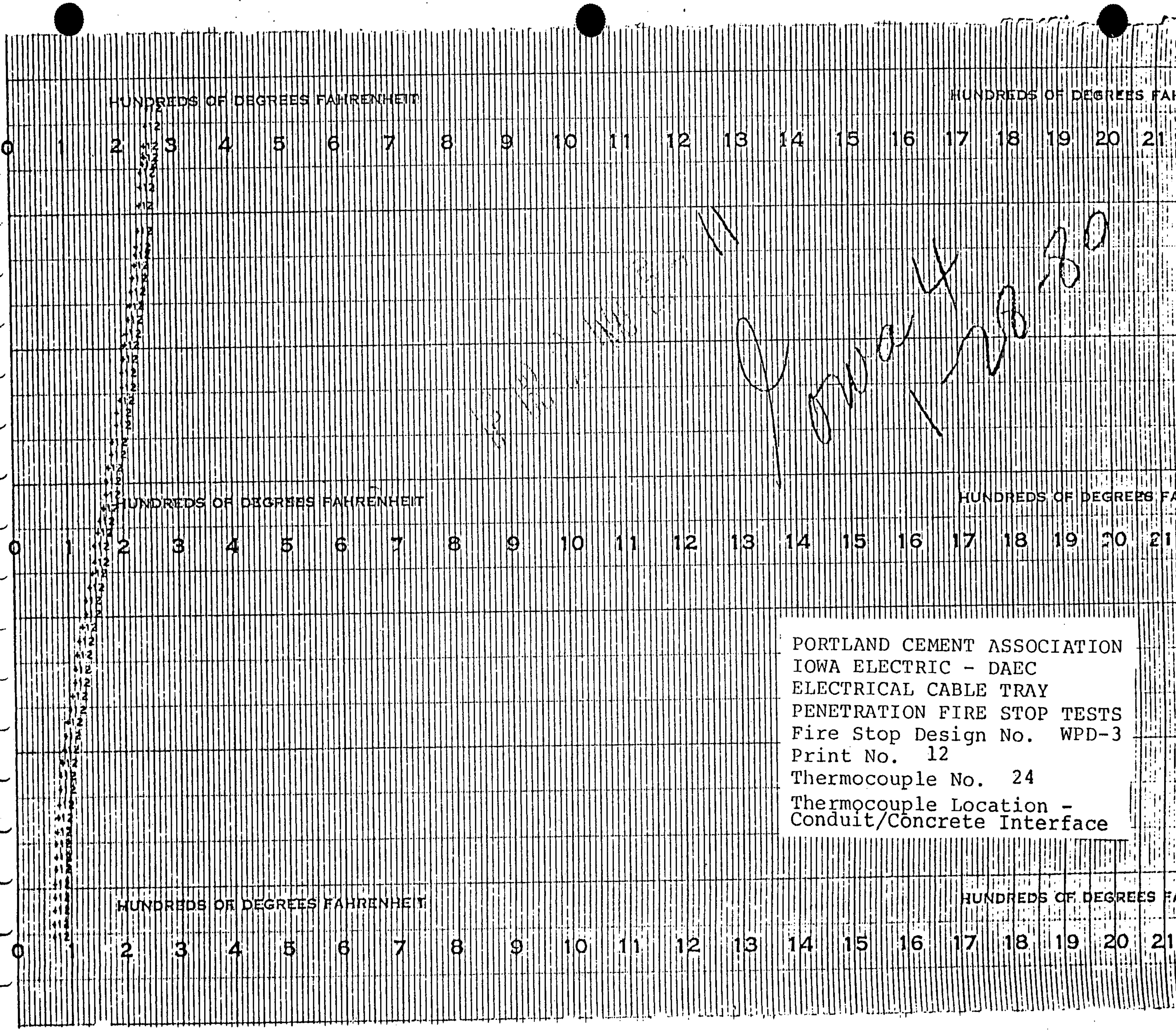
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 9
Thermocouple No. 21
Thermocouple Location -
Conduit/Concrete Interface



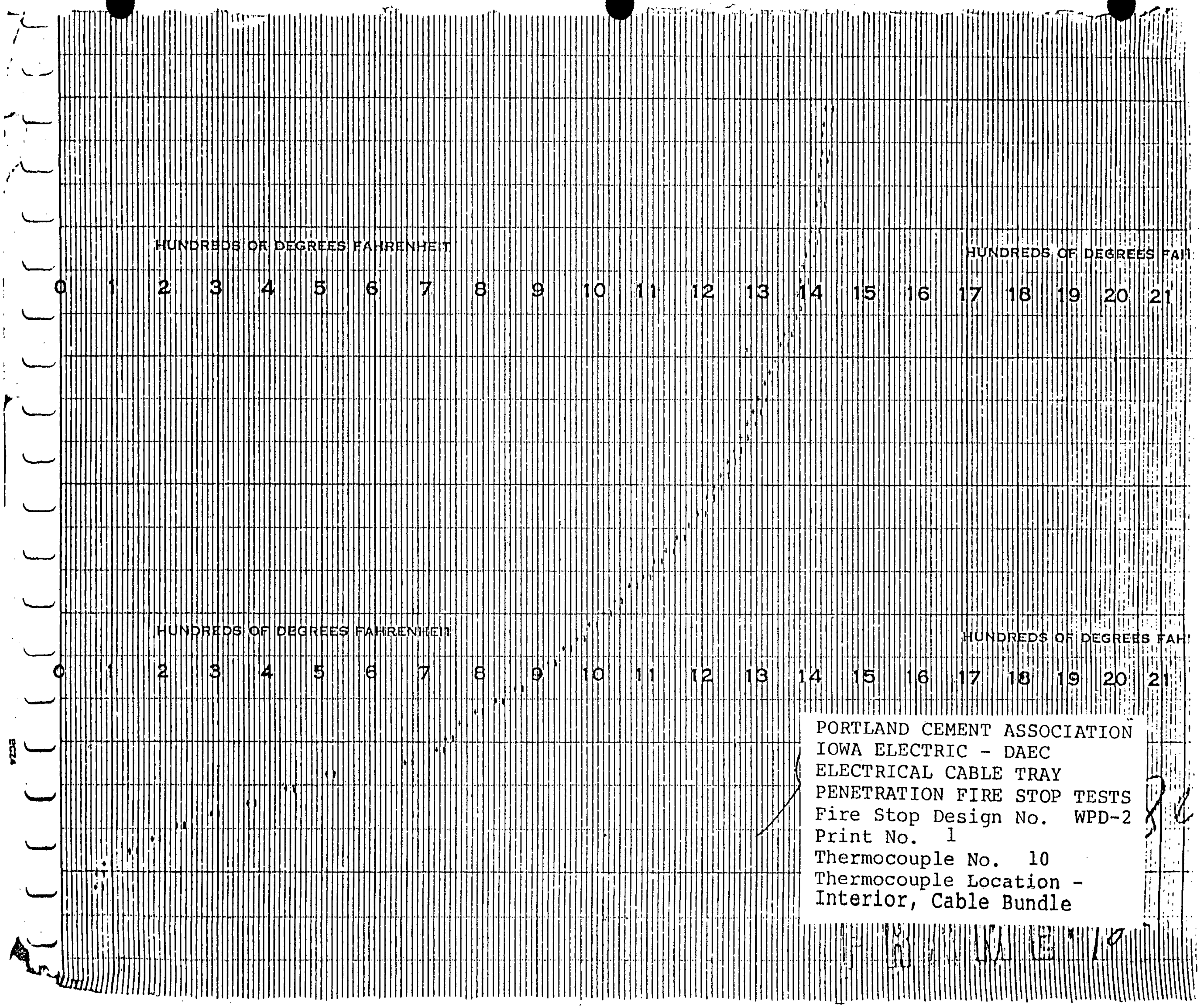
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 10
Thermocouple No. 22
Thermocouple Location -
Interior, Cable Bundle



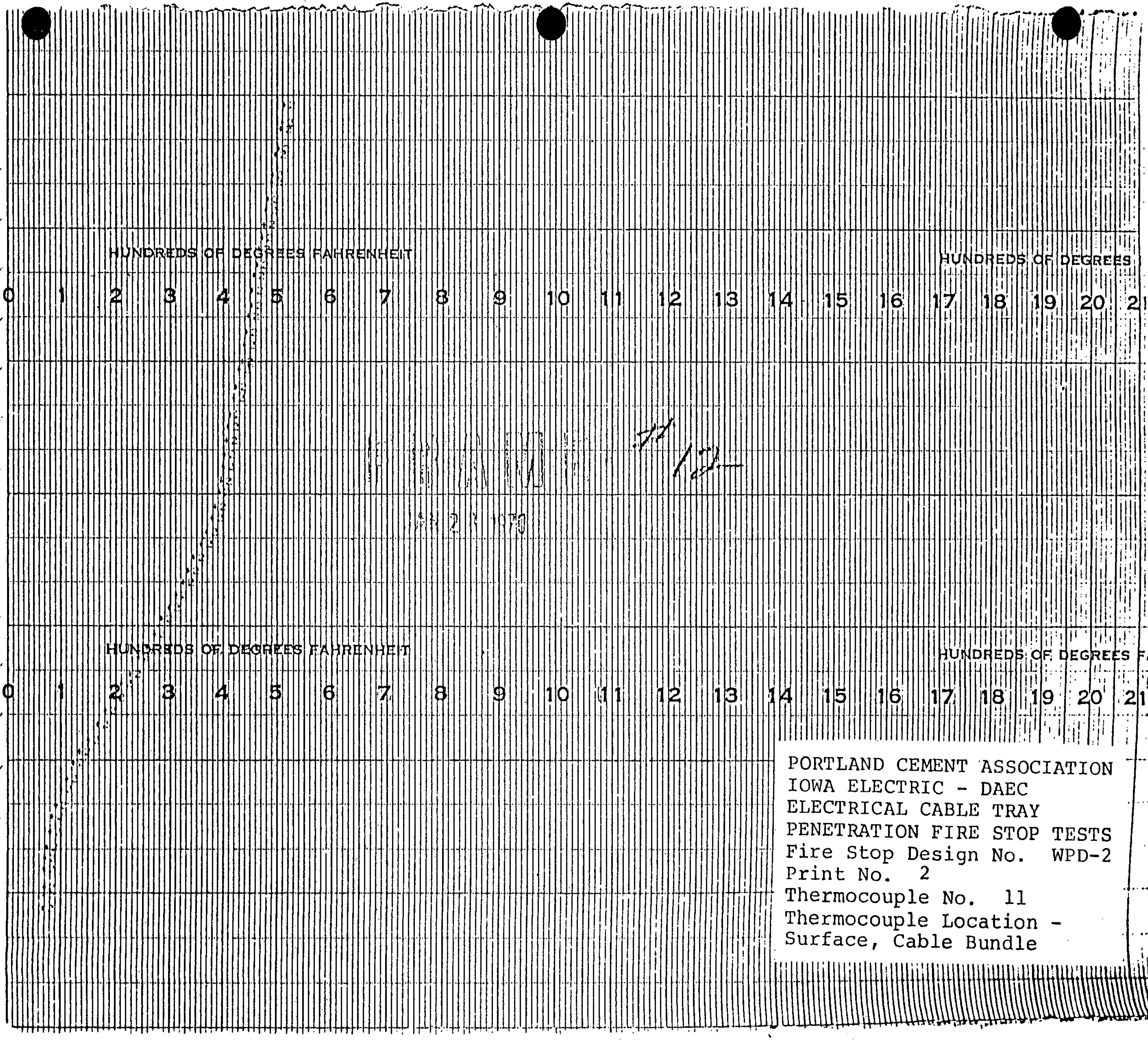
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 11
Thermocouple No. 23
Thermocouple Location -
Surface, Cable Bundle



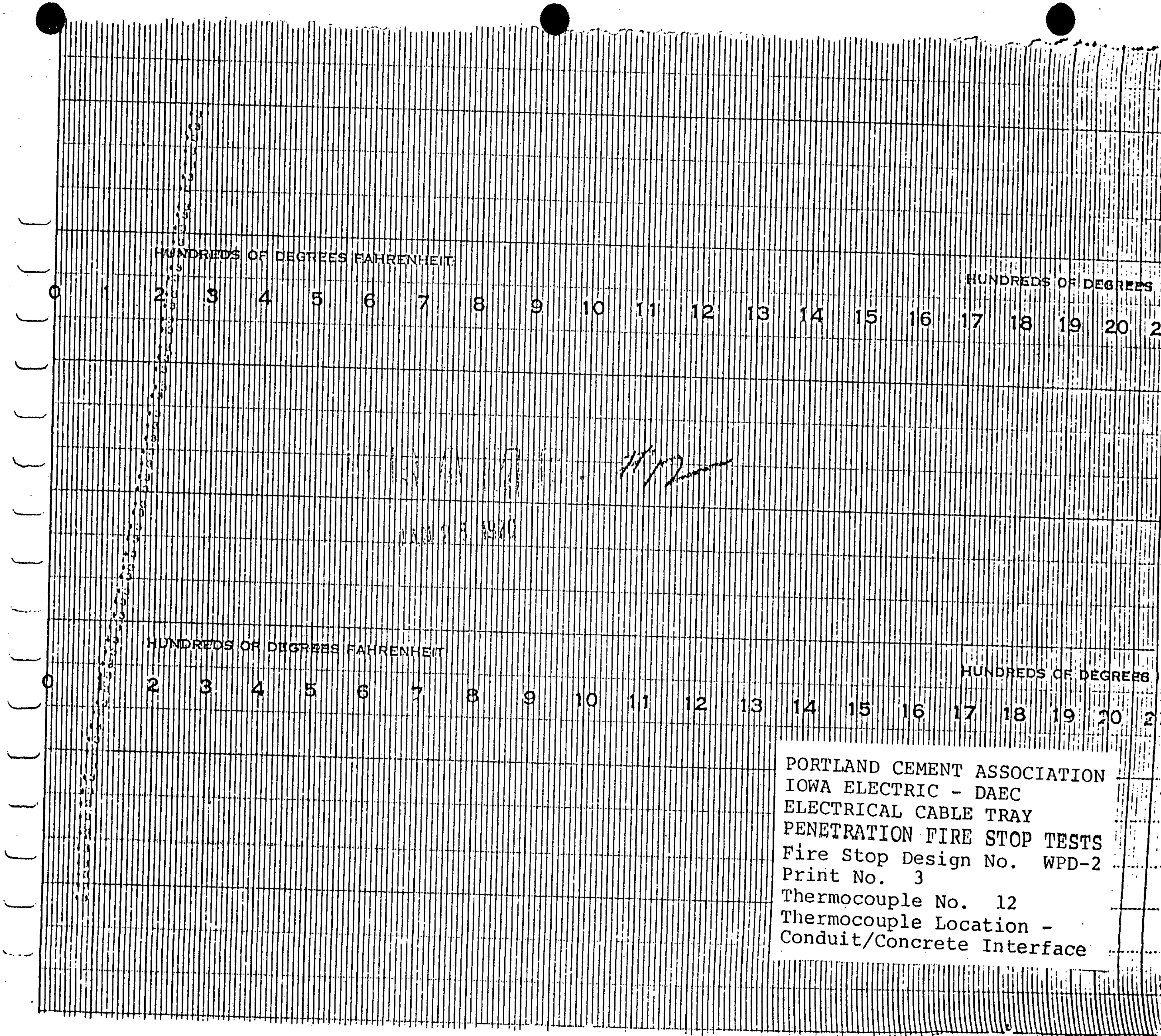
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 12
Thermocouple No. 24
Thermocouple Location -
Conduit/Concrete Interface



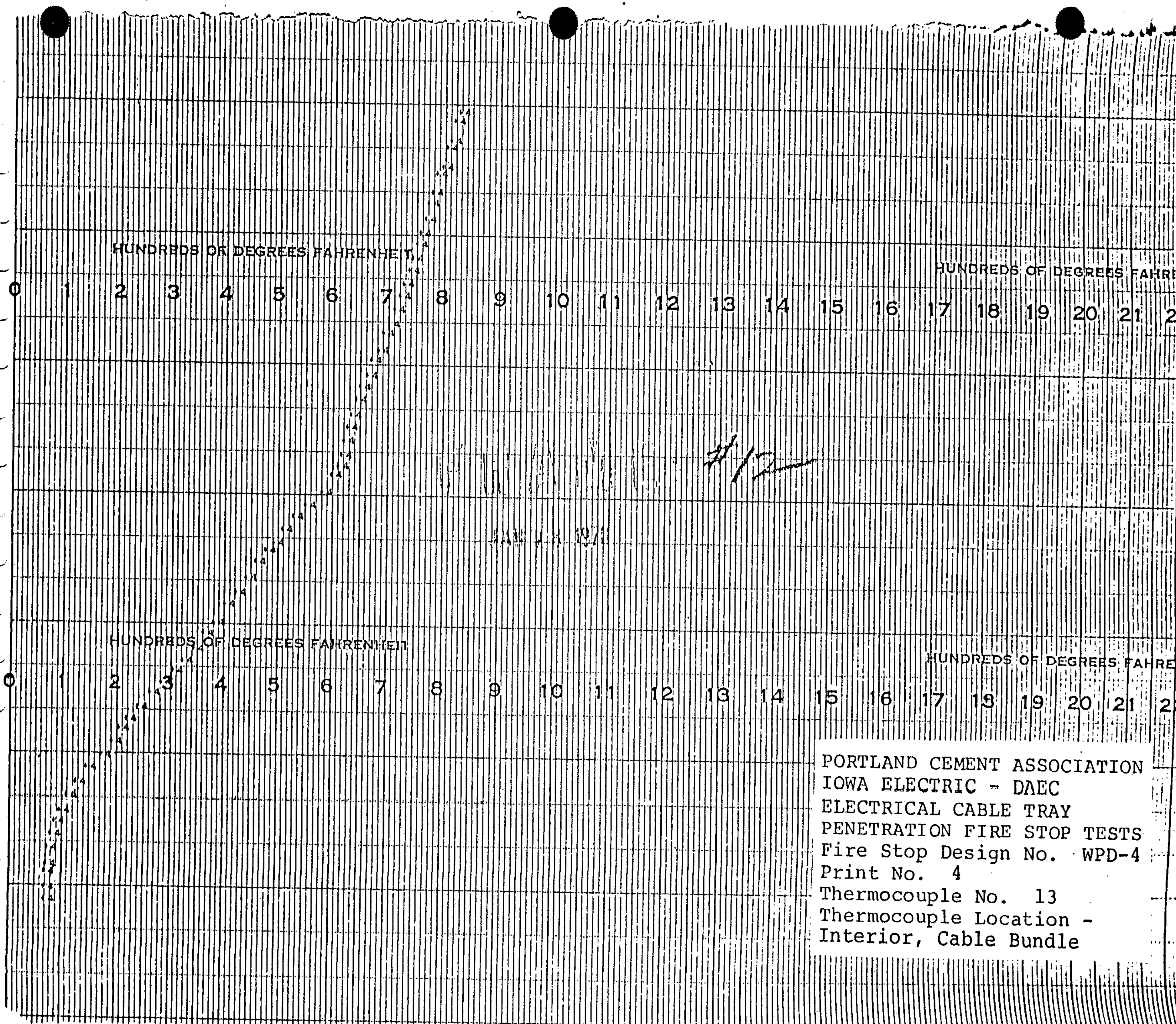
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 1
Thermocouple No. 10
Thermocouple Location -
Interior, Cable Bundle



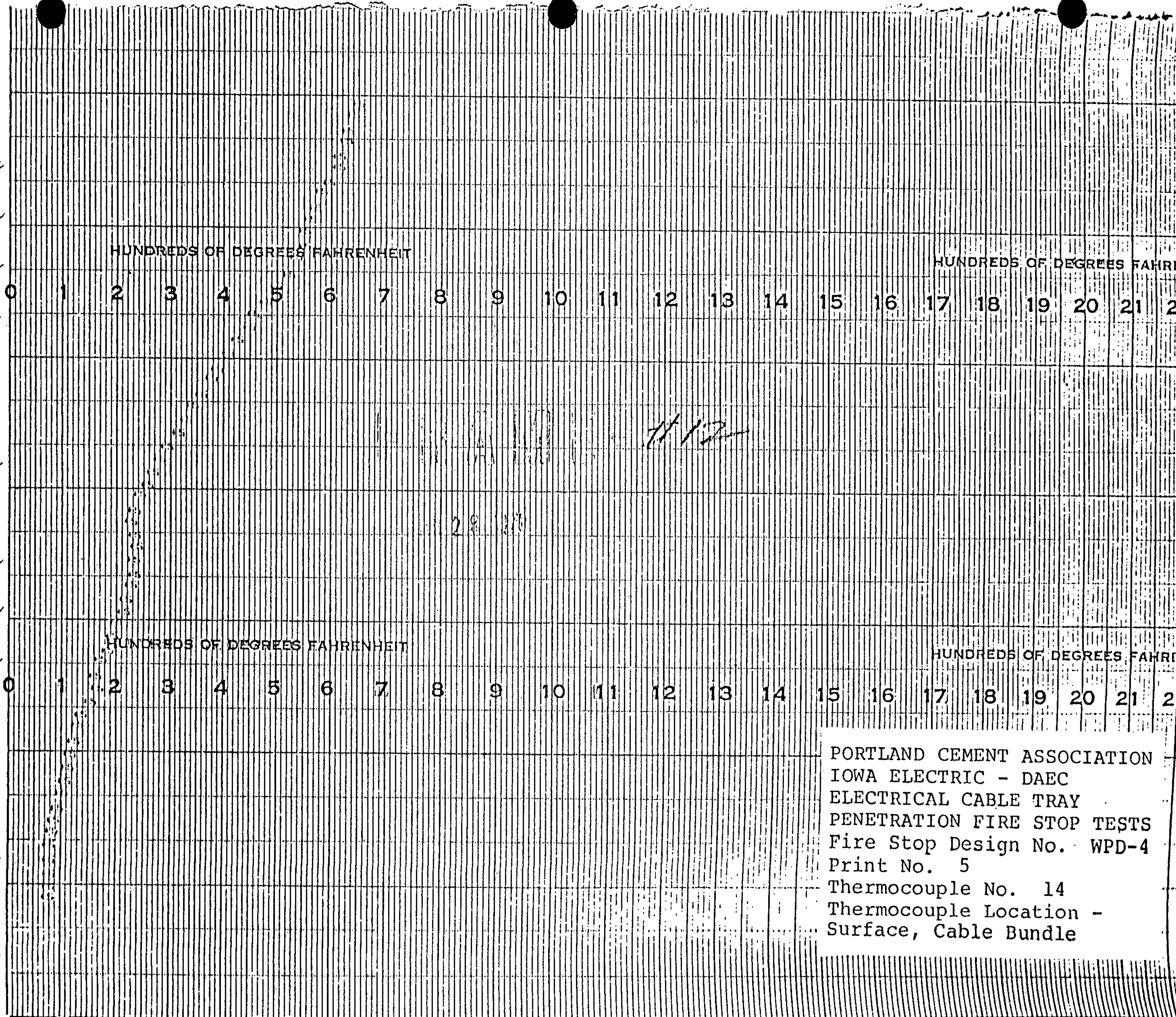
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 2
Thermocouple No. 11
Thermocouple Location -
Surface, Cable Bundle



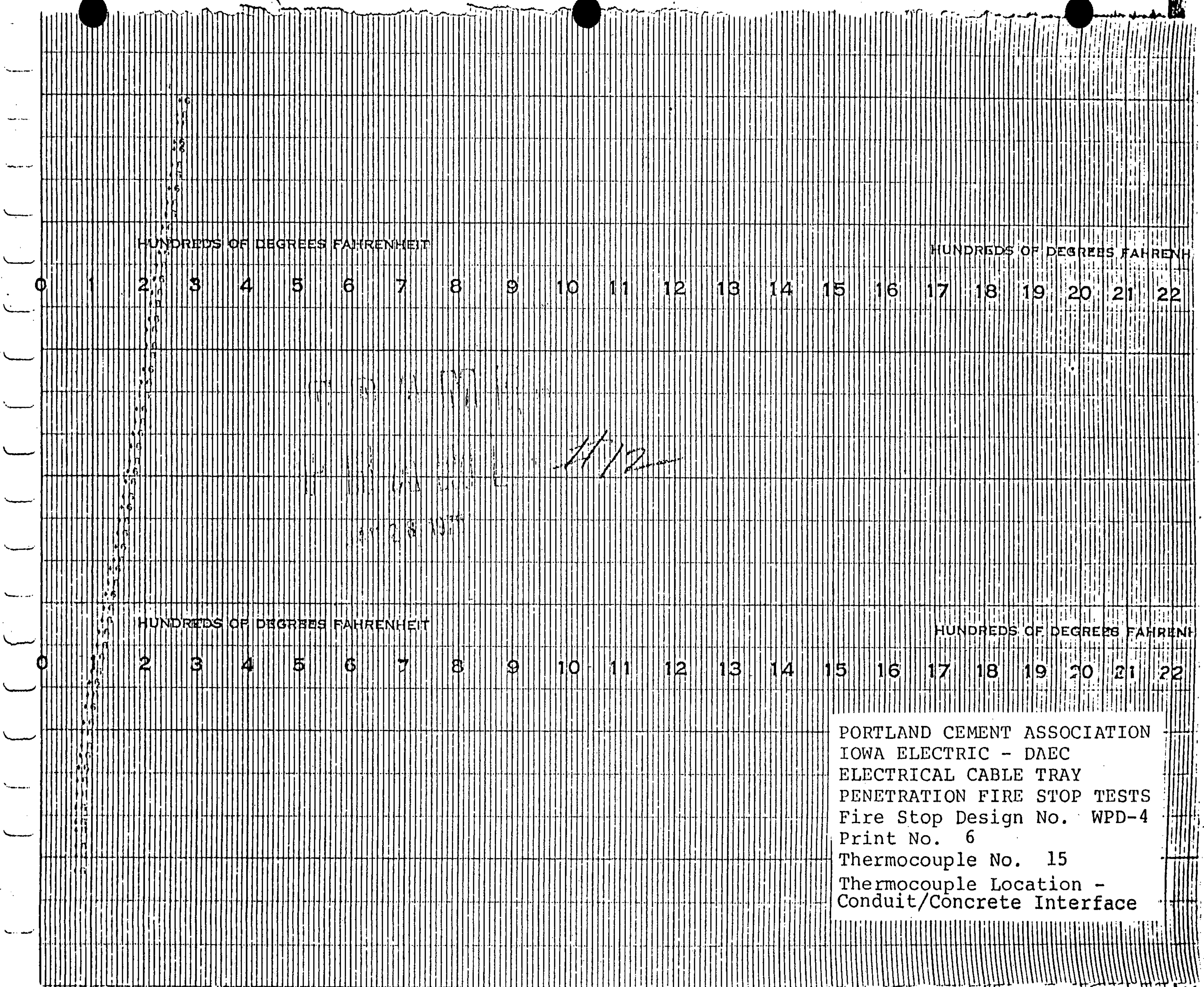
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 3
Thermocouple No. 12
Thermocouple Location -
Conduit/Concrete Interface



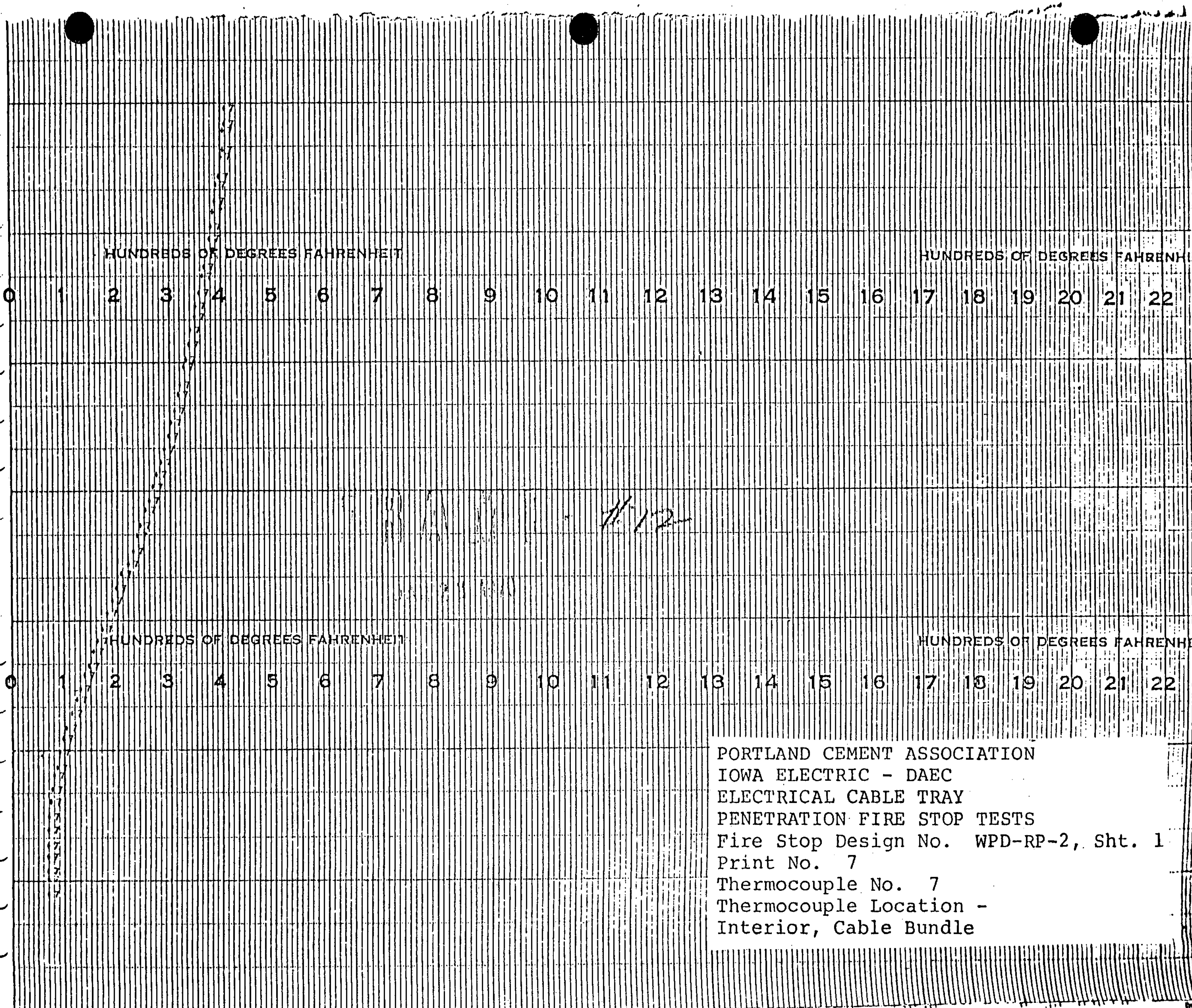
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 4
Thermocouple No. 13
Thermocouple Location -
Interior, Cable Bundle



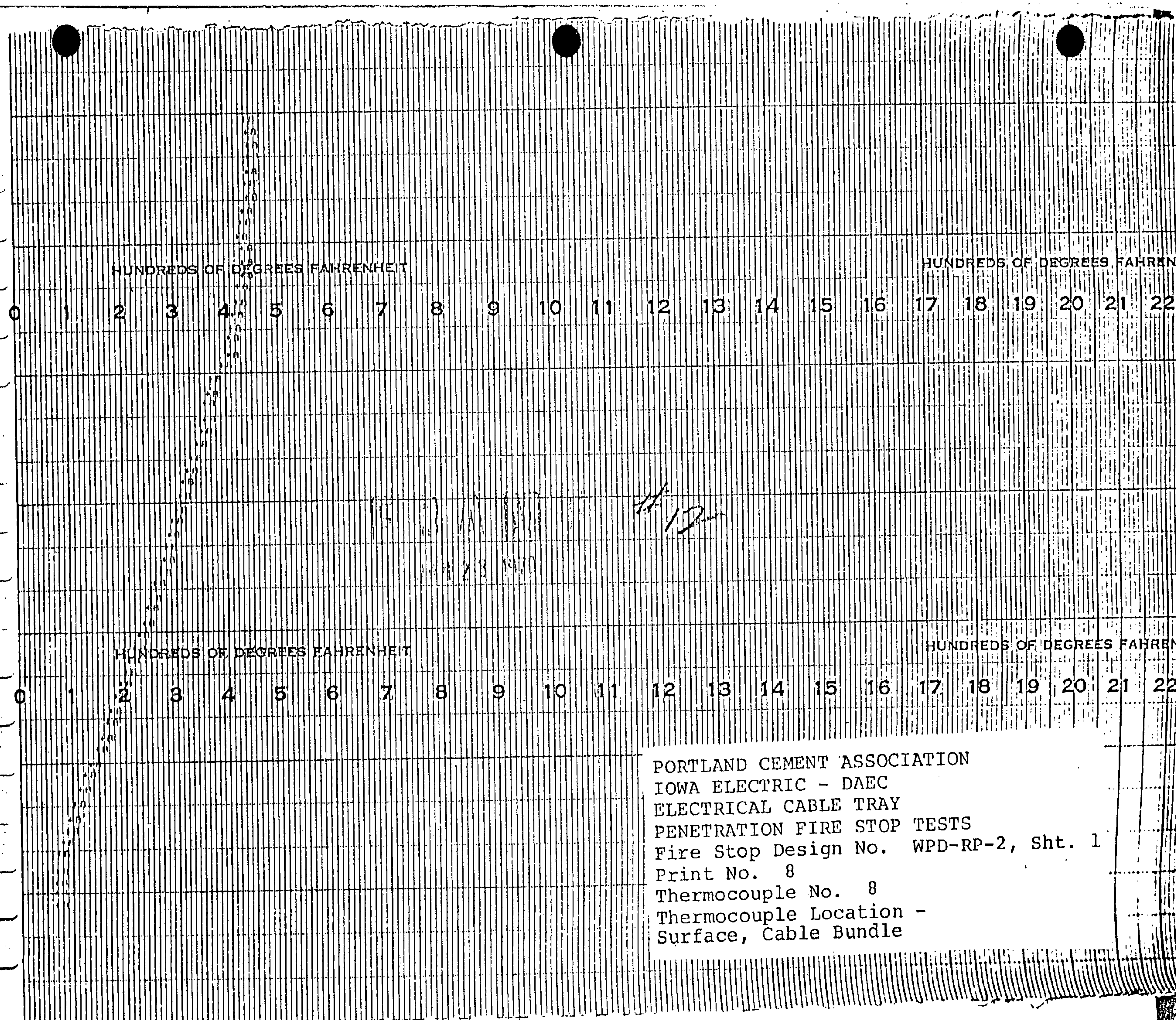
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 5
Thermocouple No. 14
Thermocouple Location -
Surface, Cable Bundle



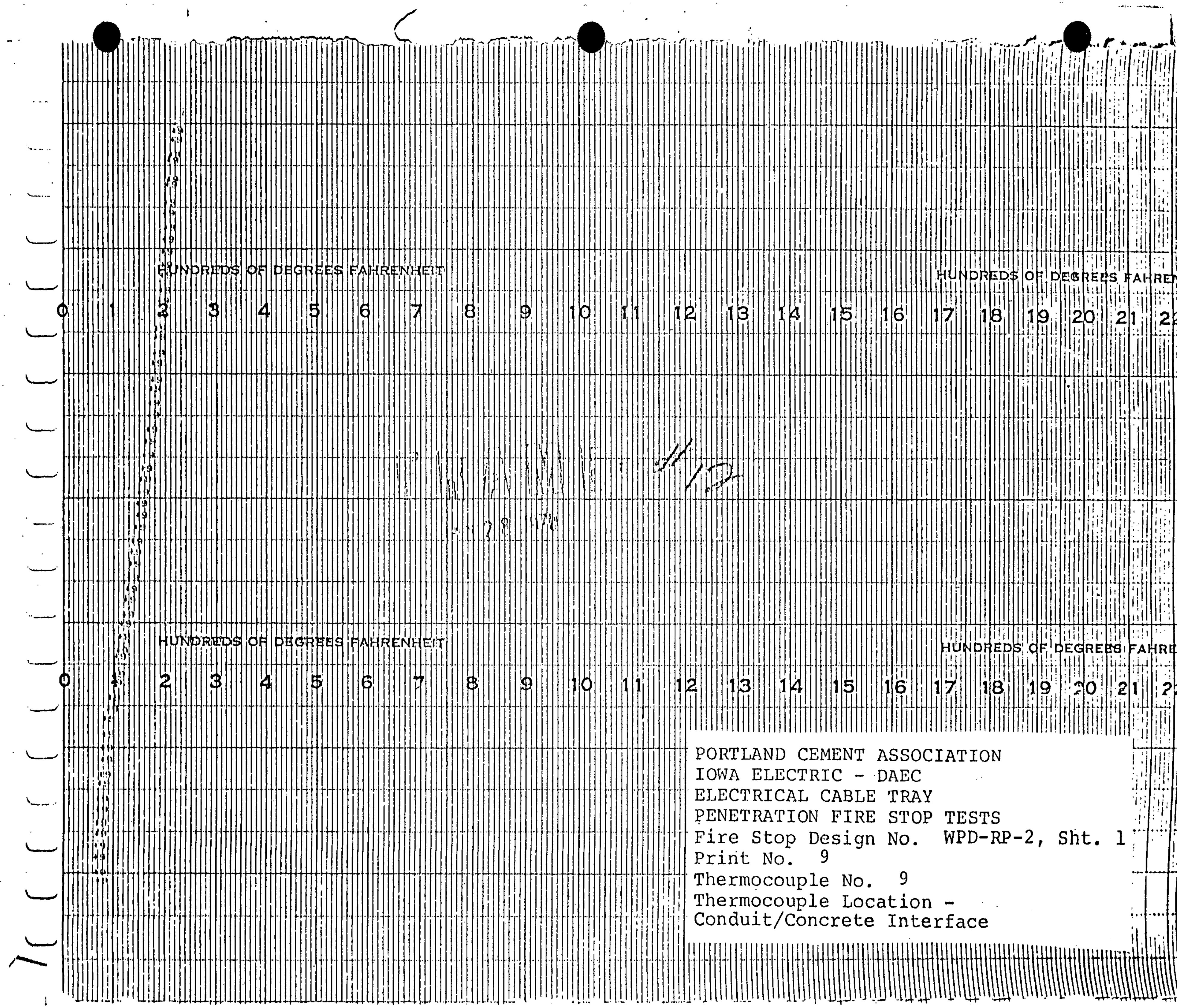
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 6
Thermocouple No. 15
Thermocouple Location -
Conduit/Concrete Interface



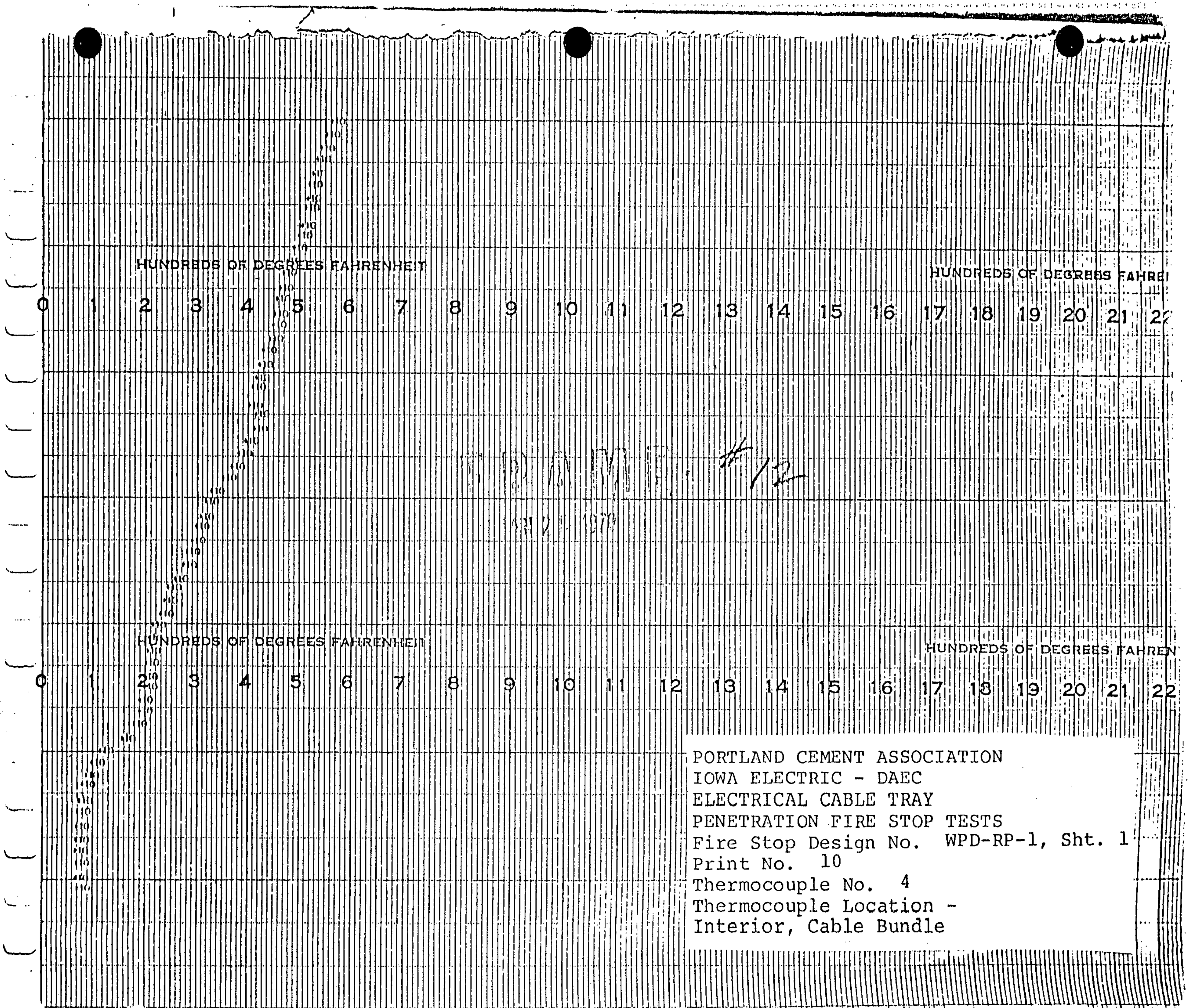
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 1
Print No. 7
Thermocouple No. 7
Thermocouple Location -
Interior, Cable Bundle



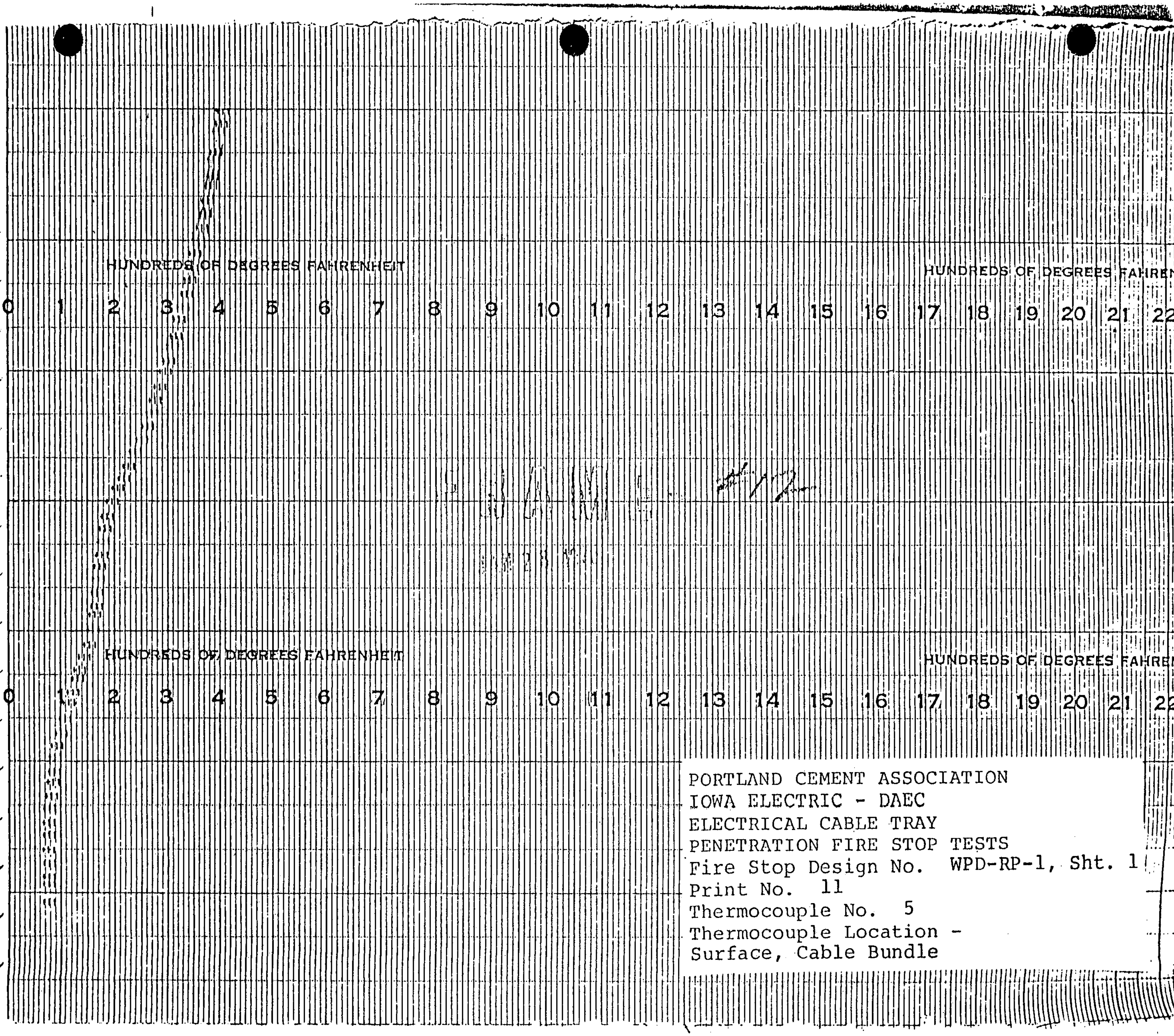
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 1
Print No. 8
Thermocouple No. 8
Thermocouple Location -
Surface, Cable Bundle



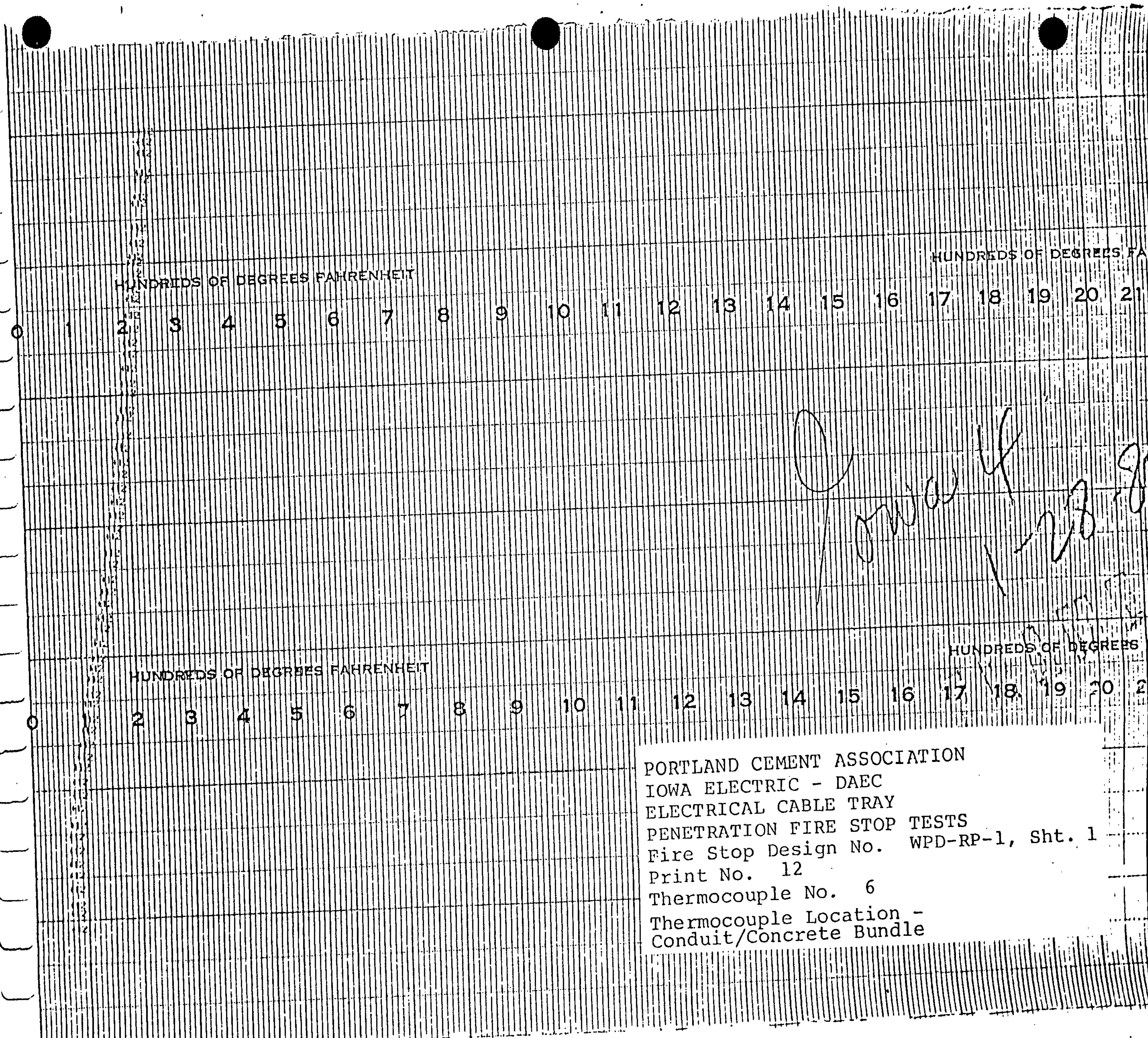
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 1
Print No. 9
Thermocouple No. 9
Thermocouple Location -
Conduit/Concrete Interface



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 1
Print No. 10
Thermocouple No. 4
Thermocouple Location -
Interior, Cable Bundle



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 1
Print No. 11
Thermocouple No. 5
Thermocouple Location -
Surface, Cable Bundle



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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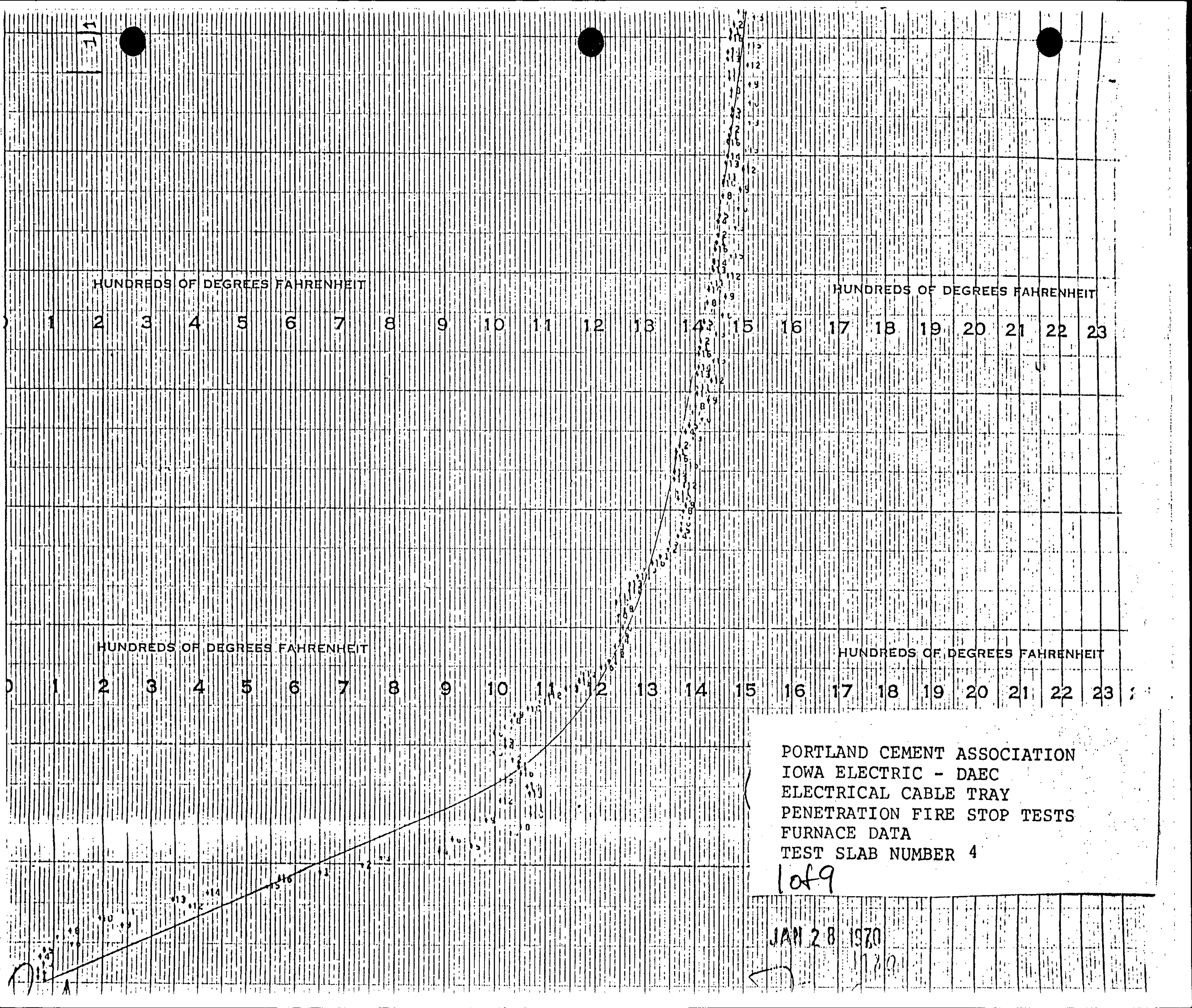
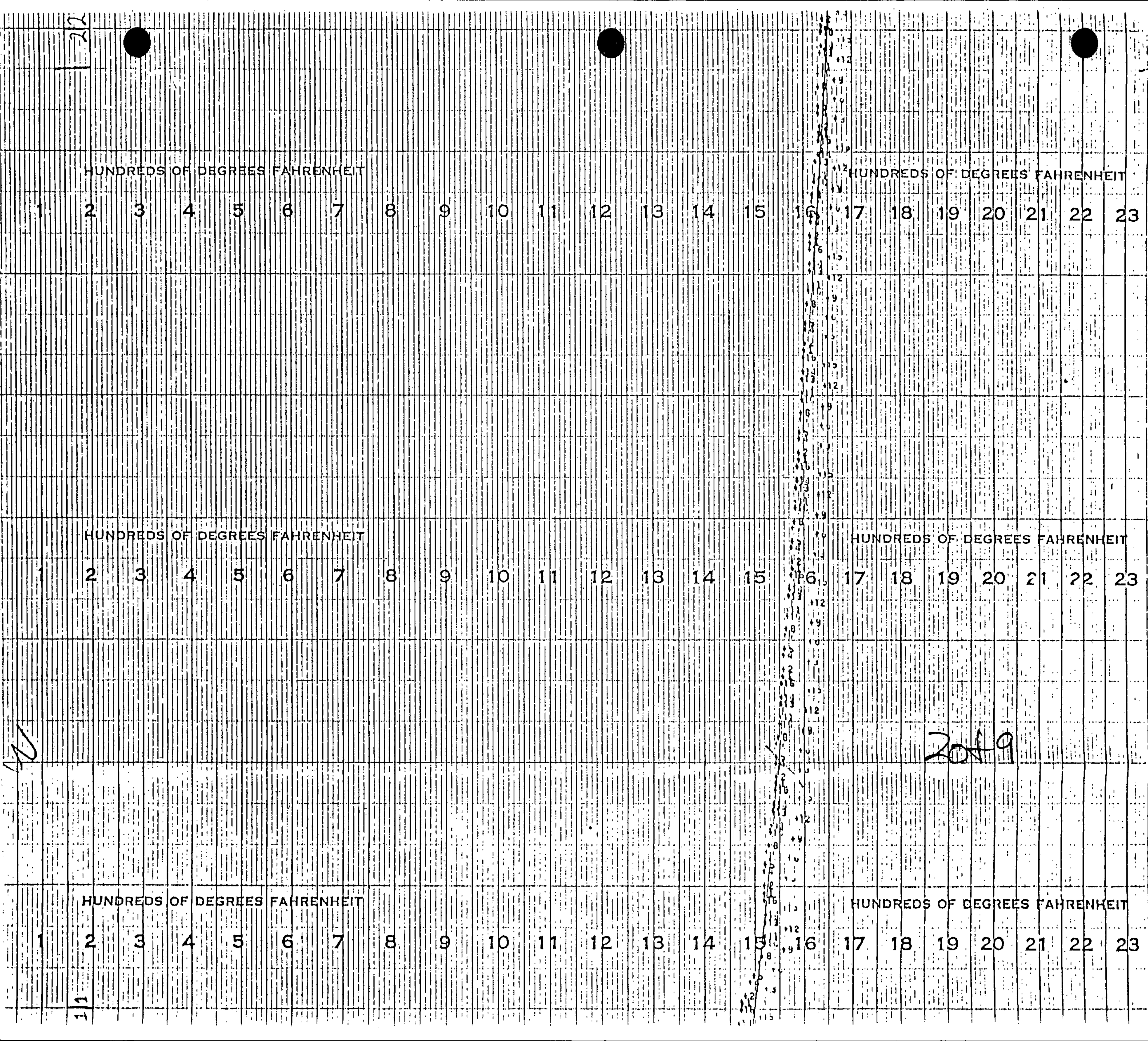
Print No. 12
Thermocouple No. 6
Thermocouple Location -
Conduit/Concrete Bundle



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 4
1 of 9

JAN 28 1970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HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
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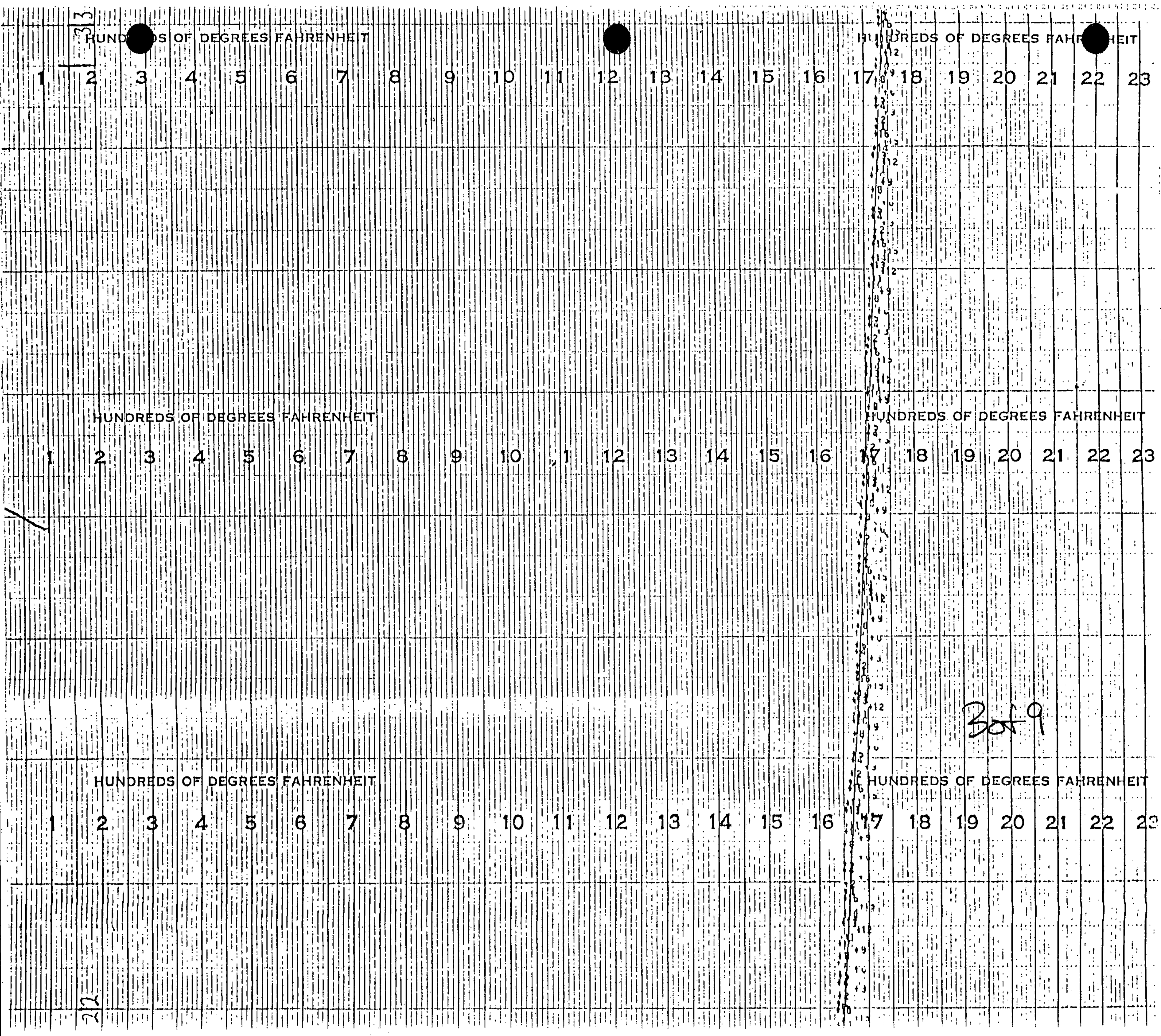
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HUNDREDS OF DEGREES FAHRENHEIT
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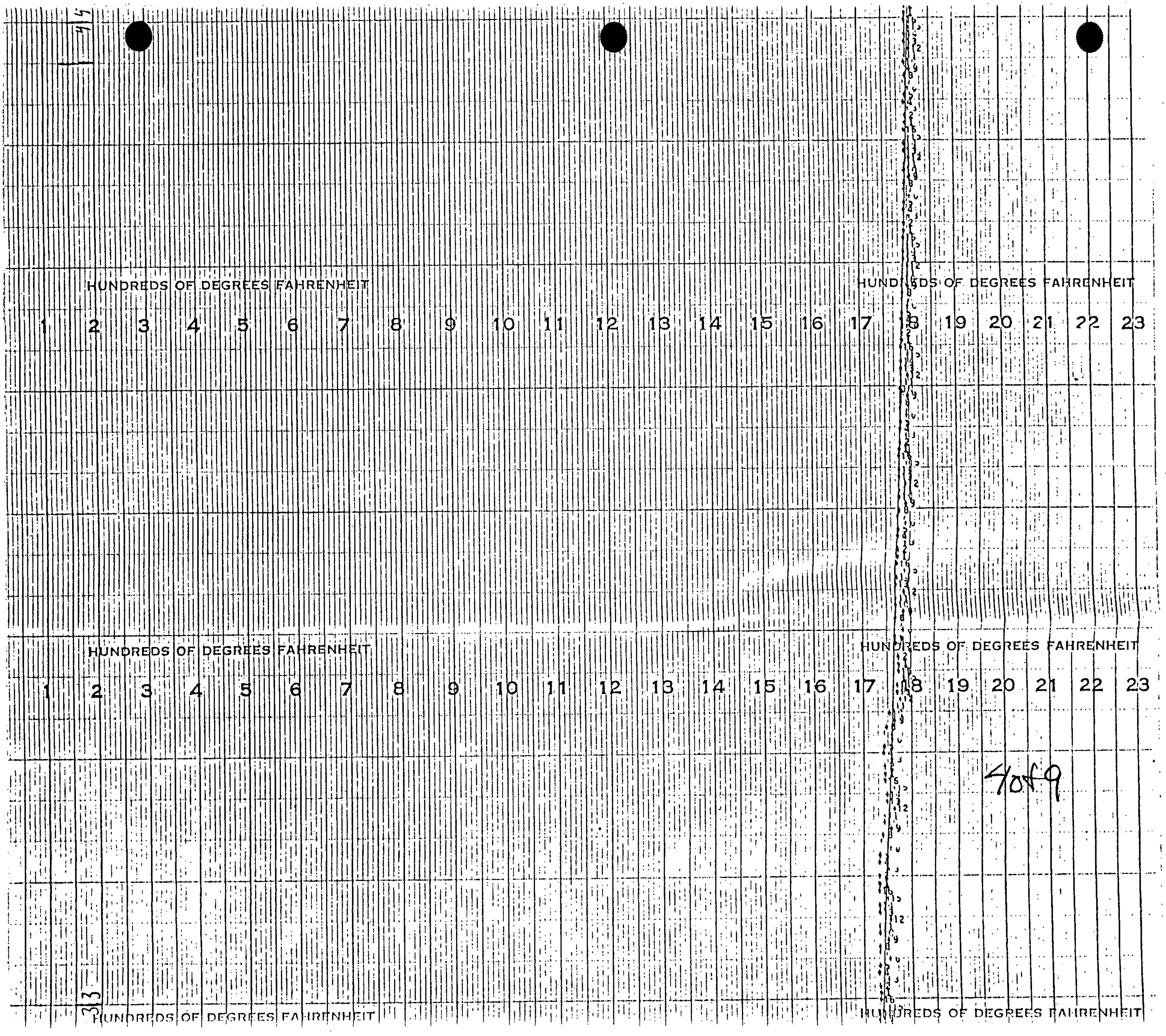
3 of 9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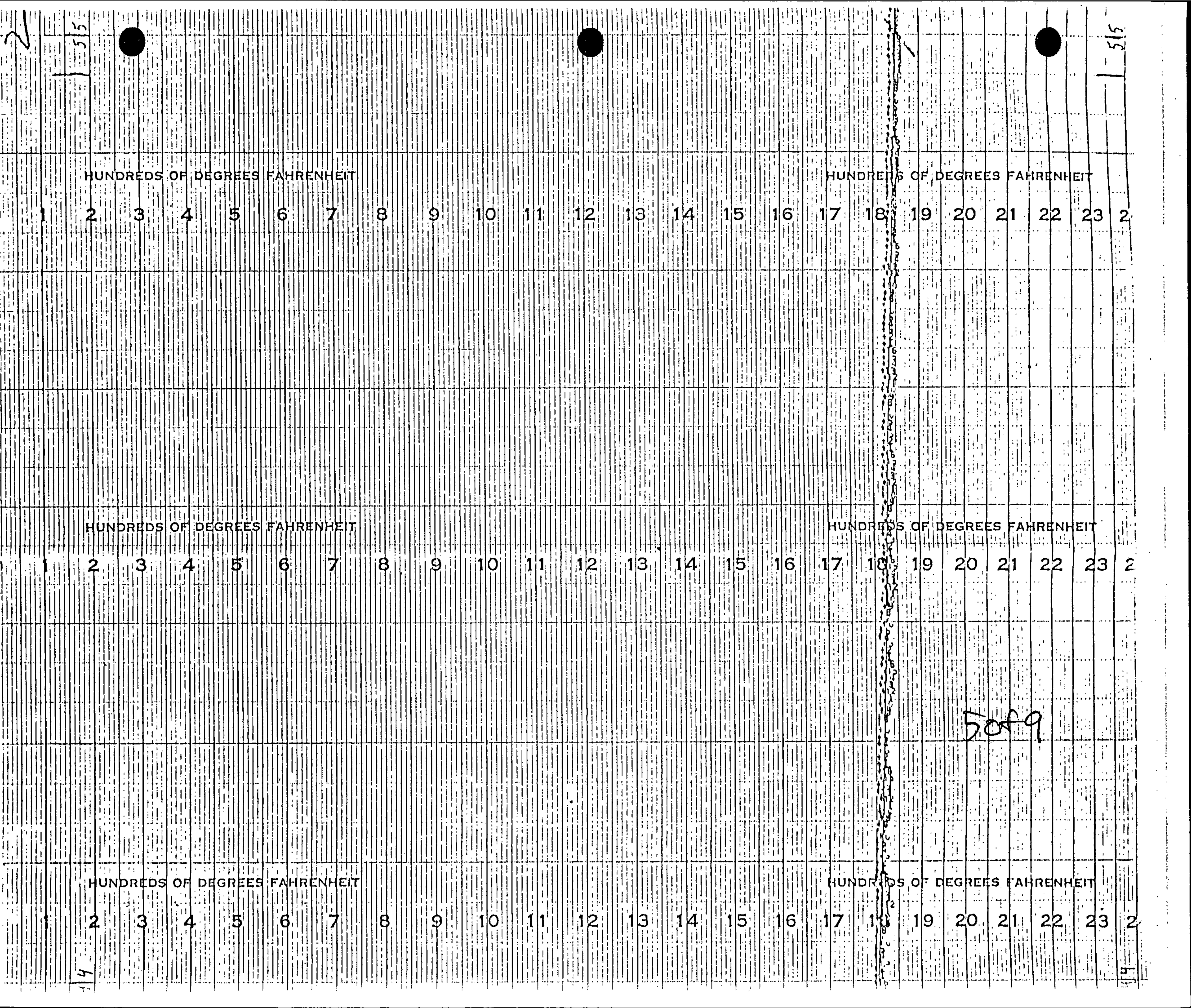
HUNDREDS OF DEGREES FAHRENHEIT
4 of 9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HUNDREDS OF DEGREES FAHRENHEIT
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HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
5 of 9
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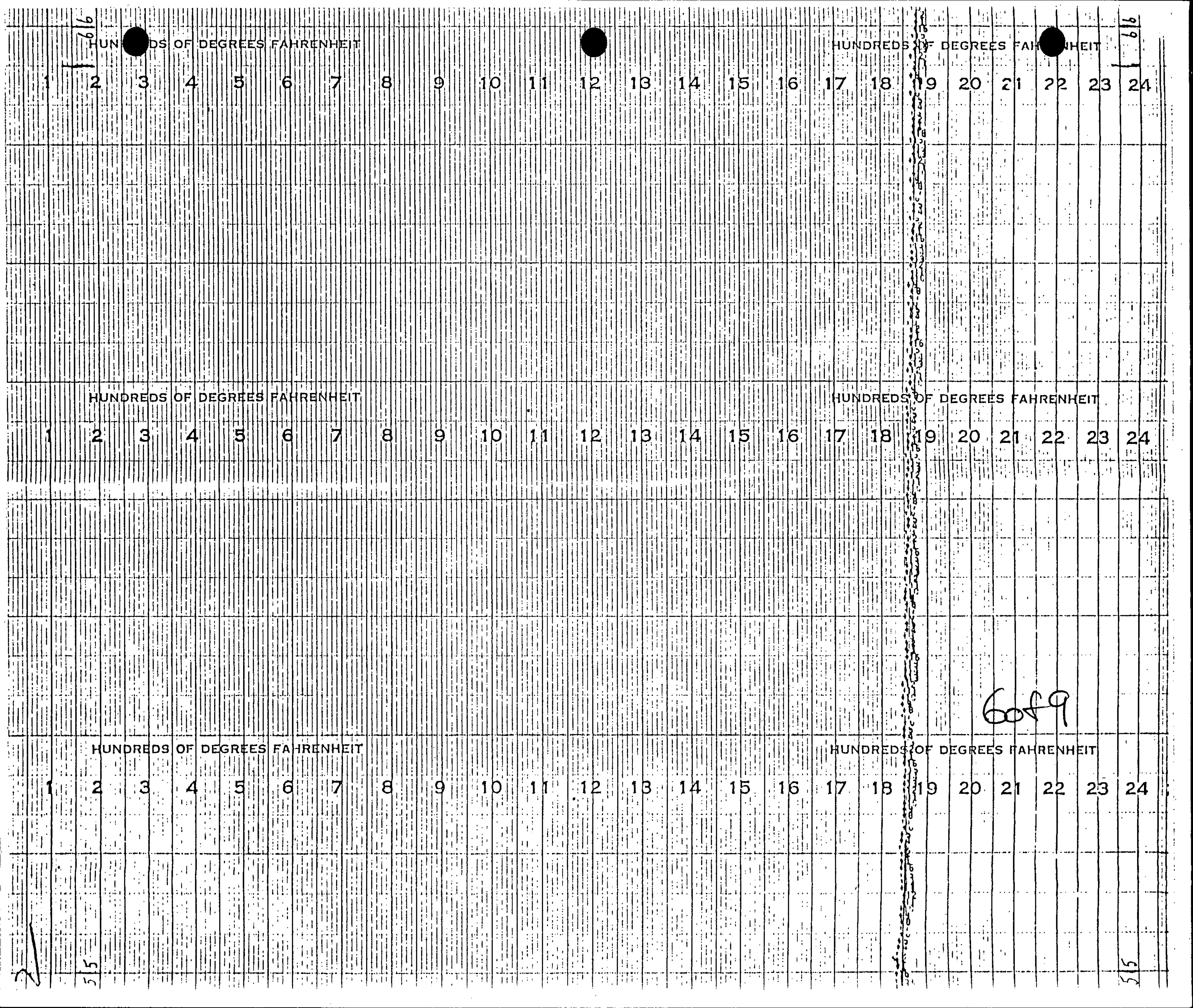
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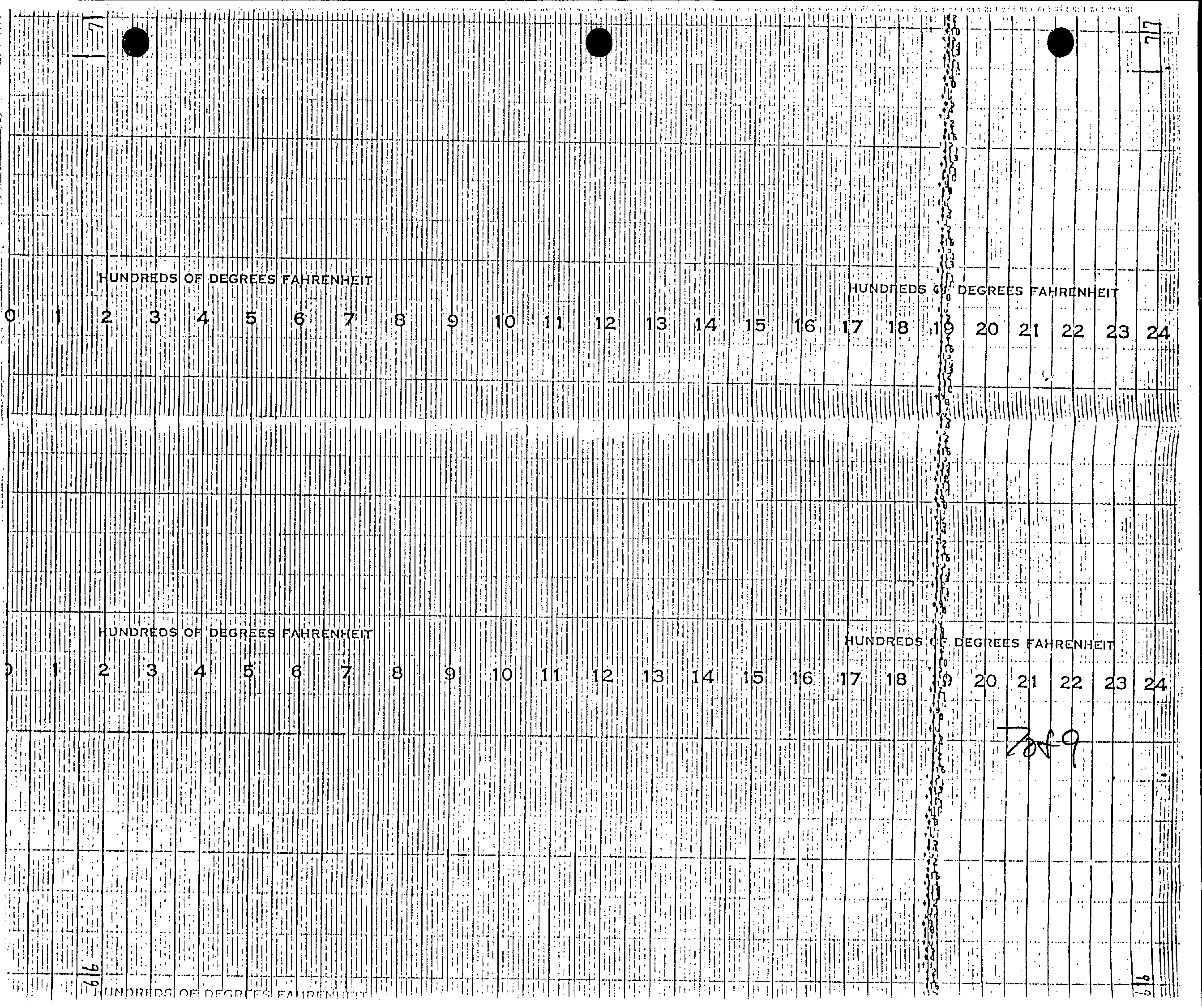
6 of 9


HUNDREDS OF DEGREES FAHRENHEIT
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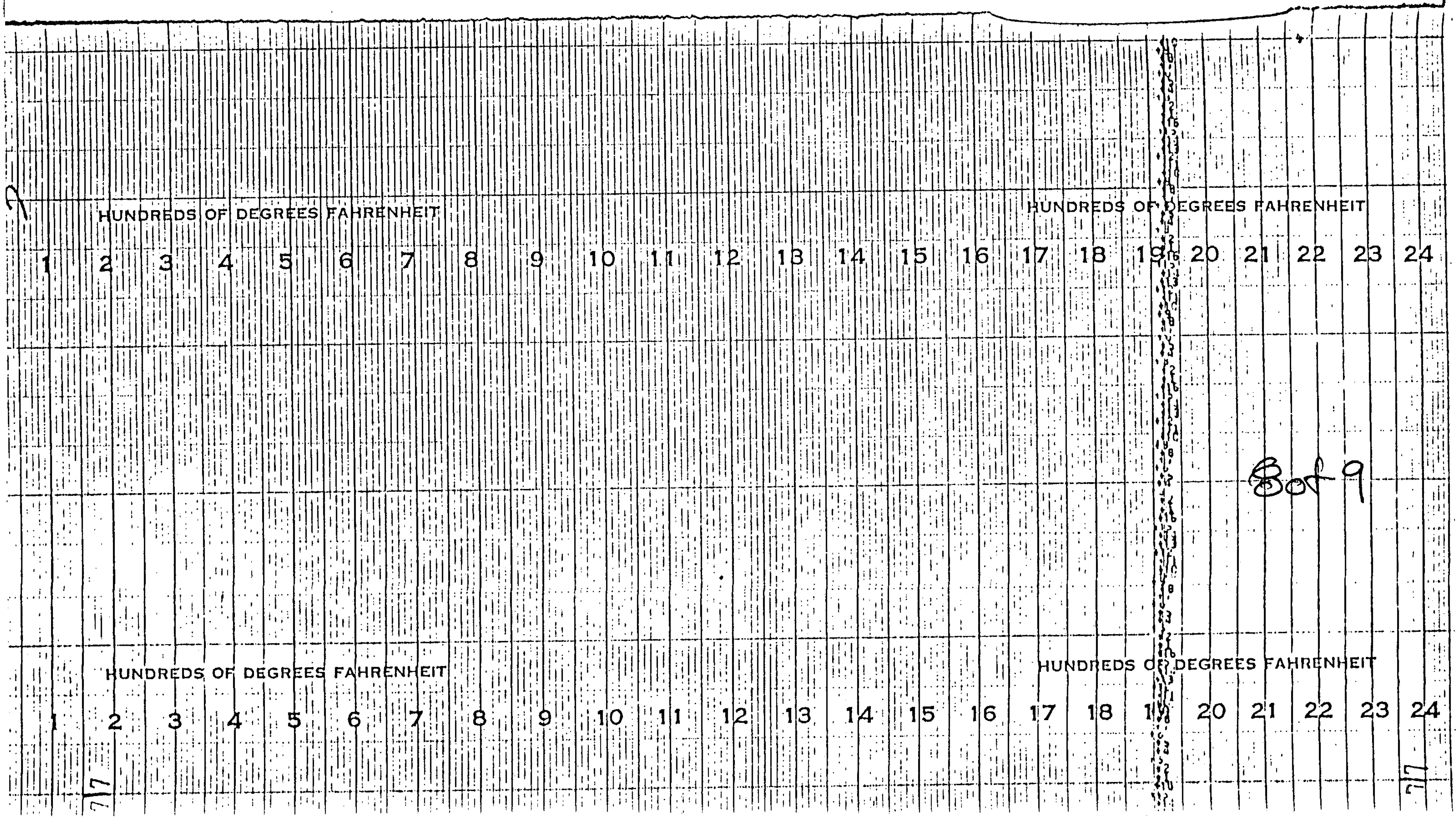
7 of 9


HUNDREDS OF DEGREES FAHRENHEIT
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HUNDREDS OF DEGREES FAHRENHEIT
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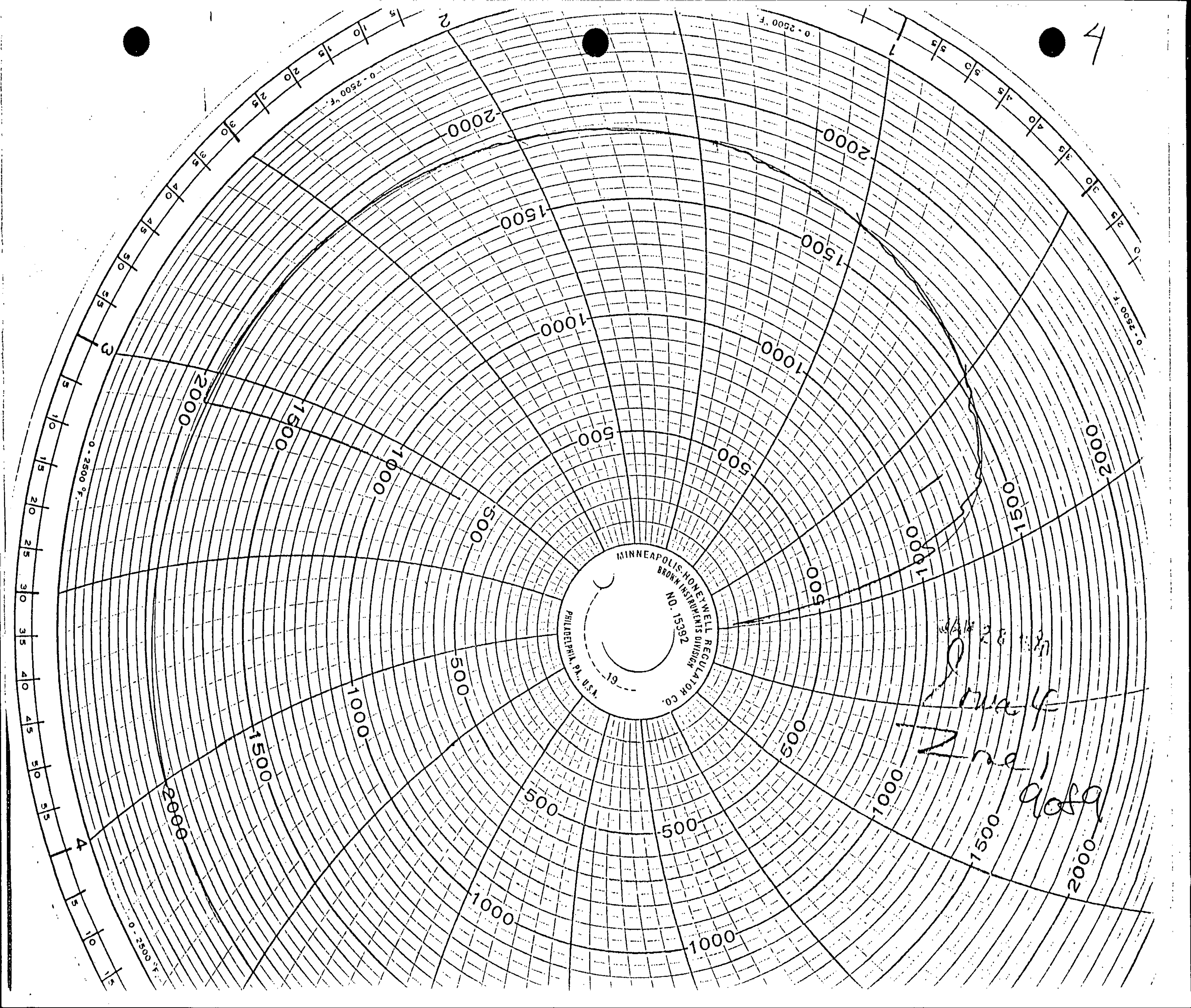
8 of 9

7/7


4
MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA., U.S.A.
19
0 - 2500 °F.
Zone 4
Zero data

TEST SLAB NUMBER 5

DATE: 02/25/80

FIRE STOP DESIGNS TESTED: WPD-2
WPD-3
WPD-4
WPD-5
WPD-RP-1, SHT 3
WPD-RP-1, SHT 4
WPD-RP-2, SHT 2
WPD-RP-2, SHT 4

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

Test Witnessed by:

M. Gillen, PCA

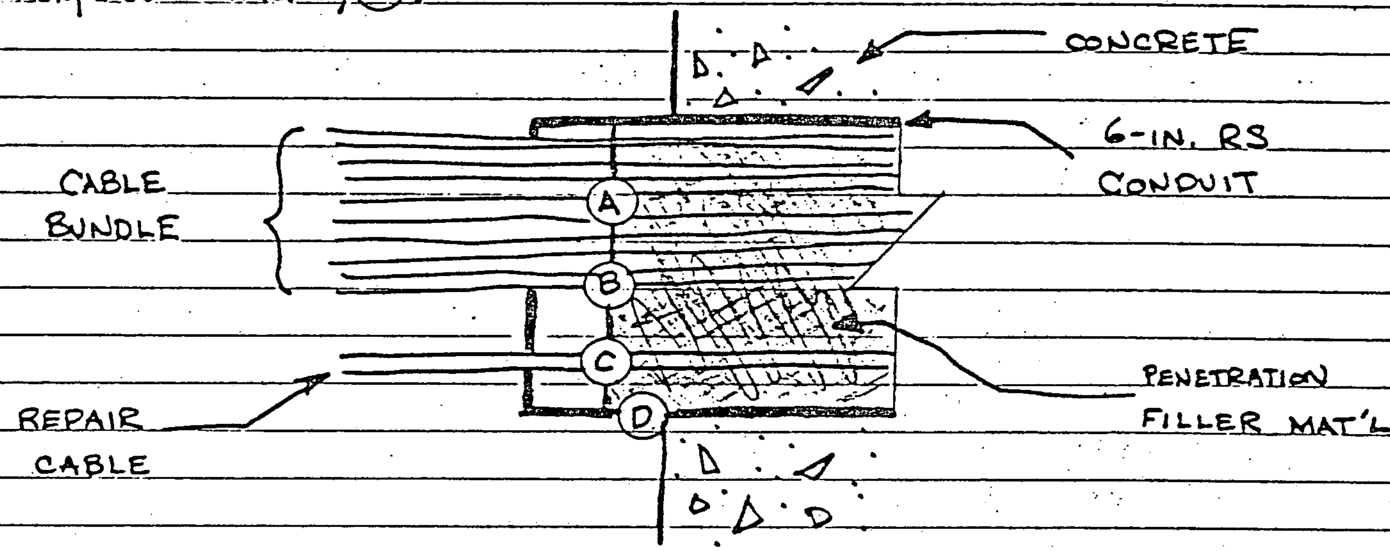
Rob Chin, IEL&P

M. S. Abrams, PCA

CR4557

THERMOCOUPLE LOCATIONS FOR IELP/EOS SPECIMEN No. 5

Thermocouples were installed in each penetration at 4 locations: in the interior of the cable bundle, (A); on the surface of the cable bundle, (B); on the repair cable (when called for), (C); and at the conduit/concrete interface on the unexposed surface, (D).



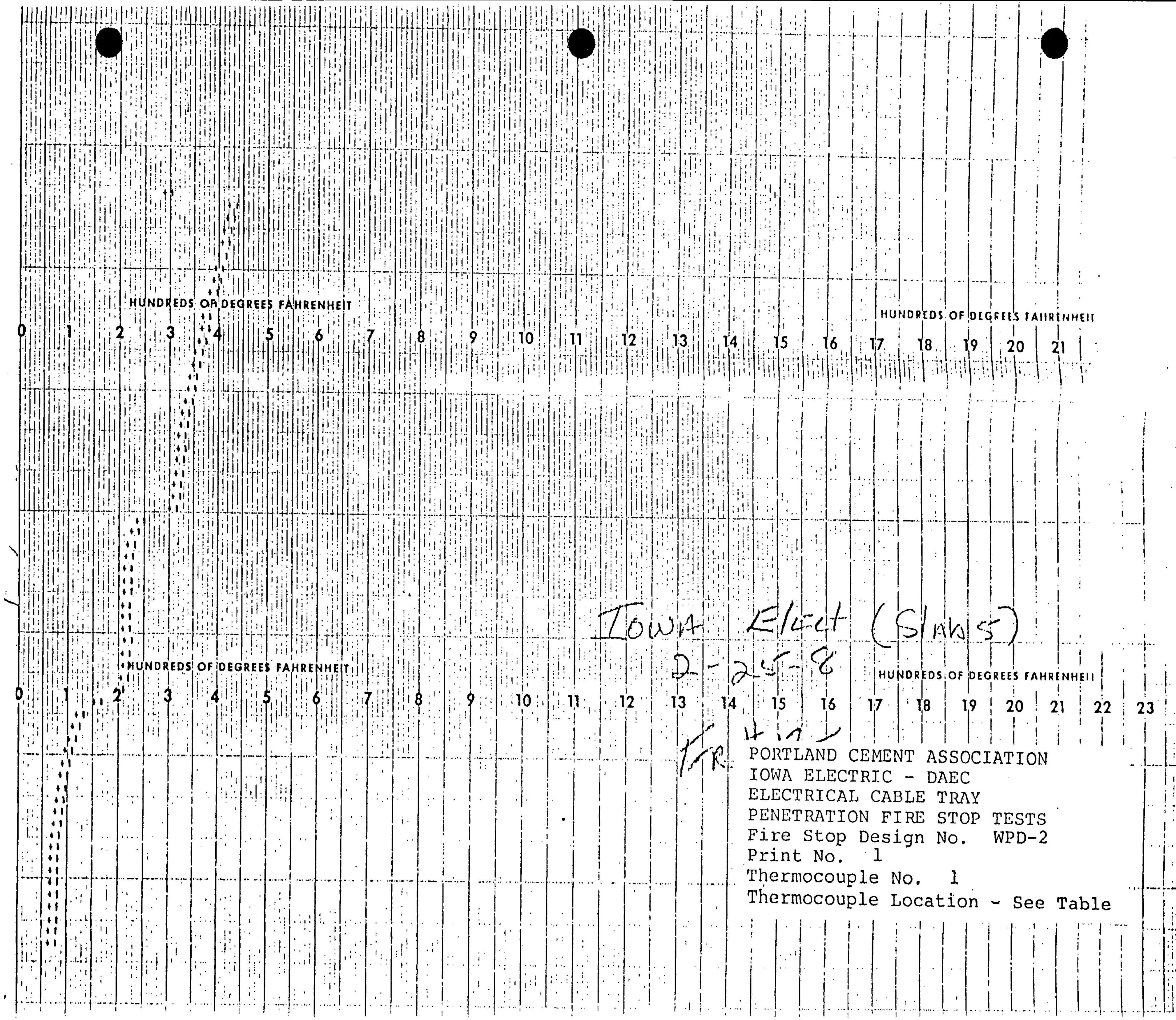
PENETRATION No.	THERMOCOUPLE No. at location: (A)	(B)	(C)	(D)
C4 (repeat)	#1	#2	—*	#3
C6	#7	#8	#9	#10
C7 X	#4	#5	—*	#6
C8	#11	#12	#13	#14
C9	#29	#30	#31	#32
C10 X	#22	#23	—*	#24
C11	#25	#26	#27	#28
C12	#15	#16	#17	#18
C16 X	#19	#20	—*	#21
concrete surface	#33			

* no repair cable called for in this penetration.

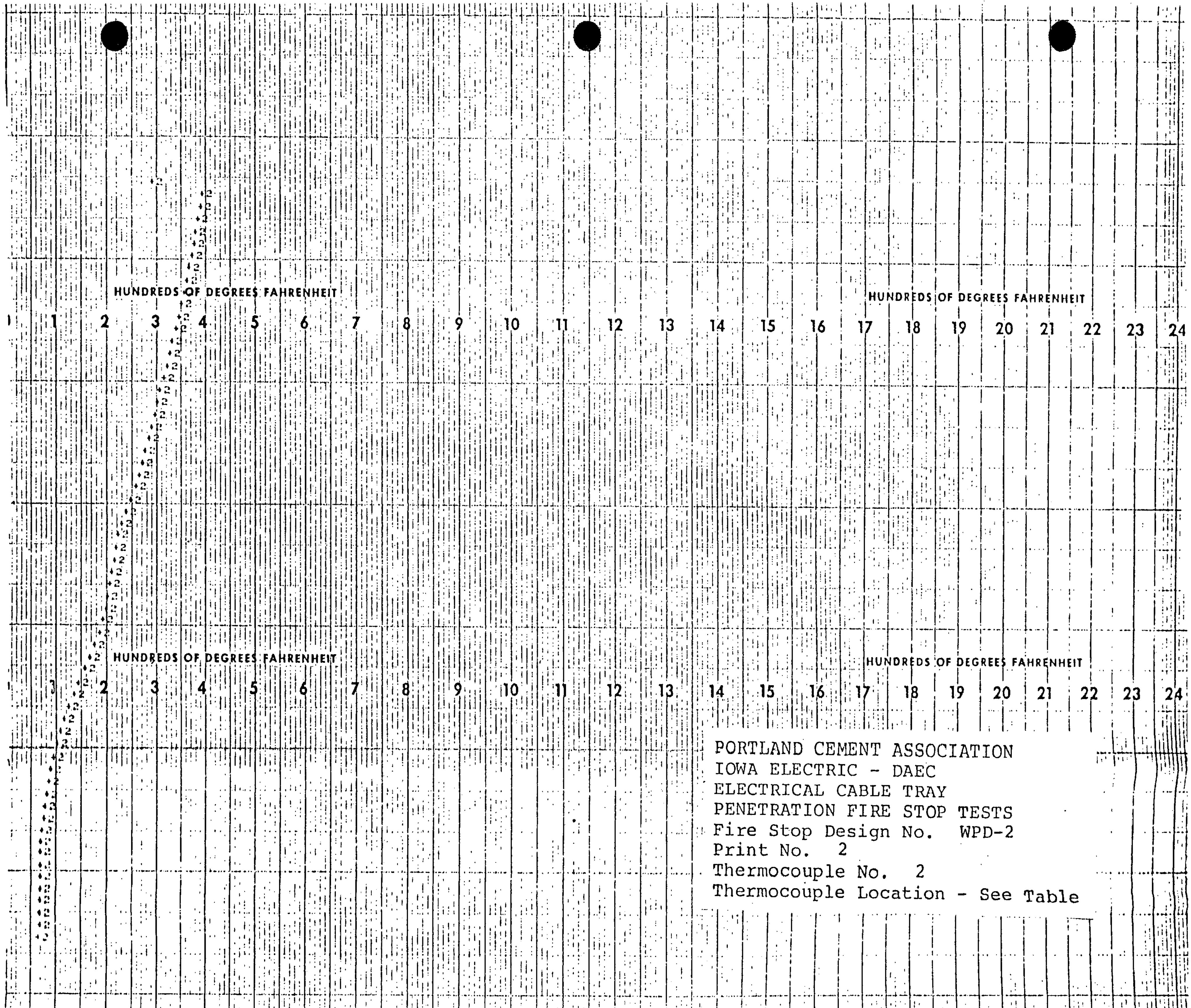
THERMOCOUPLE LOCATIONS · TEST 5

SLAB 5

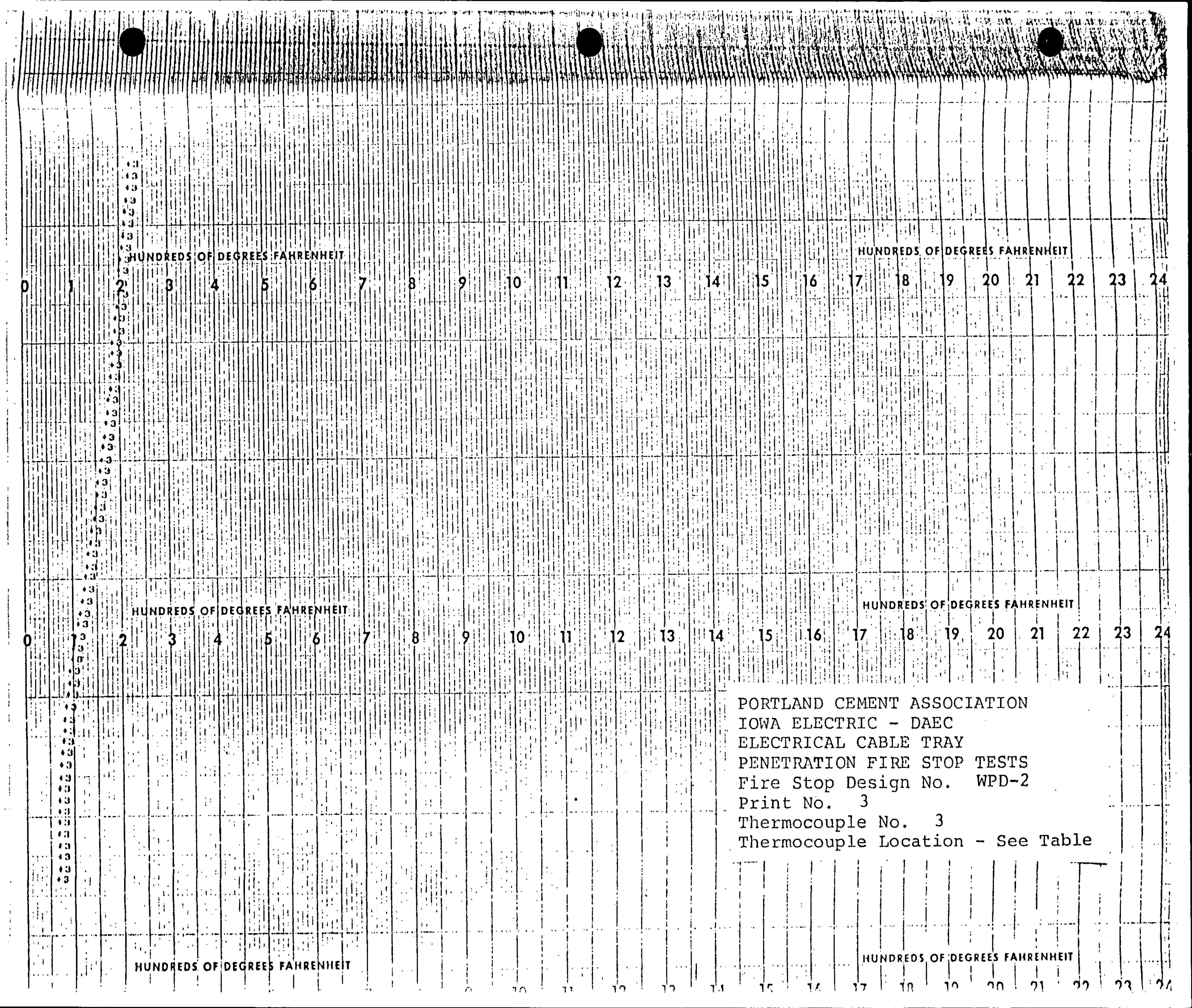
CONSTRUCTION DESIGN №	FIRE STOP DESIGN №
C4	WPD-2
C6	WPD-RP-2, SHT 2
C7 X	WPD-3
C8	WPD-RP-1, SHT 3
C9	WPD-RP-2, SHT 3
C10 X	WPD-5
C11	WPD-RP-1, SHT 4
C12	WPD-RP-2, SHT 4
C16 X	WPD-4



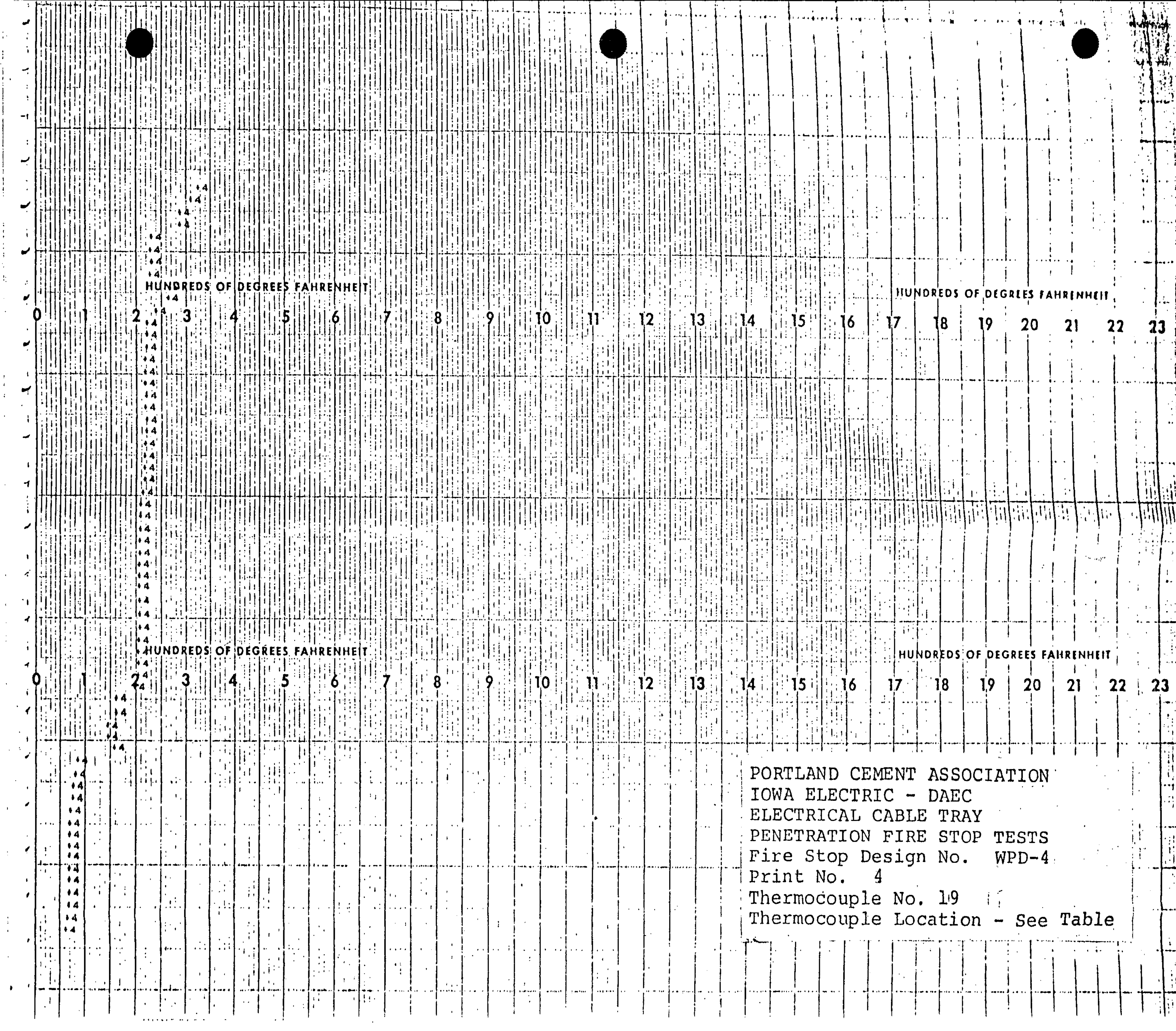
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 1
Thermocouple No. 1
Thermocouple Location - See Table



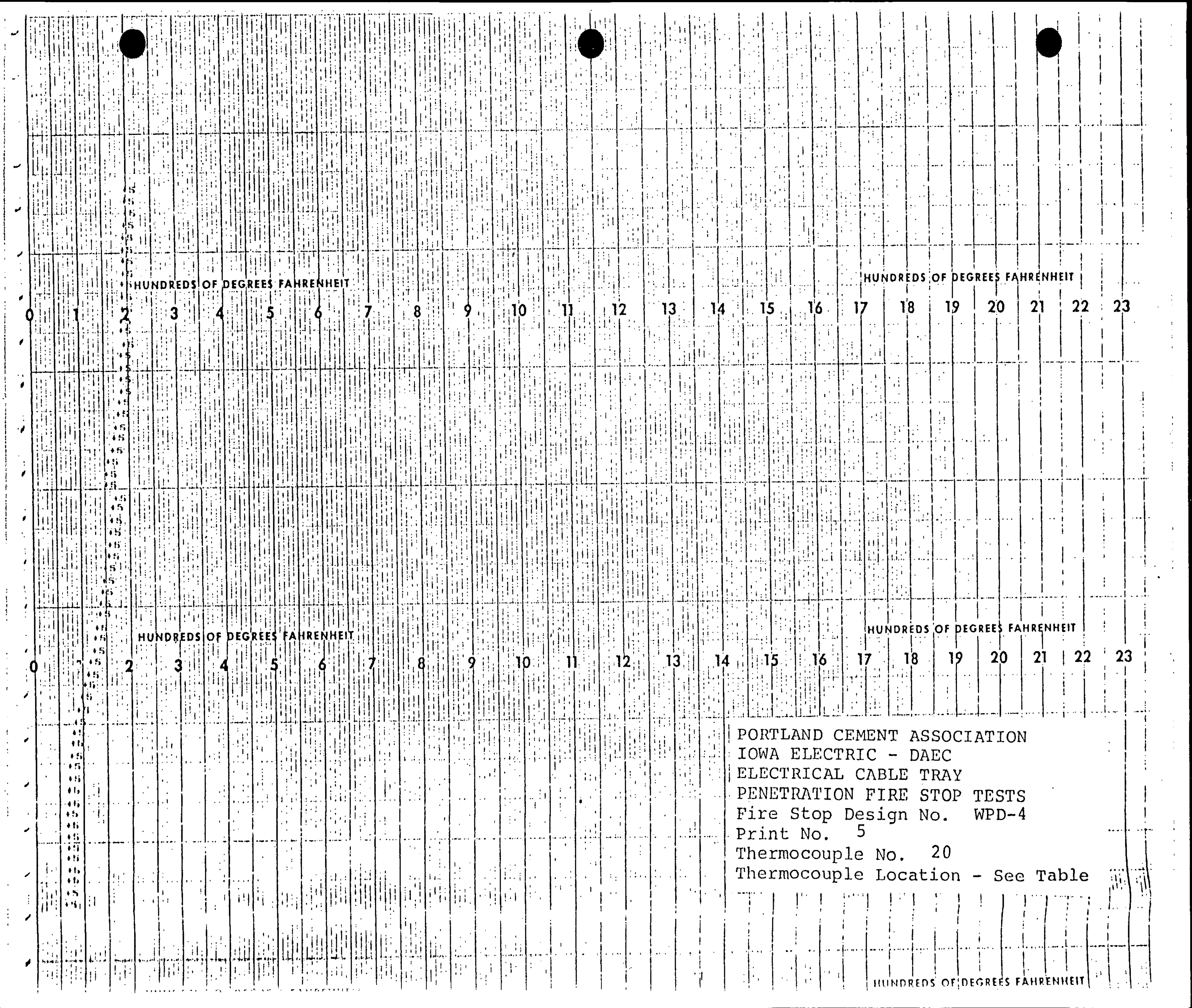
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 2
Thermocouple No. 2
Thermocouple Location - See Table



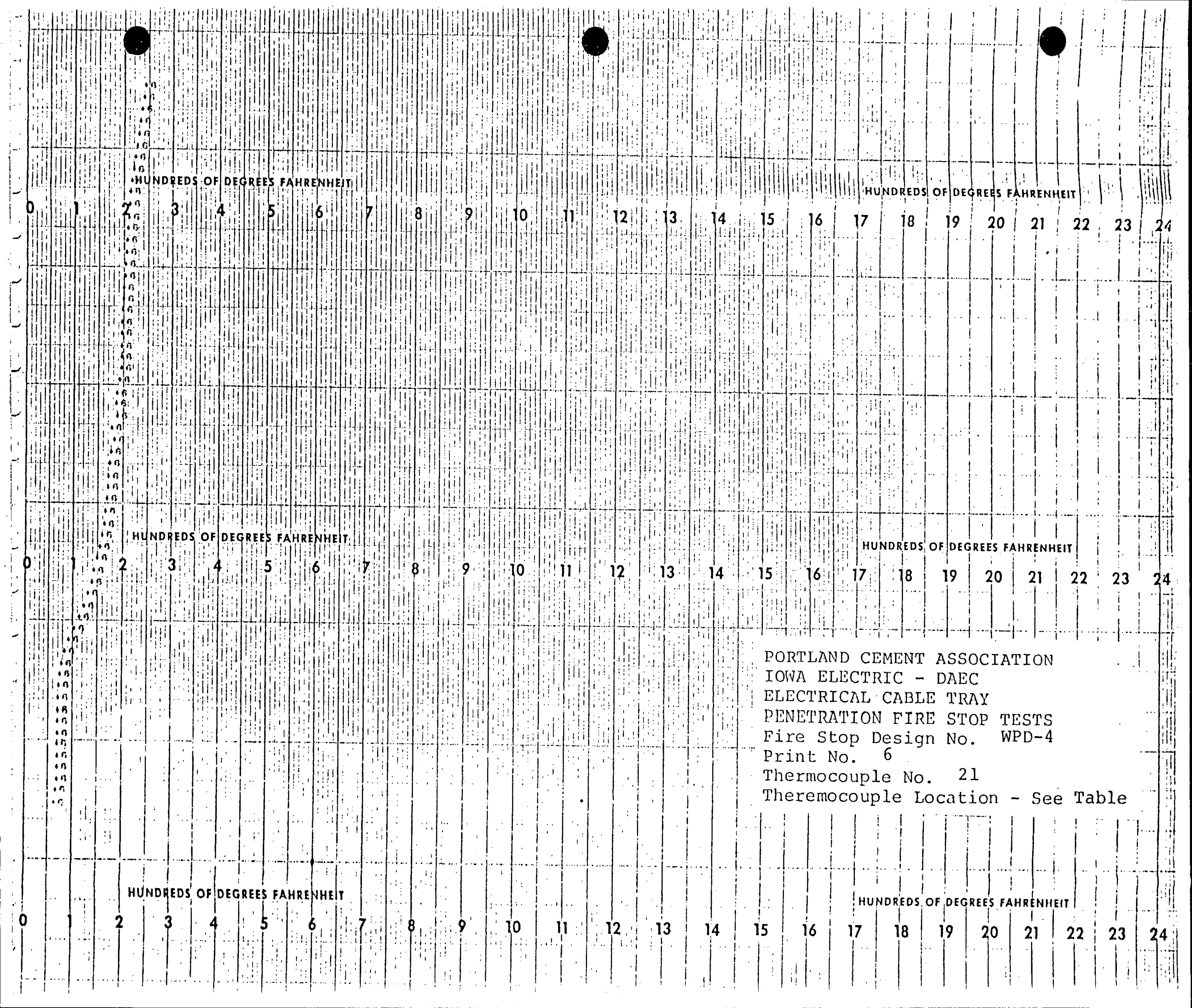
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-2
Print No. 3
Thermocouple No. 3
Thermocouple Location - See Table



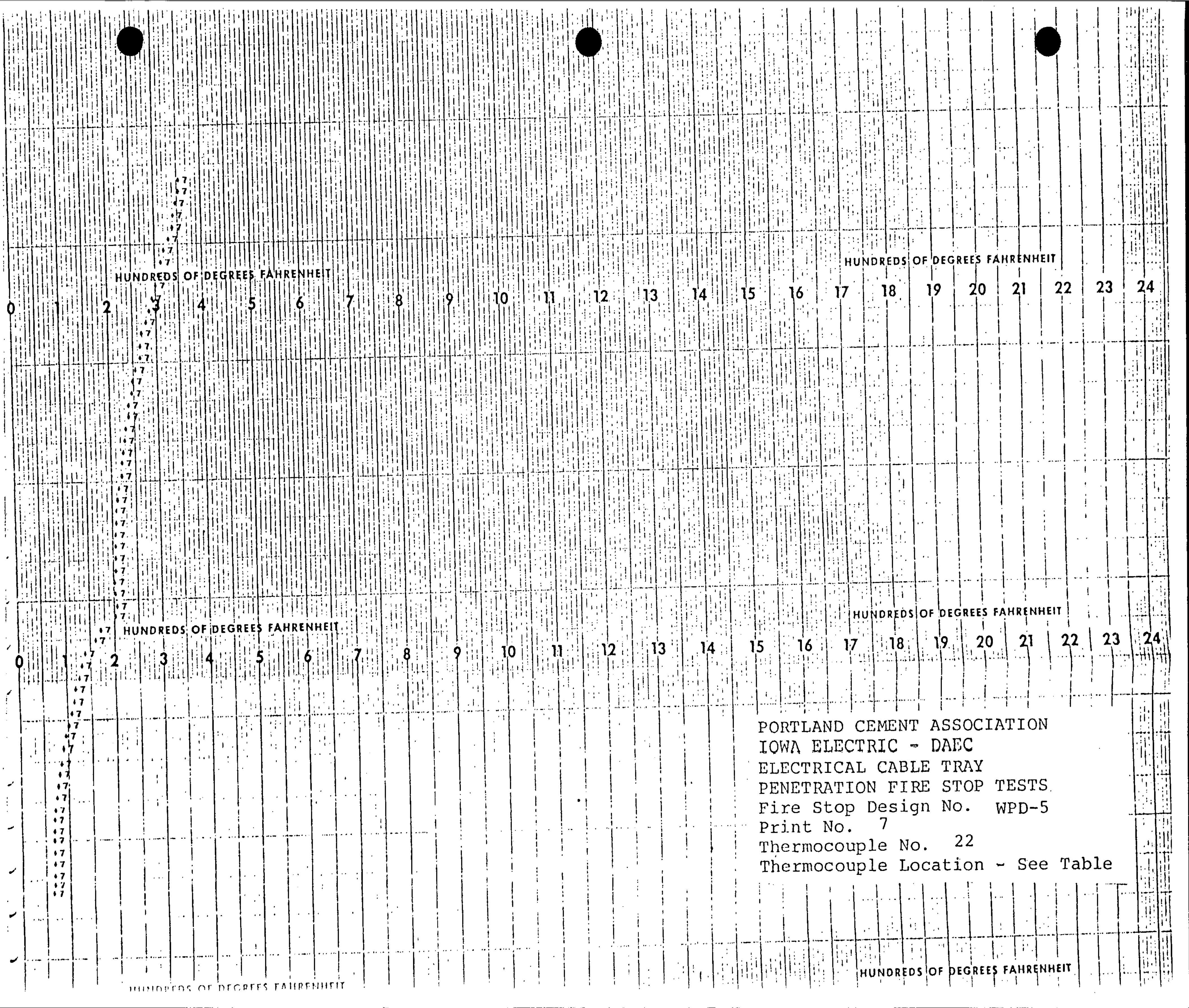
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 4
Thermocouple No. 19
Thermocouple Location - See Table



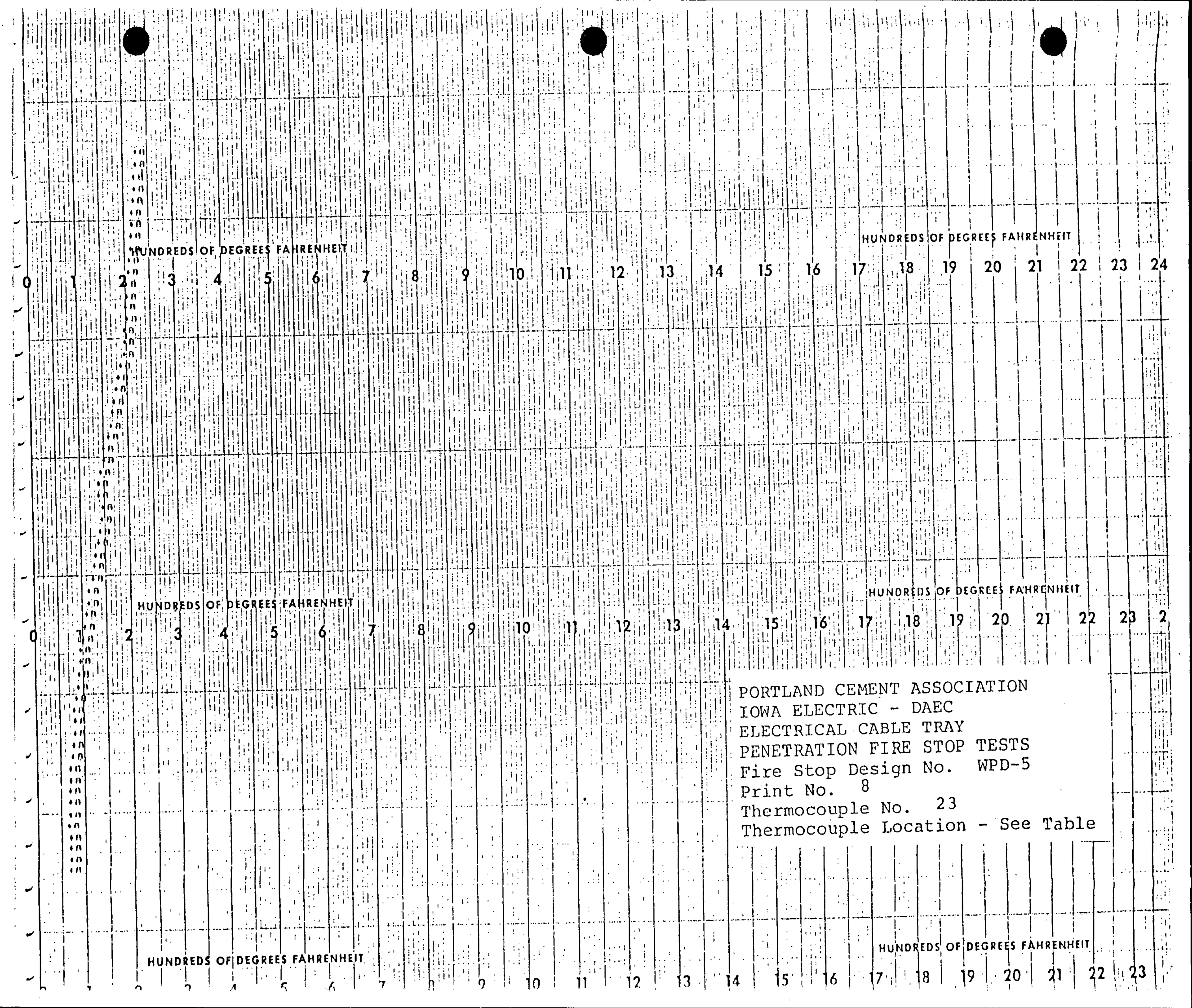
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 5
Thermocouple No. 20
Thermocouple Location - See Table



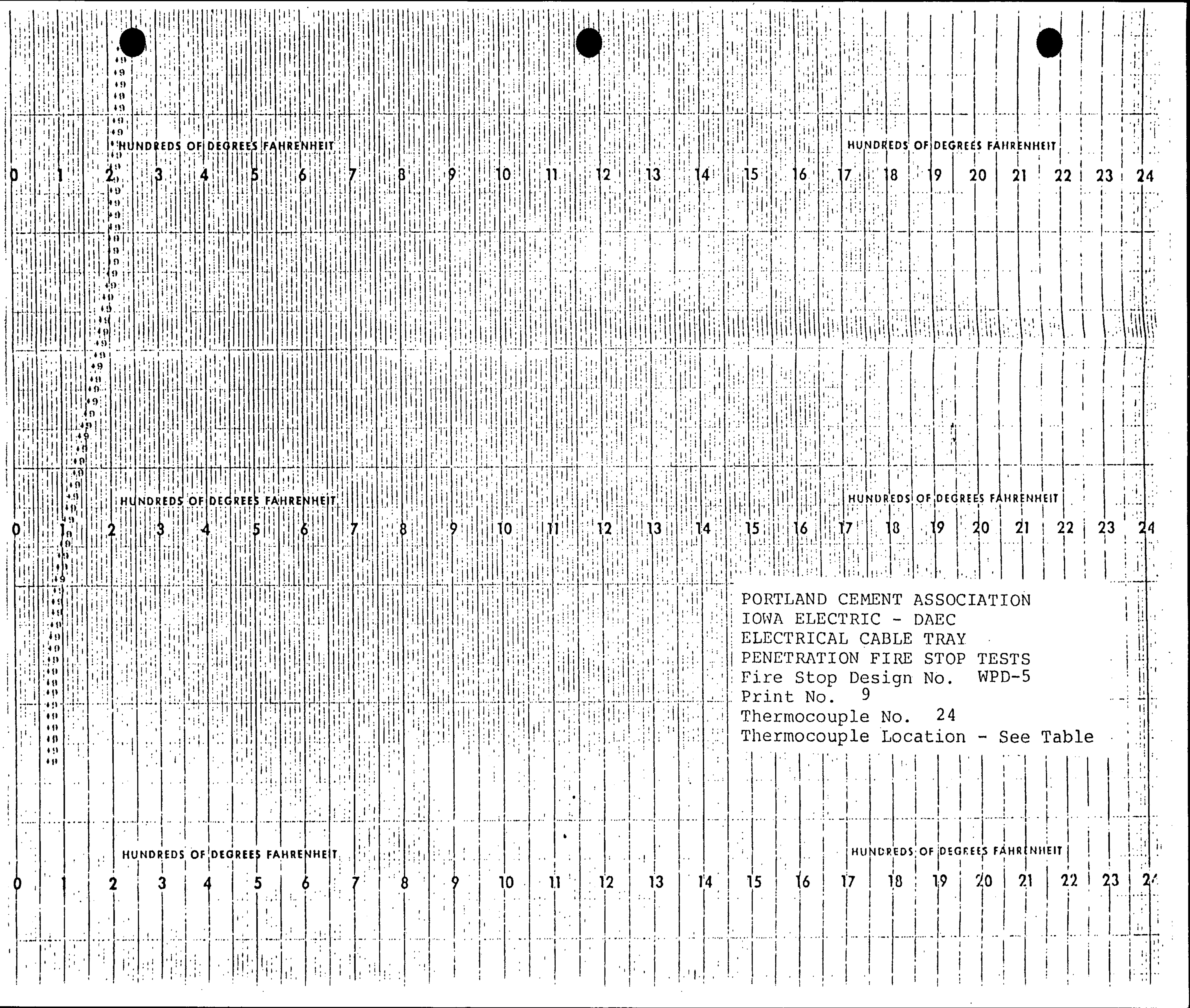
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-4
Print No. 6
Thermocouple No. 21
Theremocouple Location - See Table



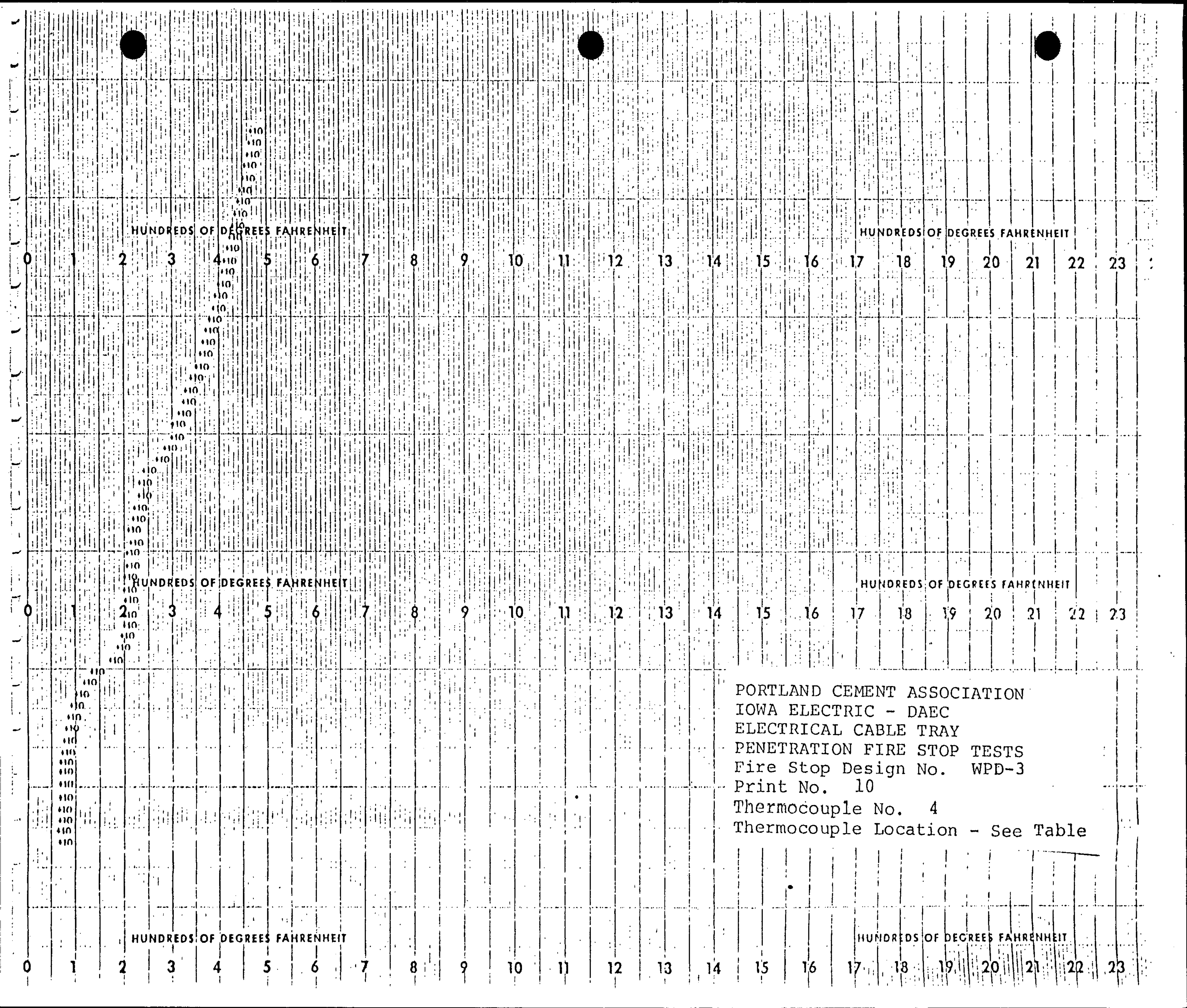
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 7
Thermocouple No. 22
Thermocouple Location - See Table



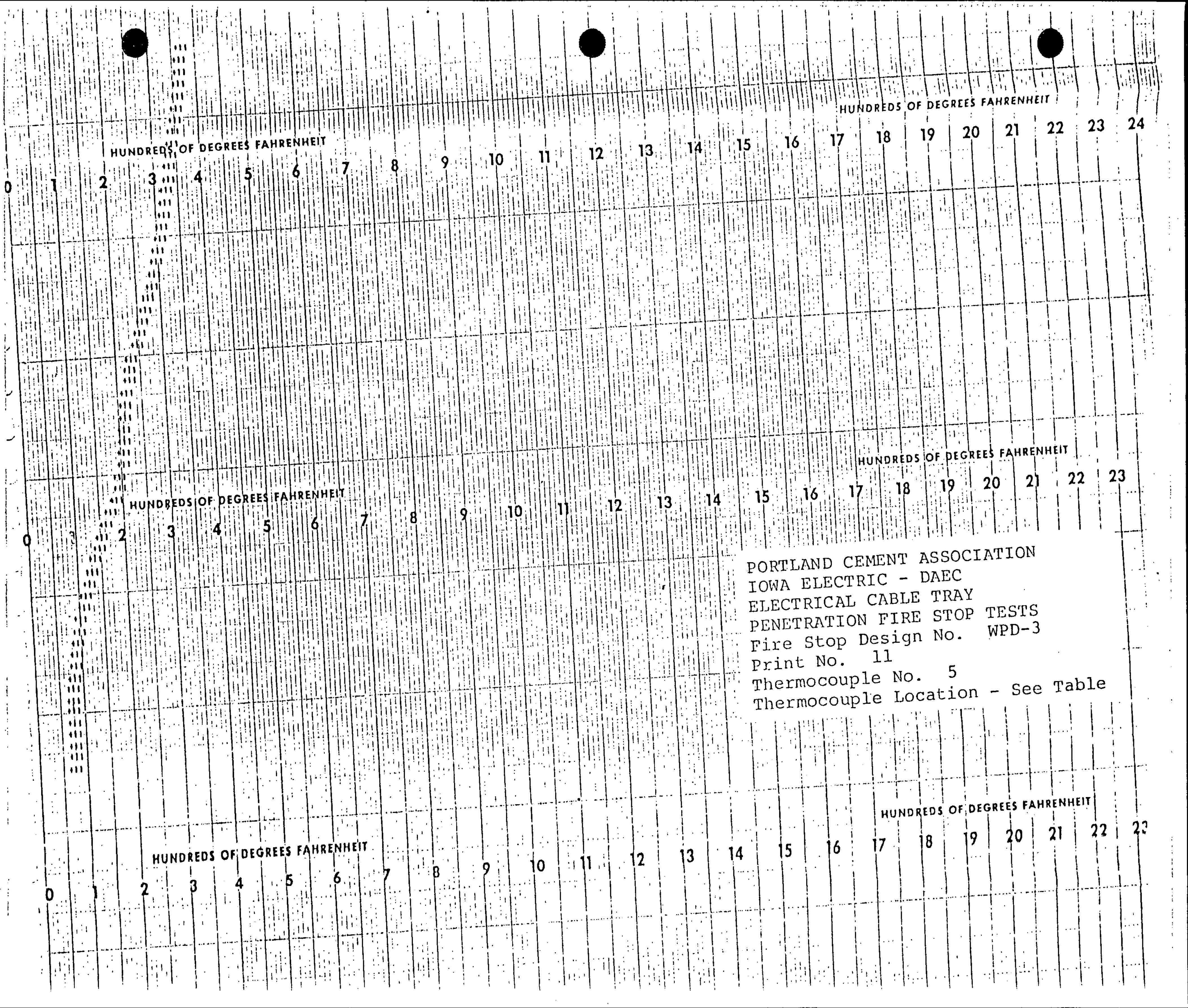
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 8
Thermocouple No. 23
Thermocouple Location - See Table



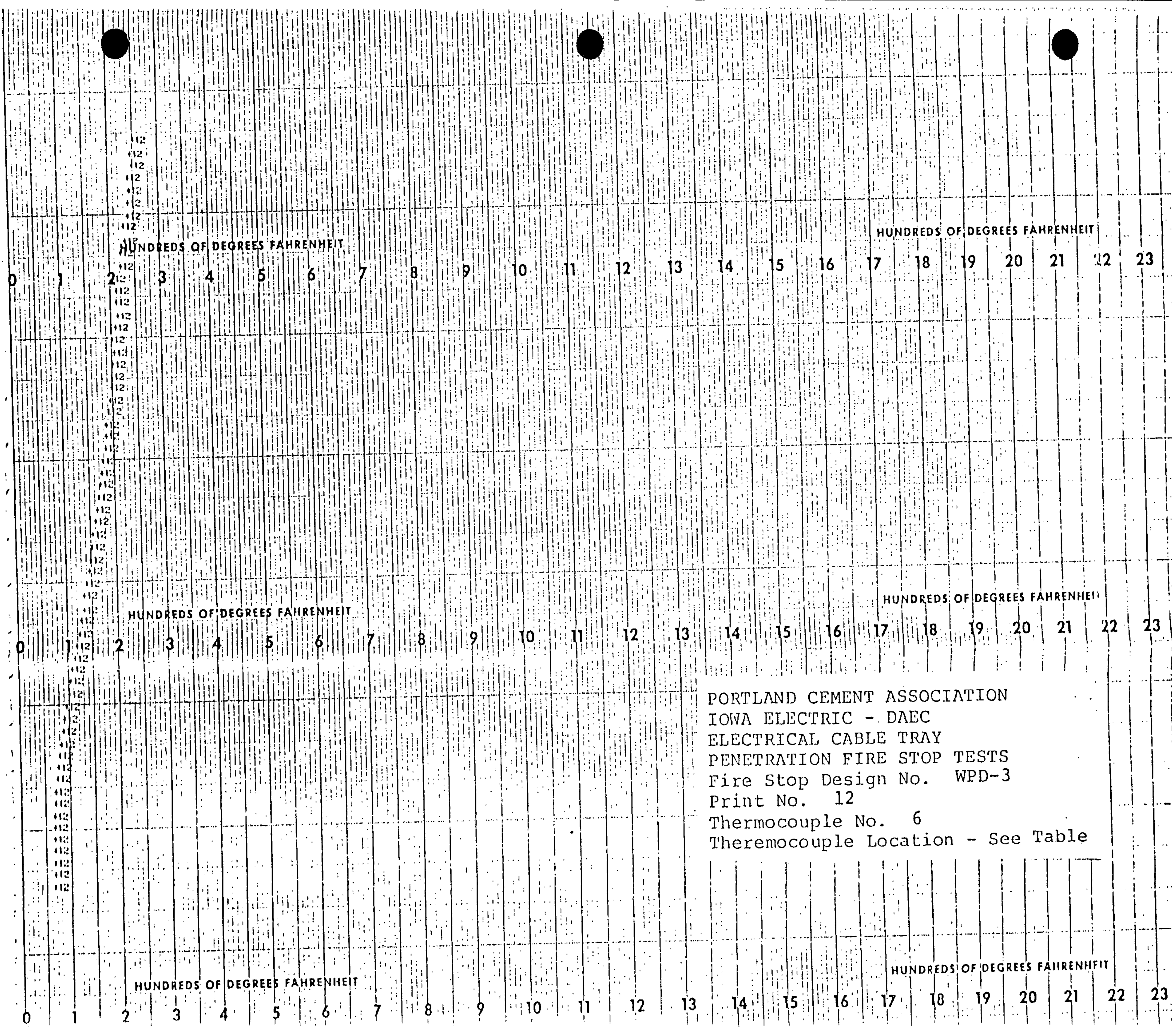
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-5
Print No. 9
Thermocouple No. 24
Thermocouple Location - See Table



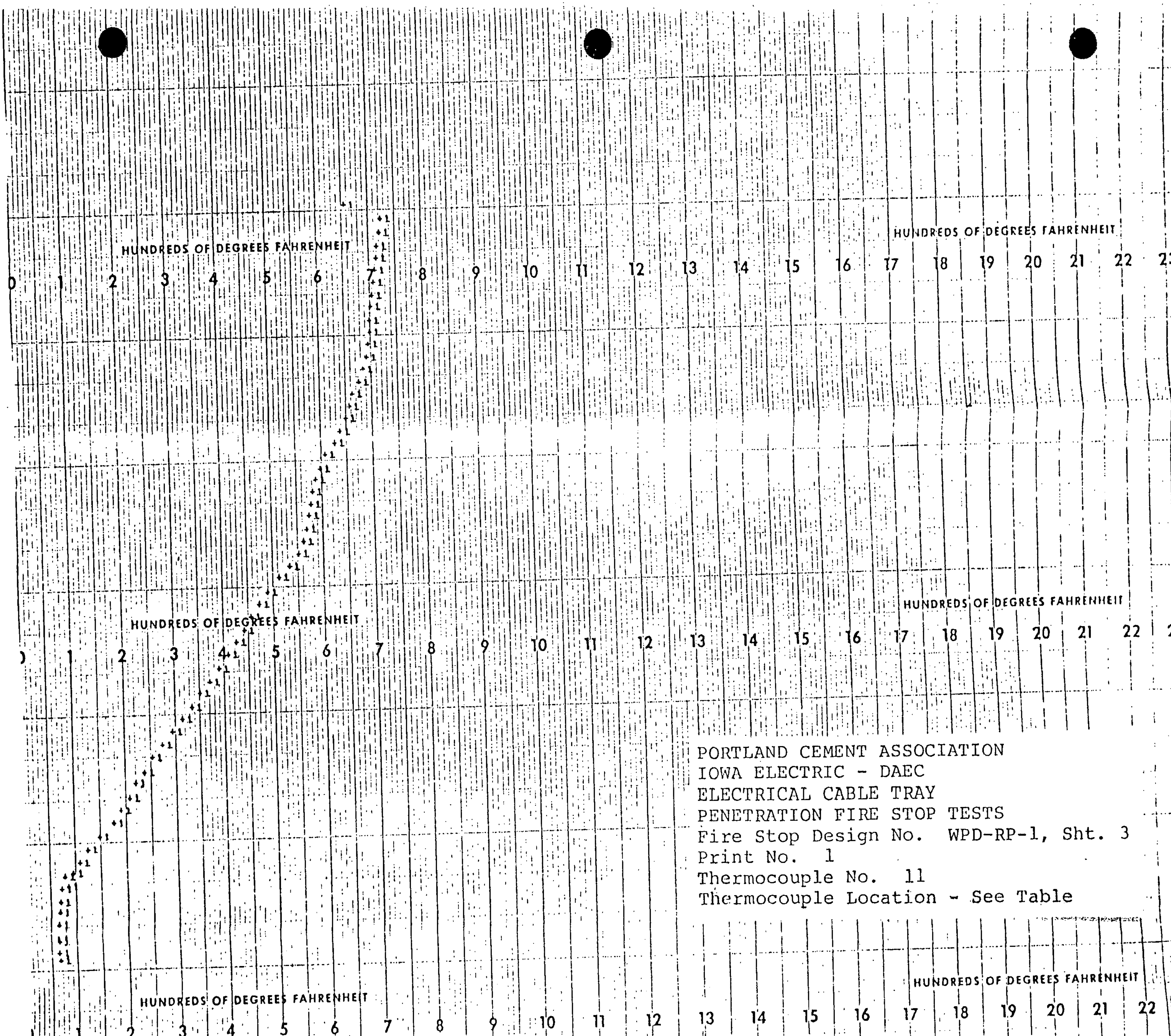
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 10
Thermocouple No. 4
Thermocouple Location - See Table



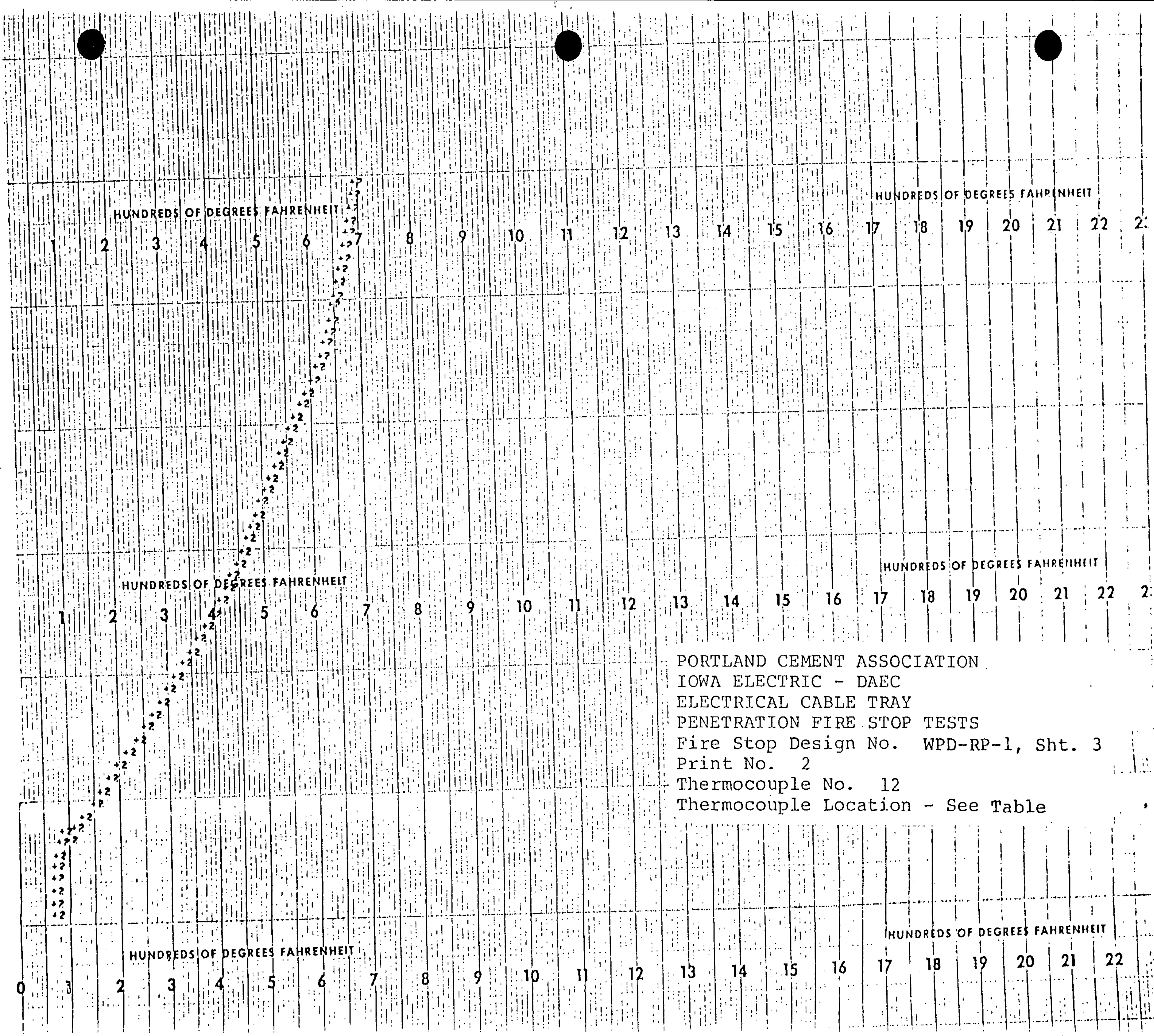
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 11
Thermocouple No. 5
Thermocouple Location - See Table



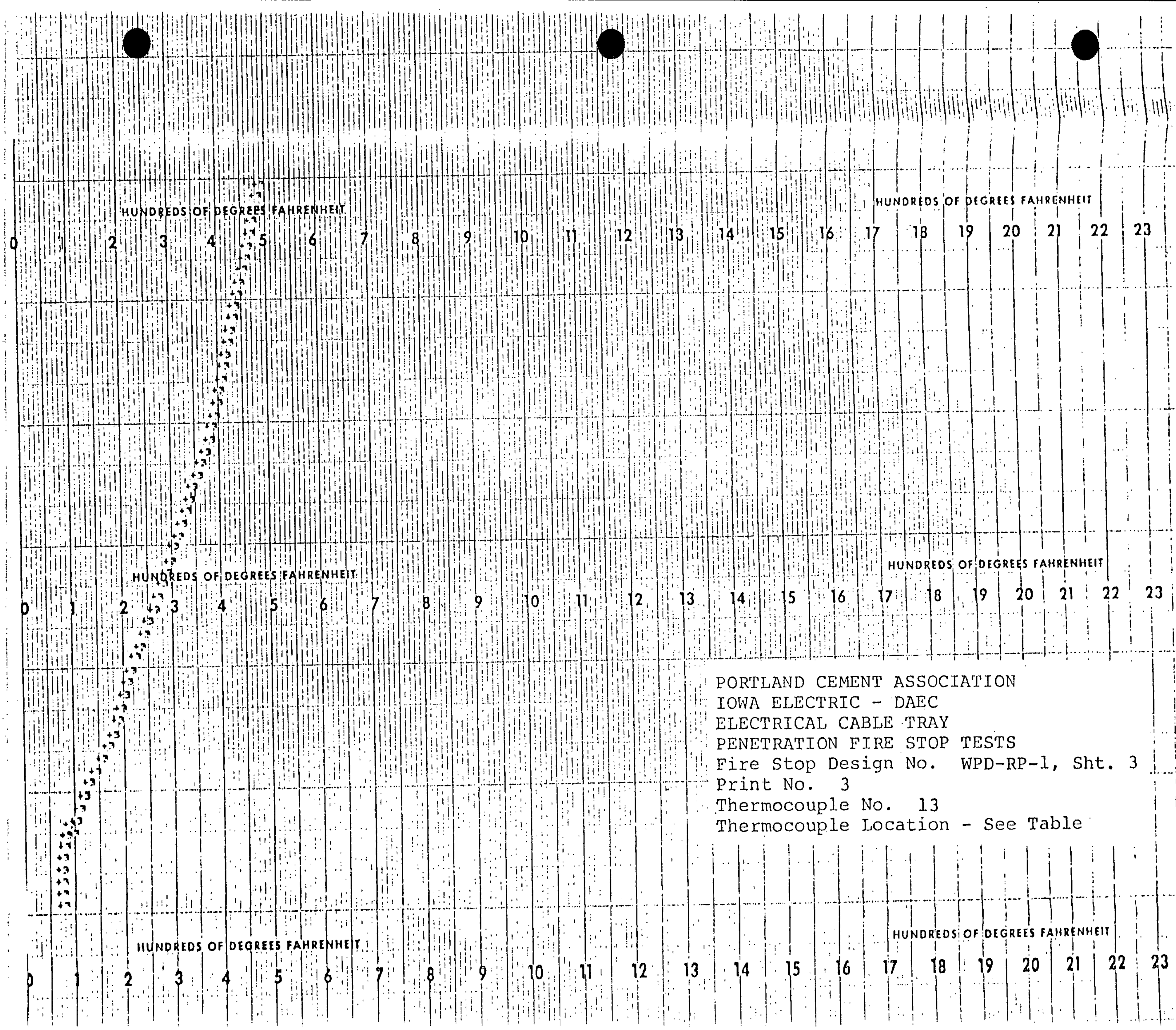
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-3
Print No. 12
Thermocouple No. 6
Theremocouple Location - See Table



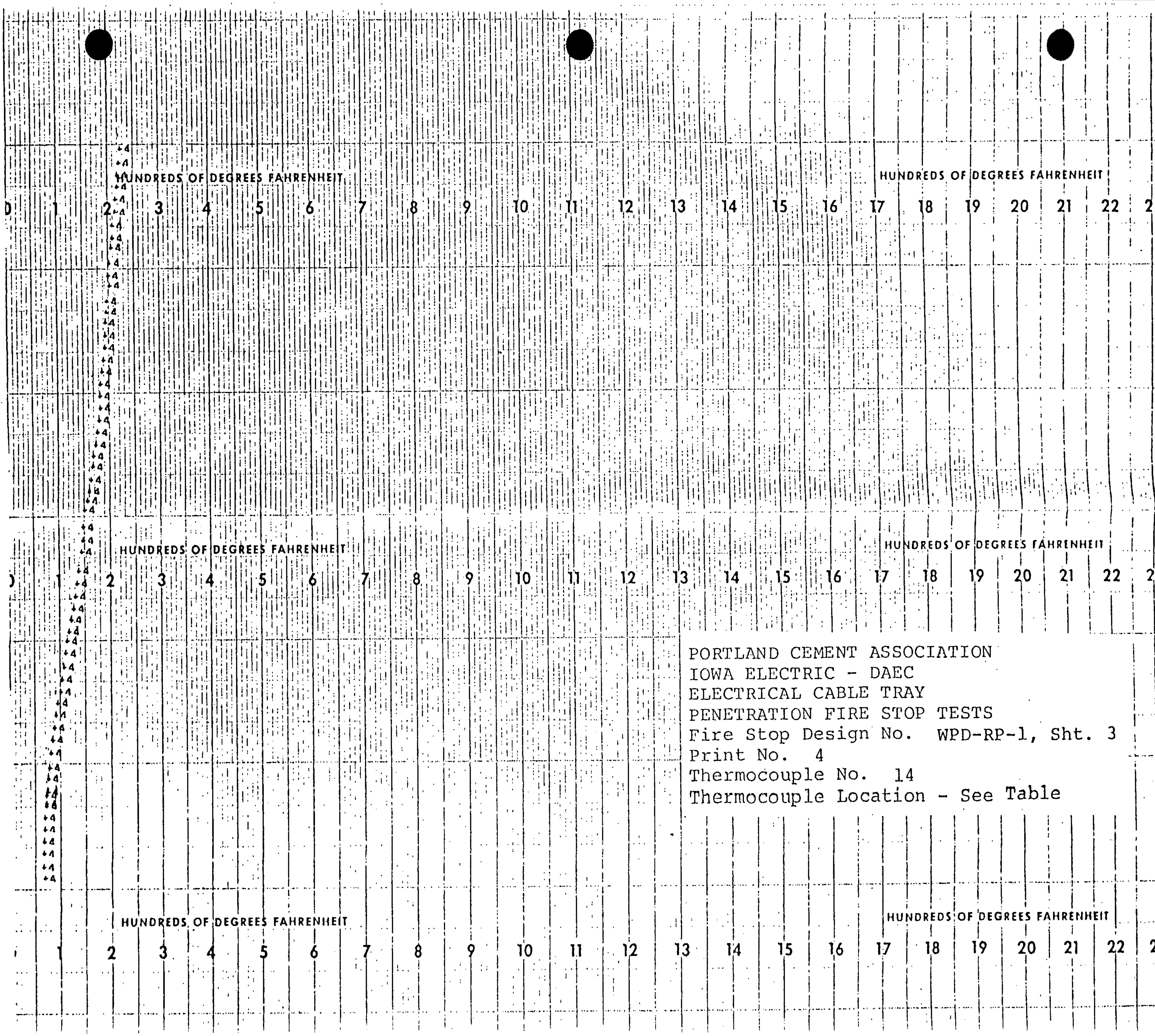
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 3
Print No. 1
Thermocouple No. 11
Thermocouple Location - See Table



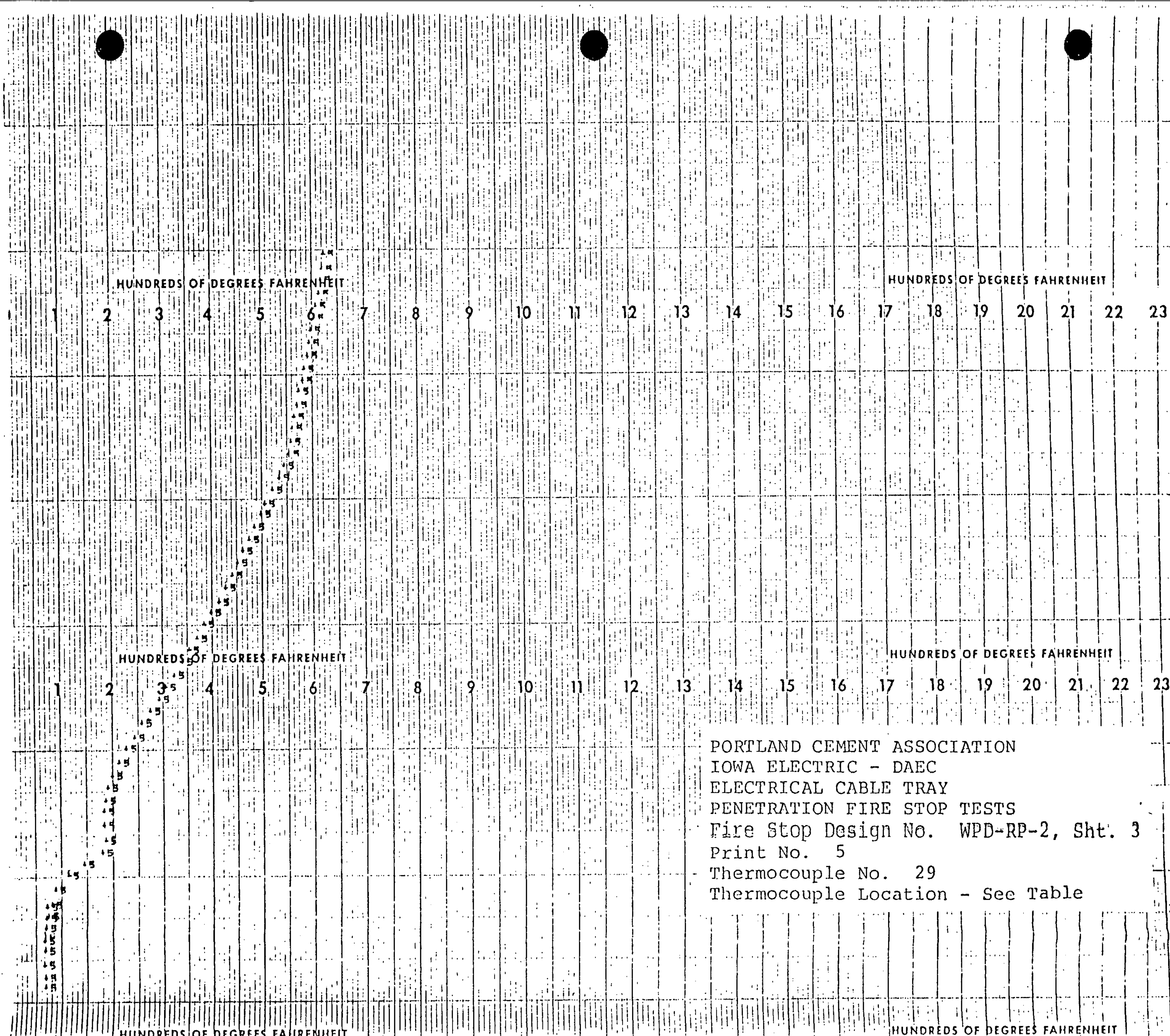
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 3
Print No. 2
Thermocouple No. 12
Thermocouple Location - See Table



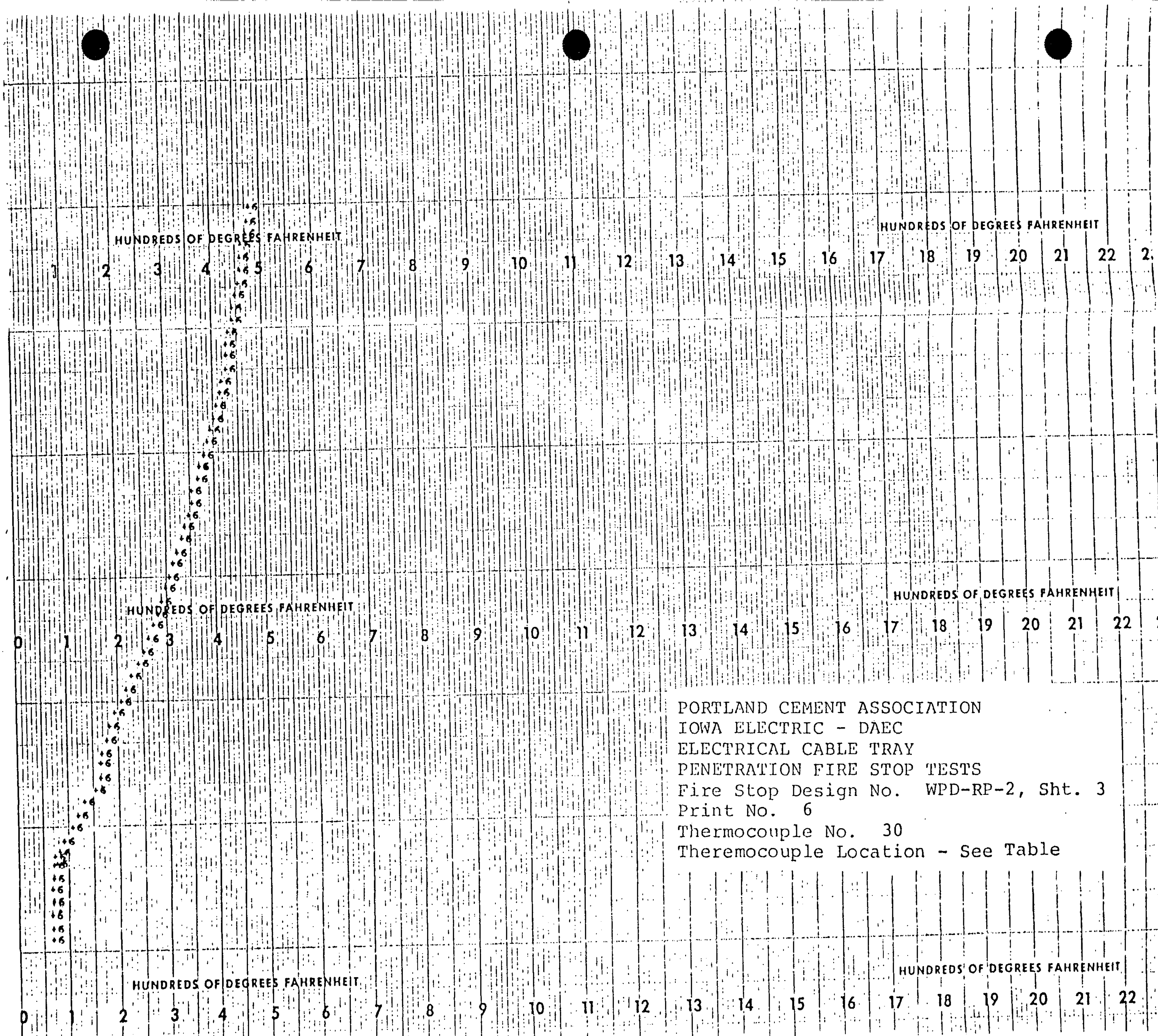
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 3
Print No. 3
Thermocouple No. 13
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-1, Sht. 3
Print No. 4
Thermocouple No. 14
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 3
Print No. 5
Thermocouple No. 29
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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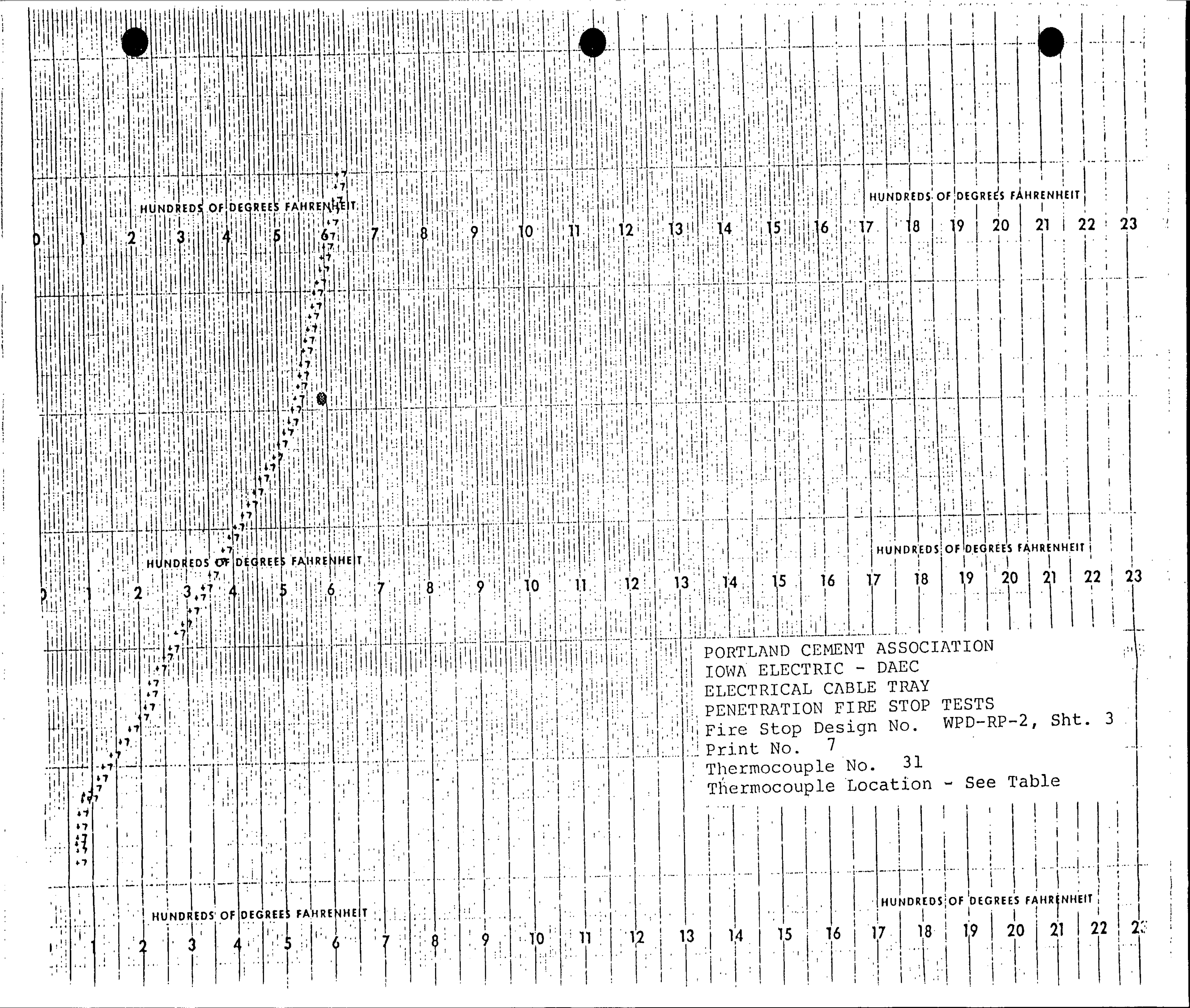
Print No. 6
Thermocouple No. 30
Theremocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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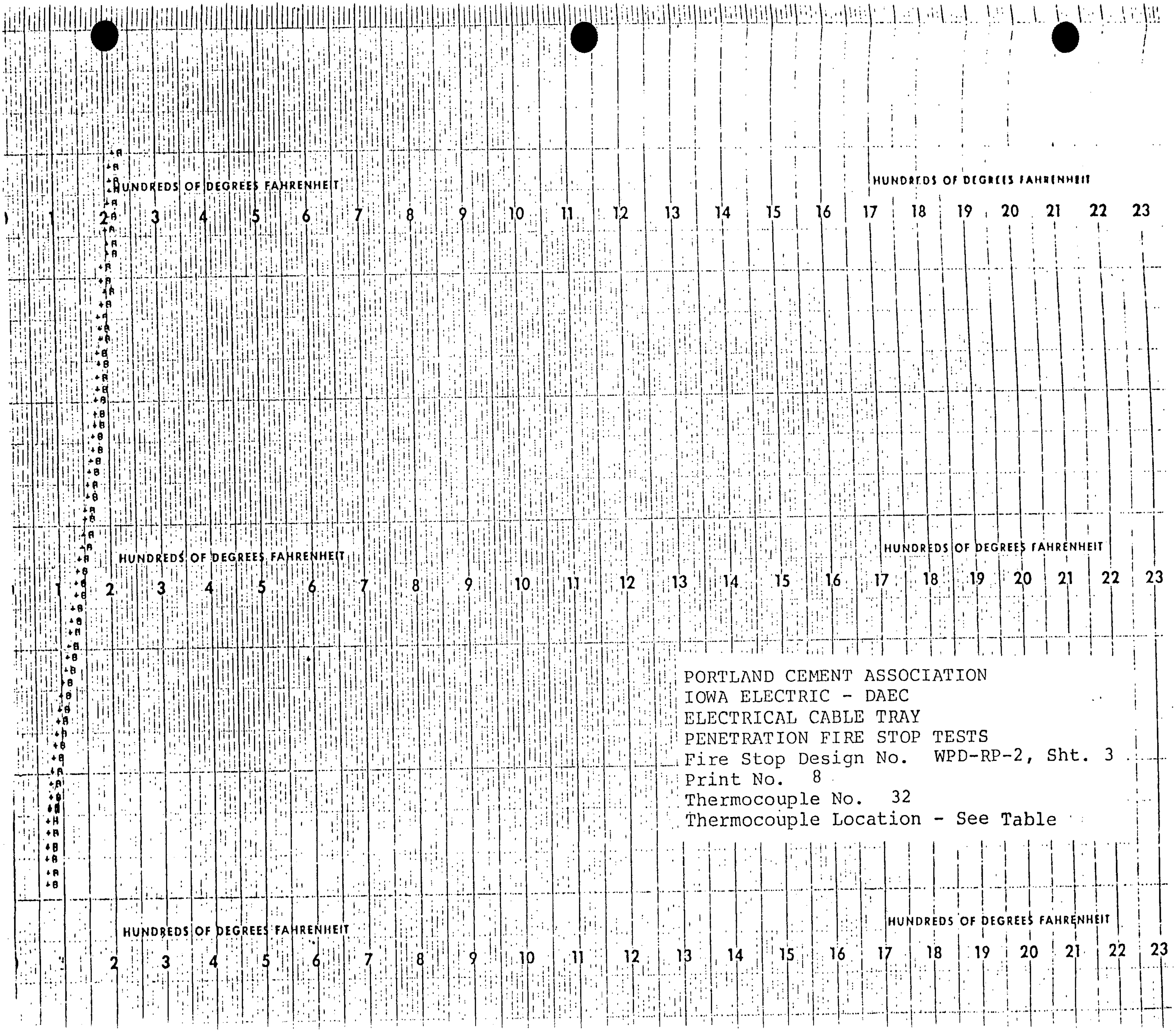
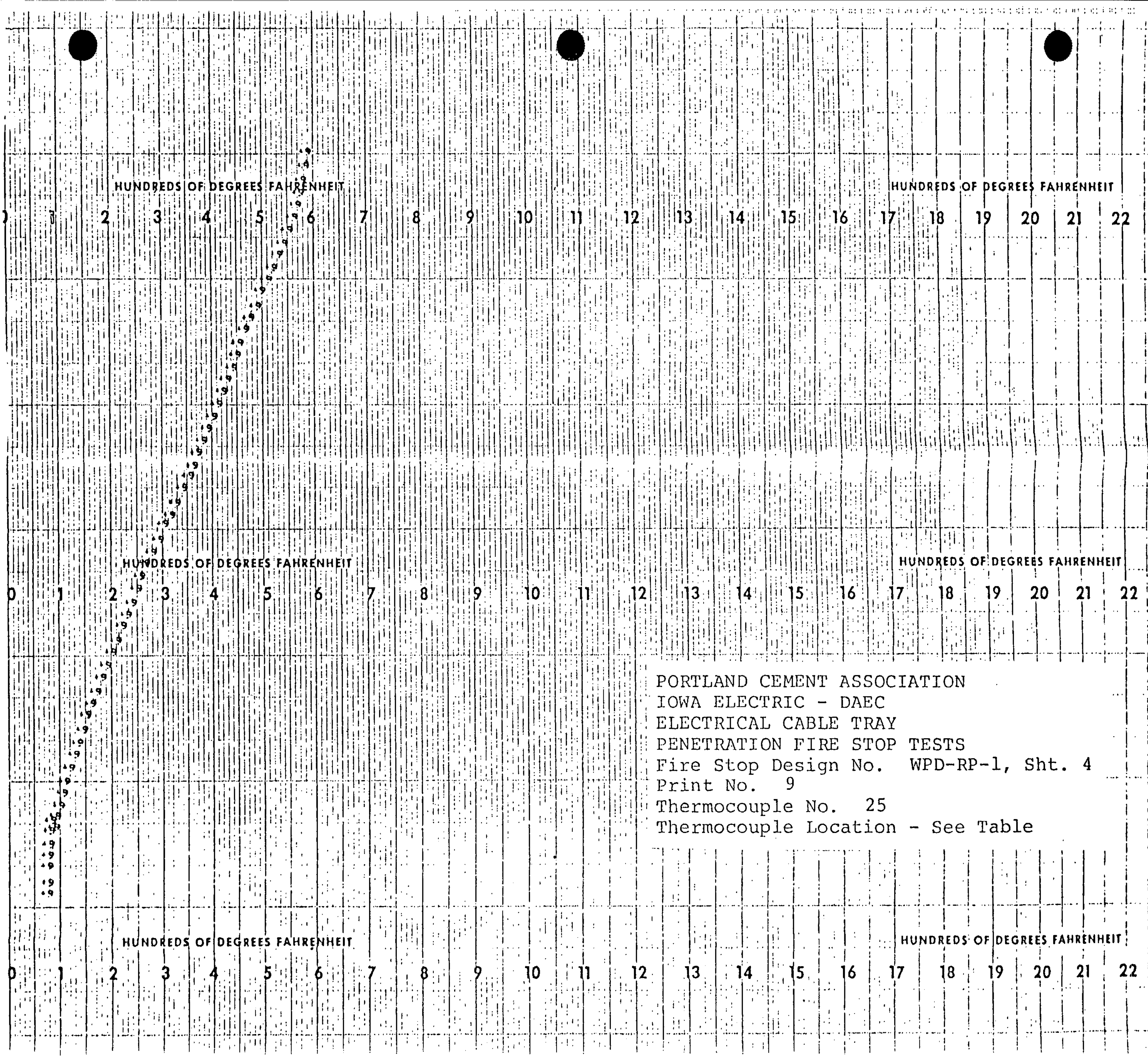
Print No. 7
Thermocouple No. 31
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 3
Print No. 8
Thermocouple No. 32
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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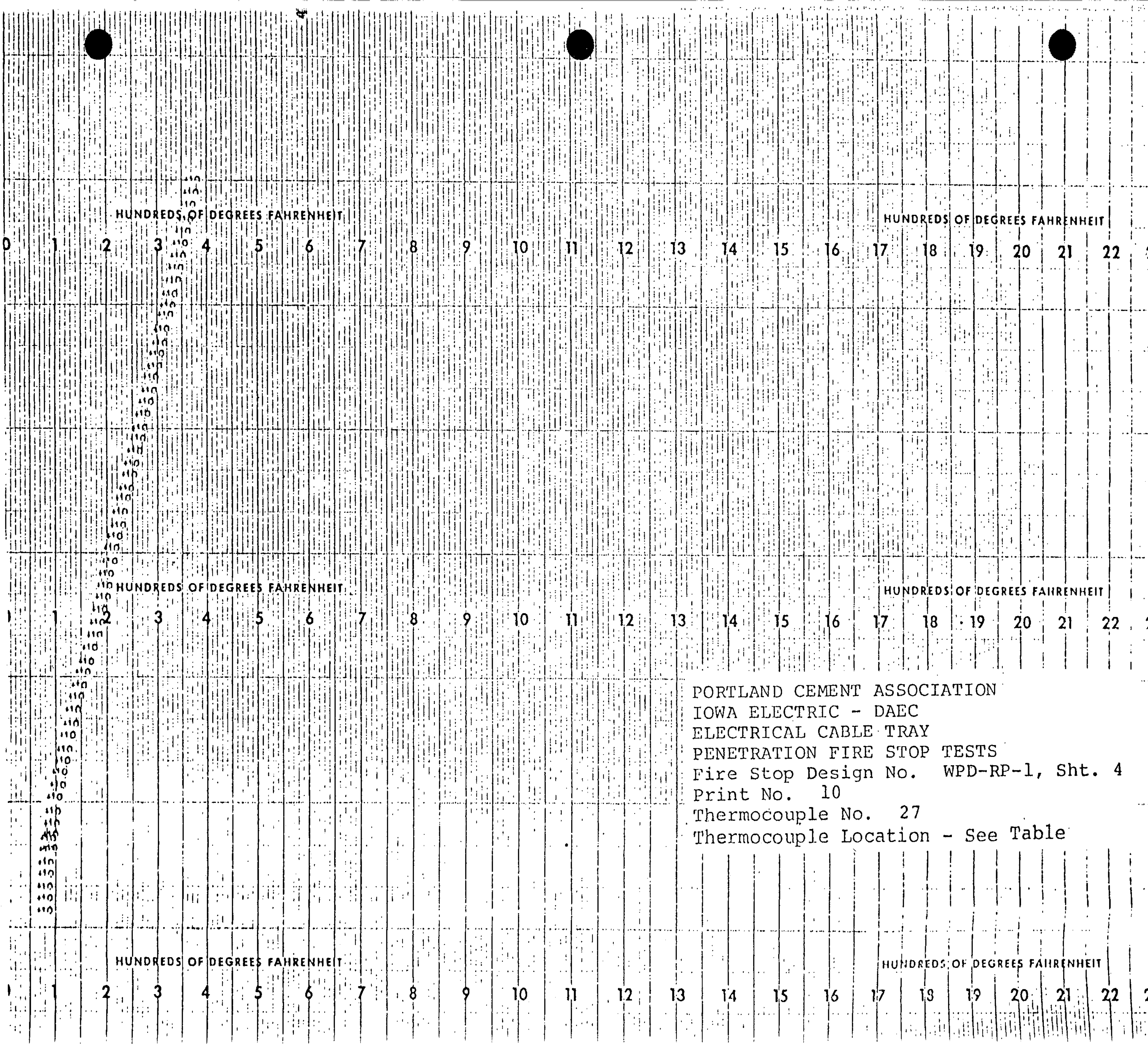
Print No. 9
Thermocouple No. 25
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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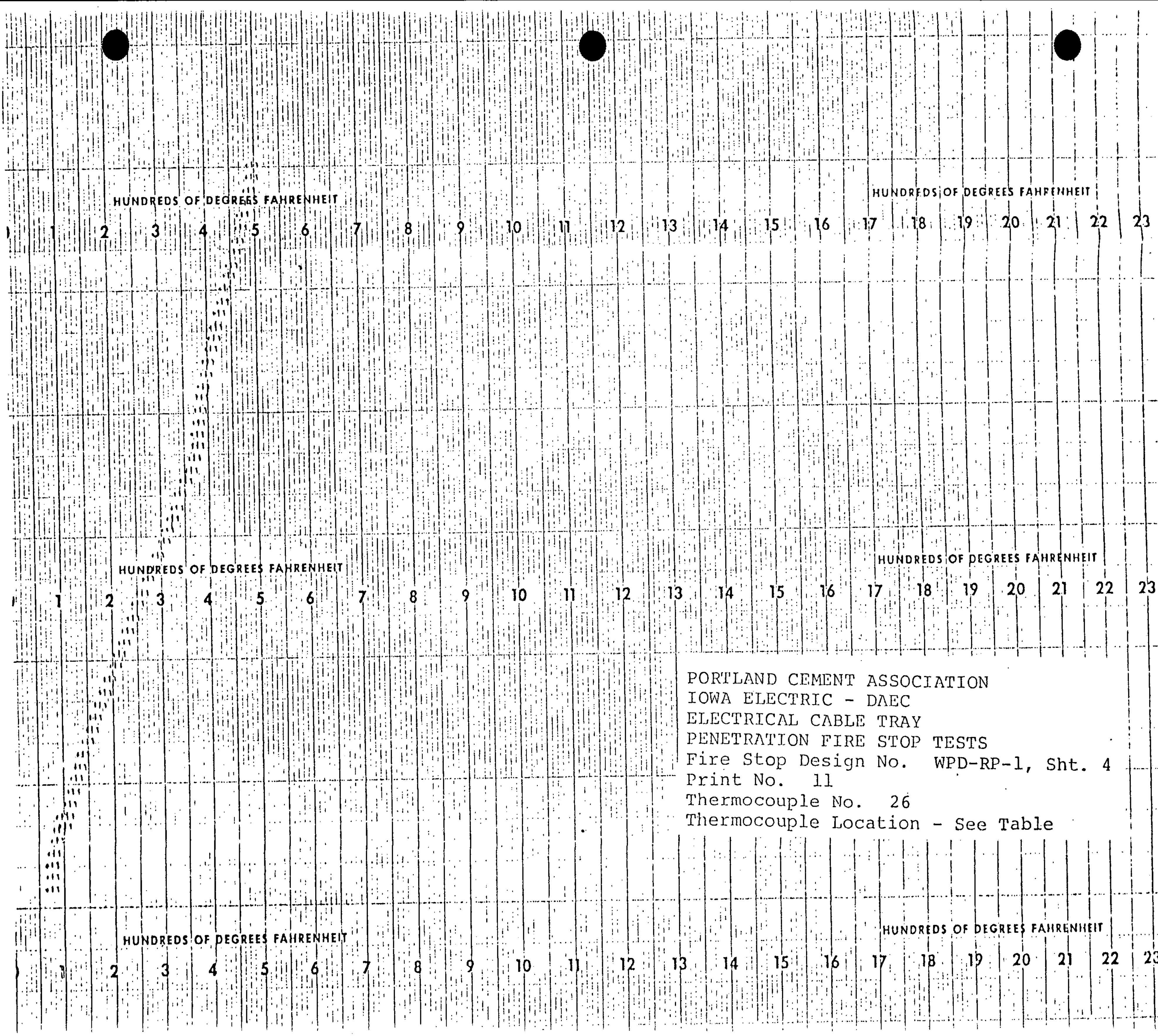
Print No. 10
Thermocouple No. 27
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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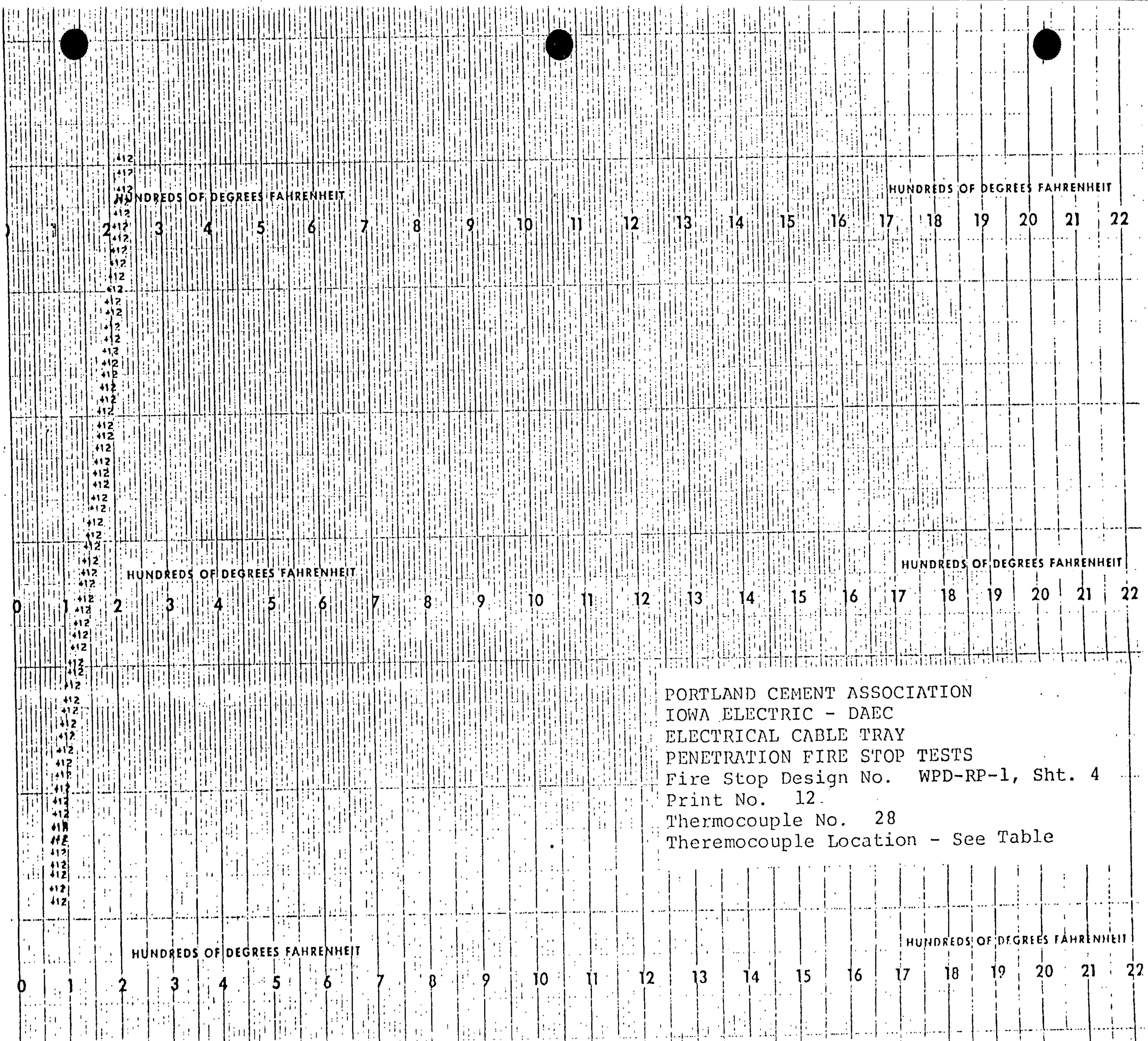
Print No. 11
Thermocouple No. 26
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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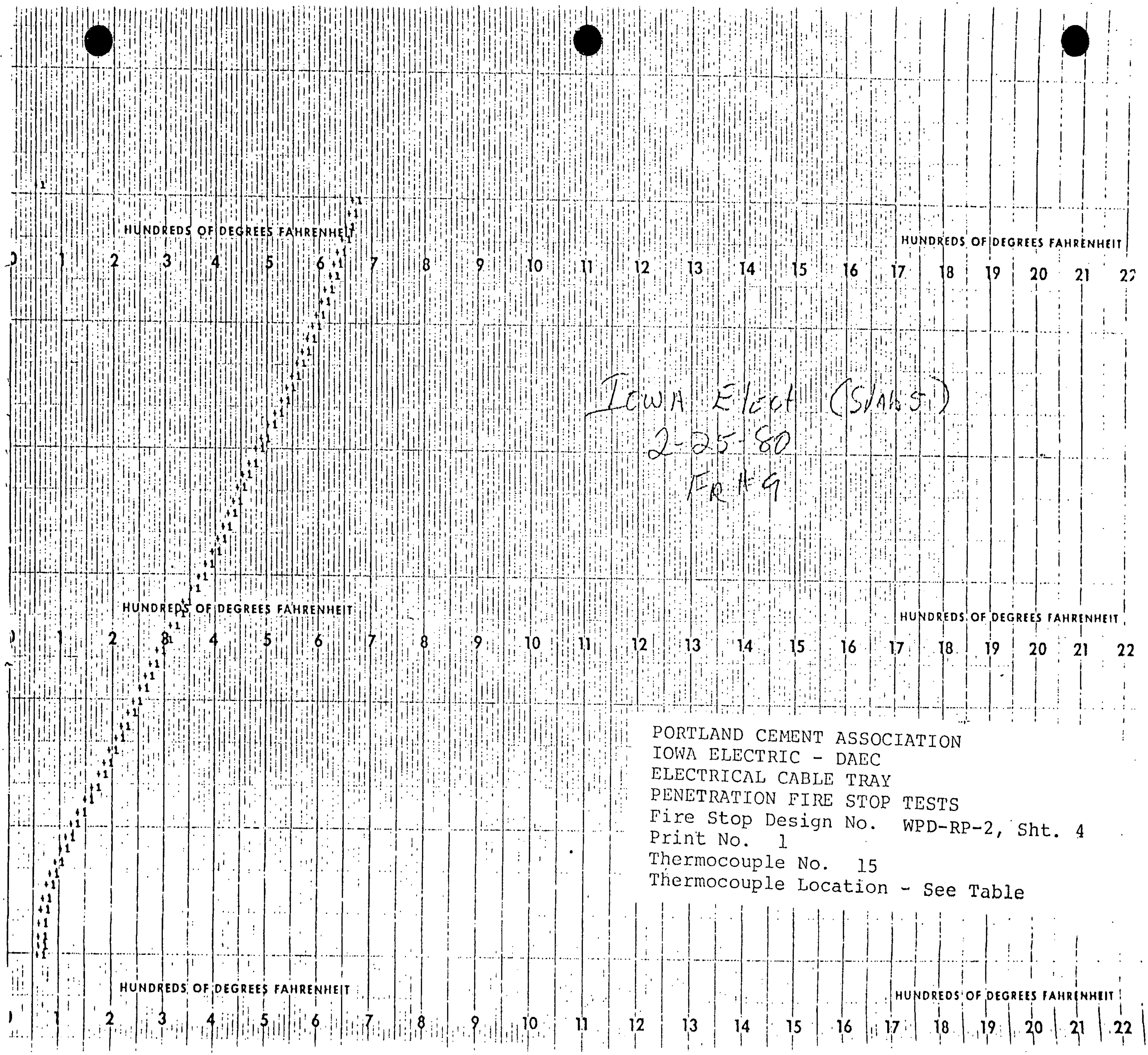
Print No. 12
Thermocouple No. 28
Theremocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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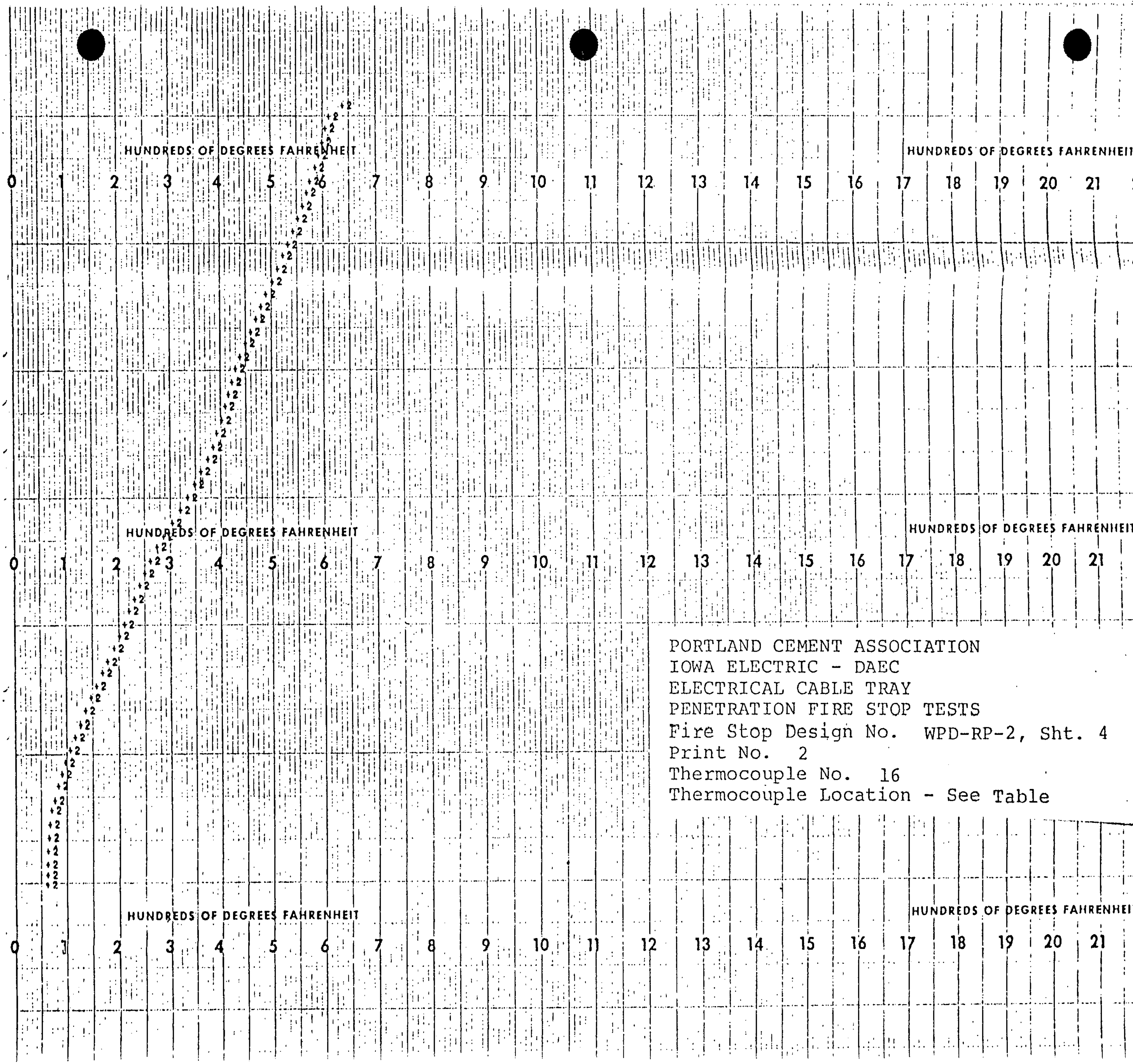
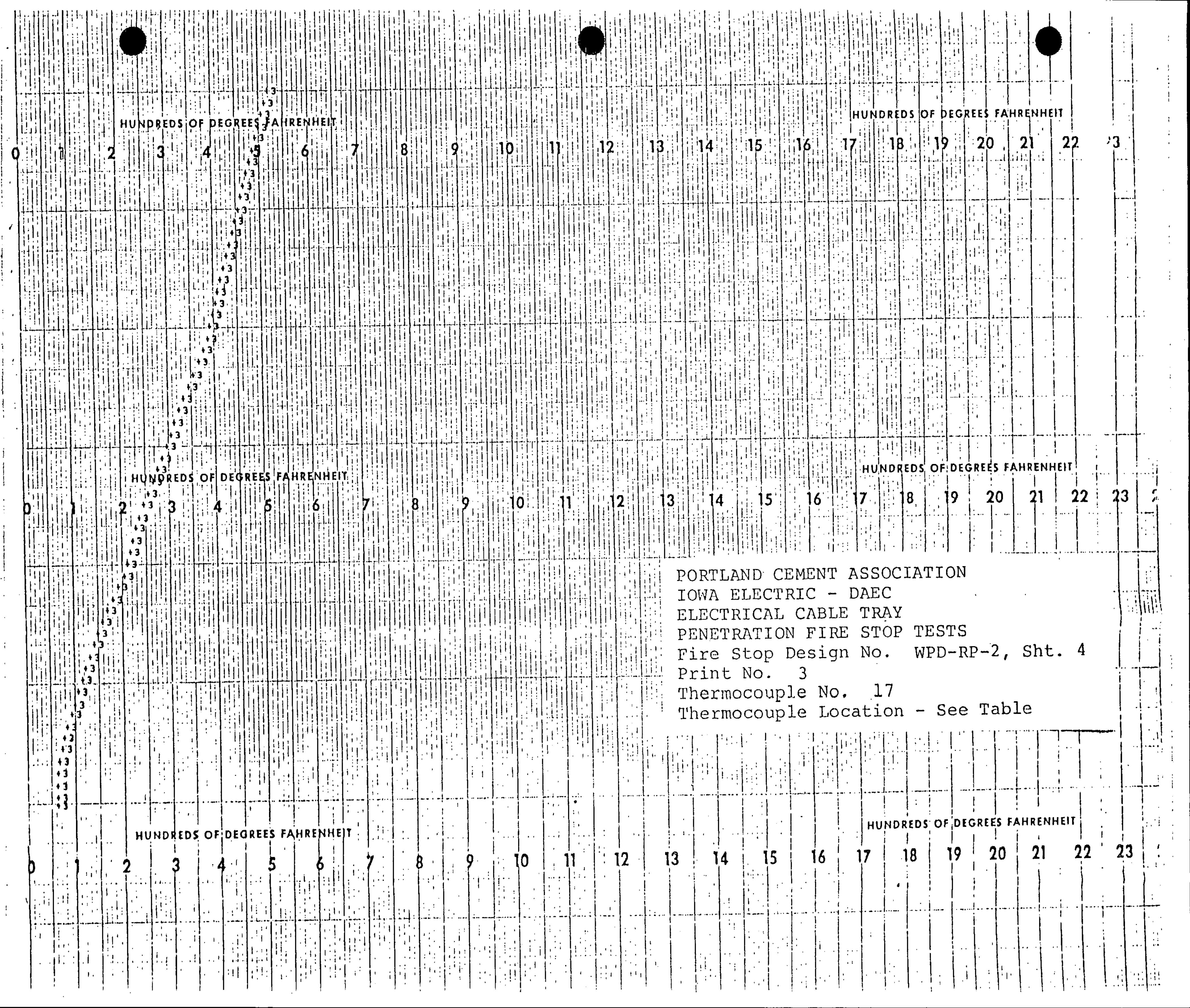
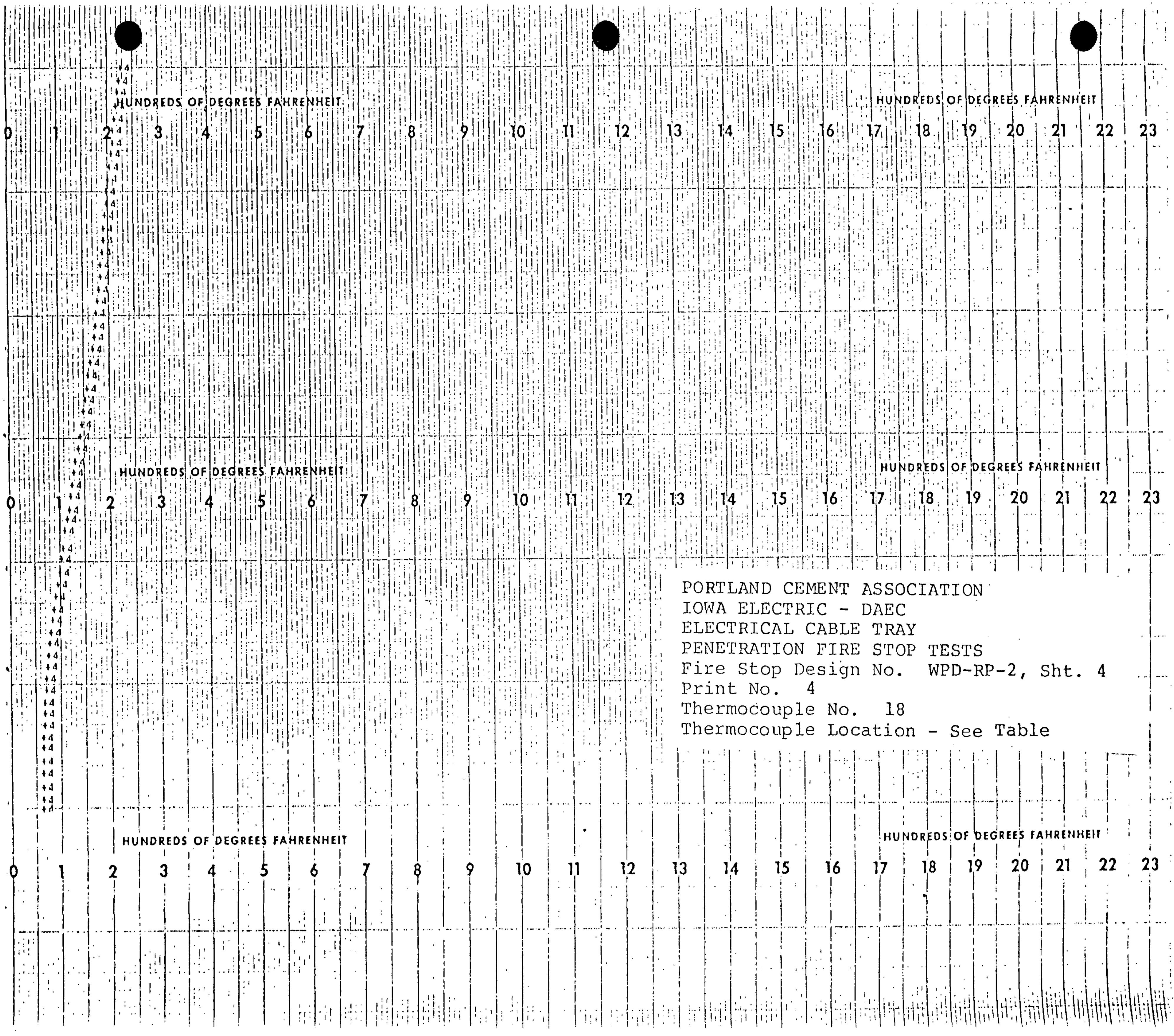
Print No. 1
Thermocouple No. 15
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 4
Print No. 2
Thermocouple No. 16
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 4
Print No. 3
Thermocouple No. 17
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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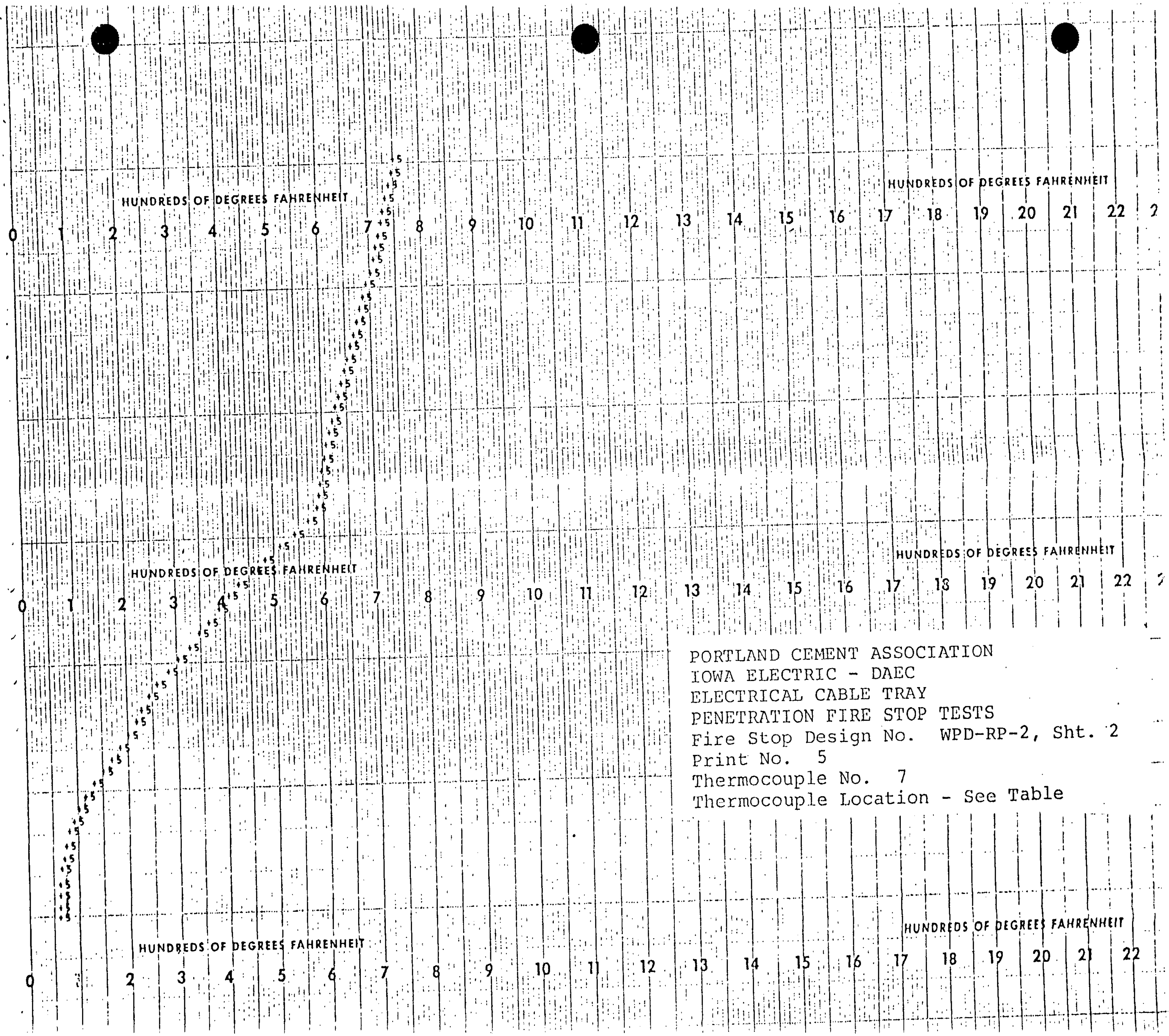
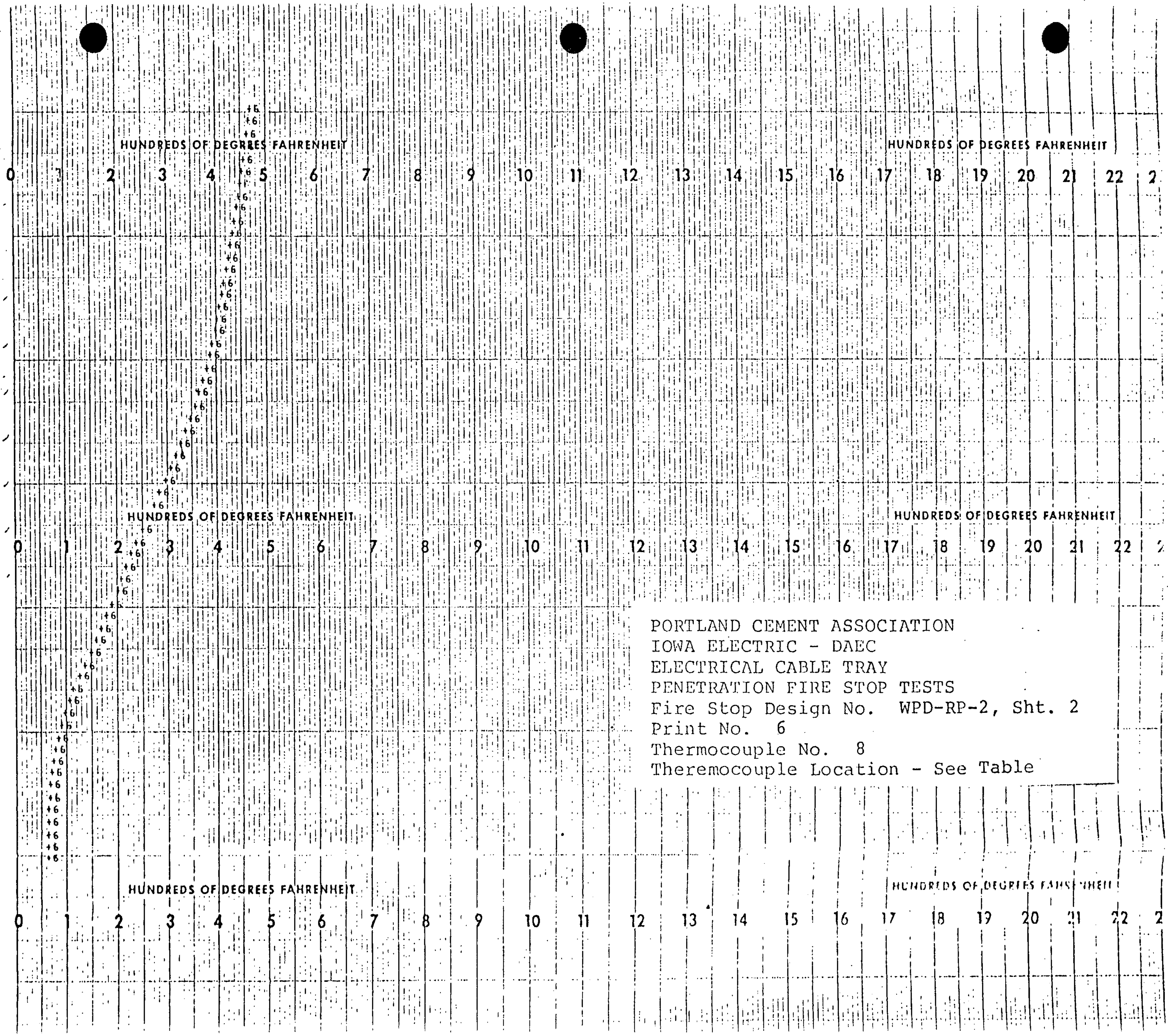
Print No. 4
Thermocouple No. 18
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 2
Print No. 5
Thermocouple No. 7
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 2
Print No. 6
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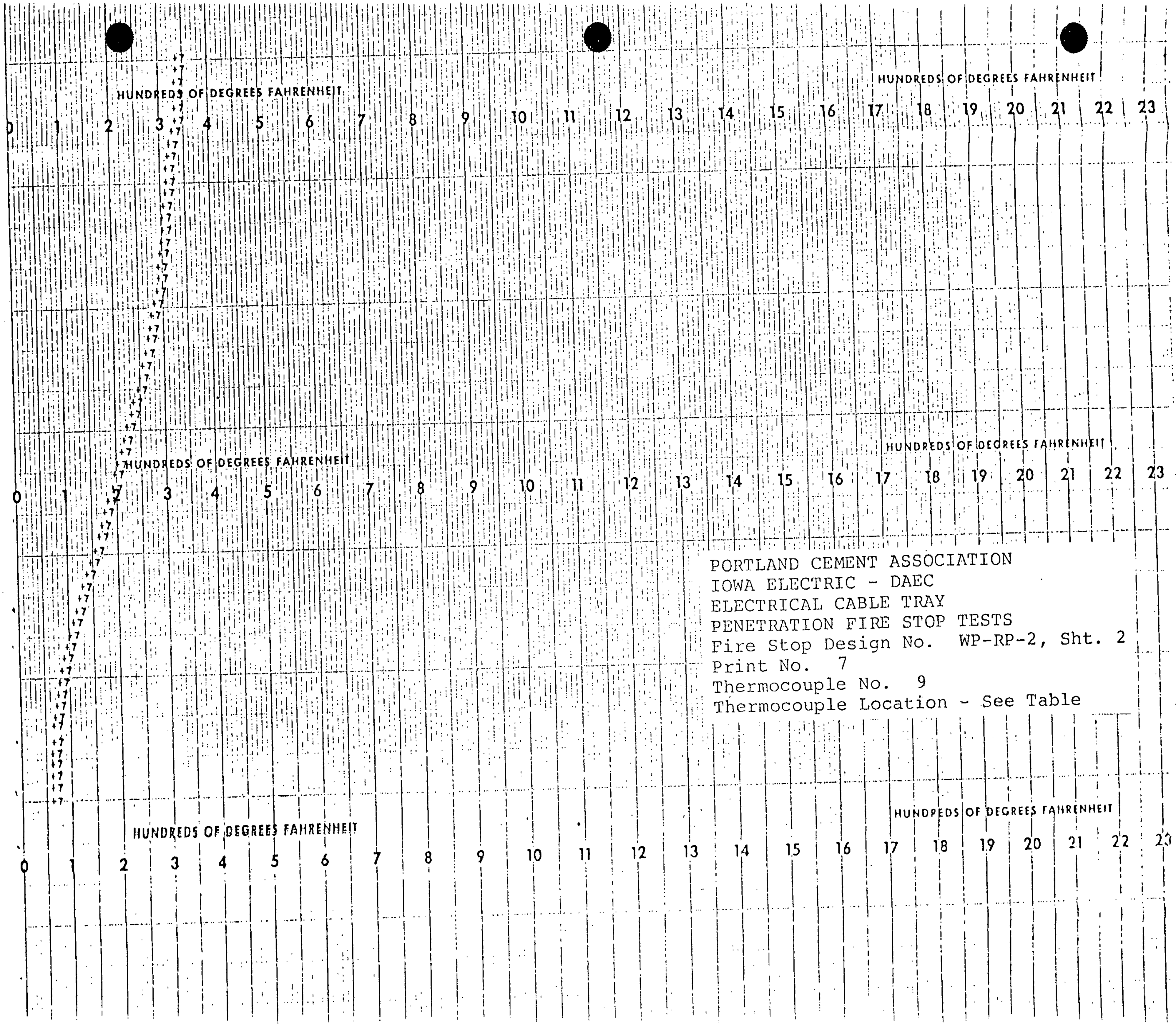
Theremocouple Location - See Table



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IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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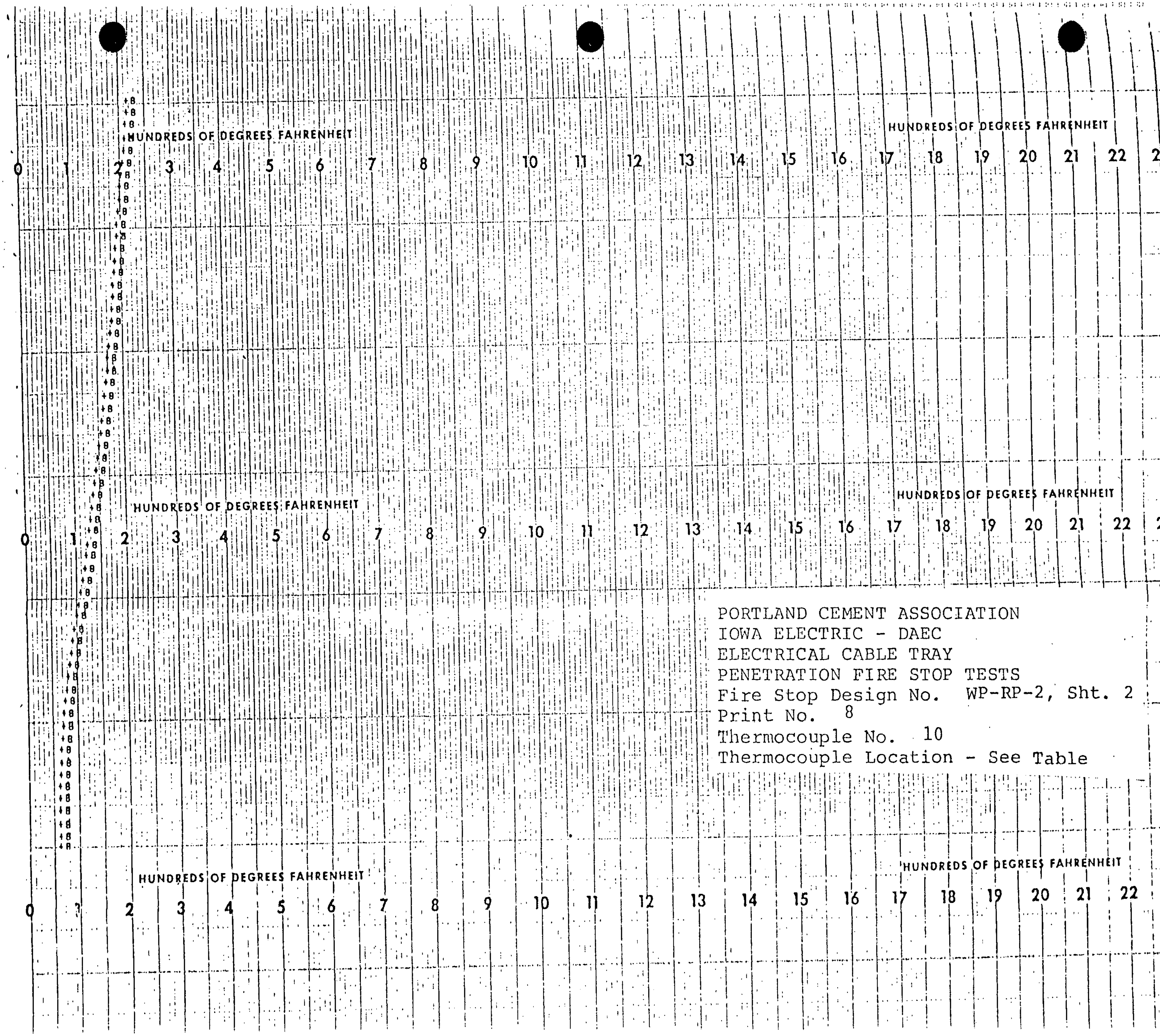
Print No. 7
Thermocouple No. 9
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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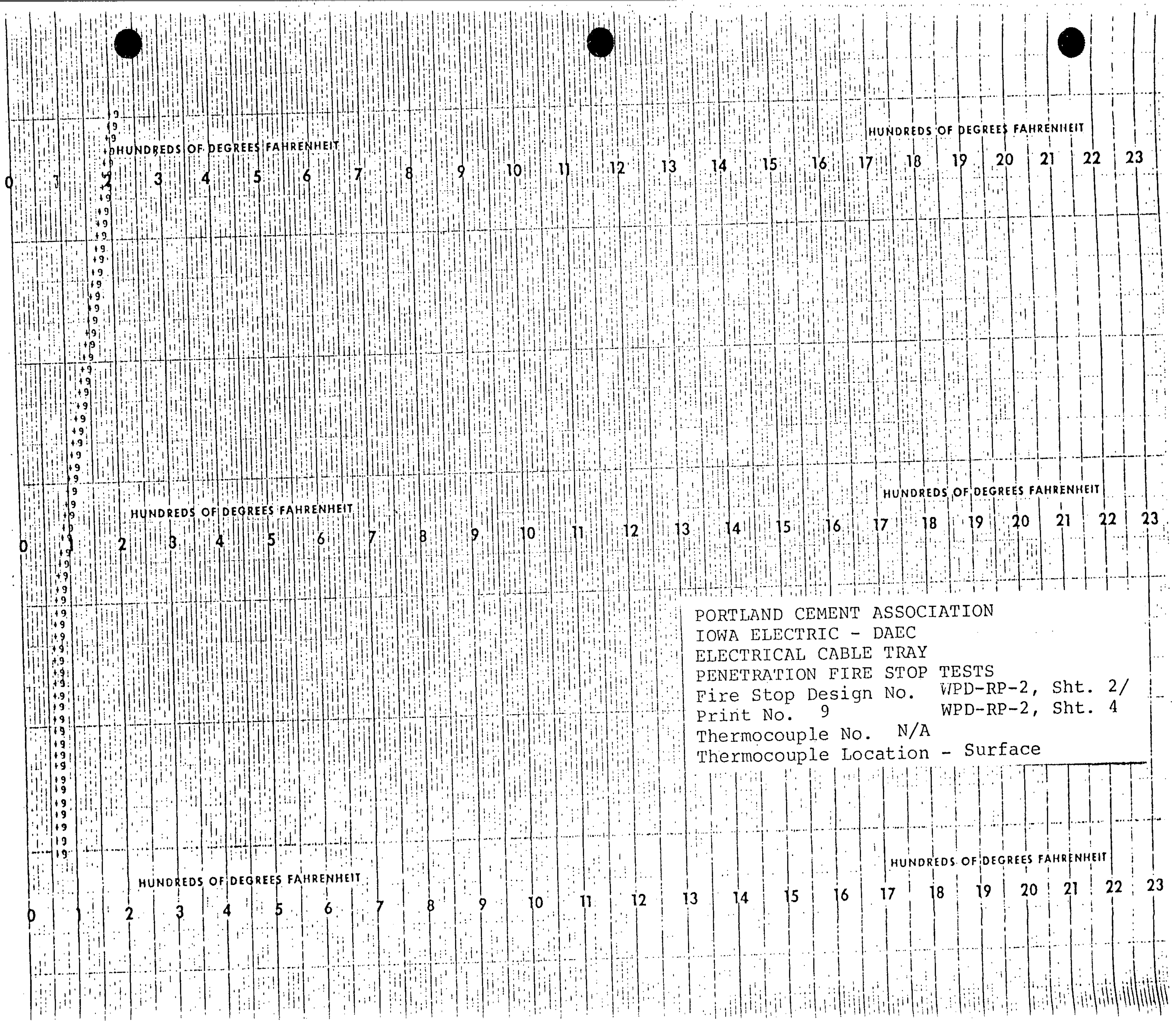
Print No. 8
Thermocouple No. 10
Thermocouple Location - See Table



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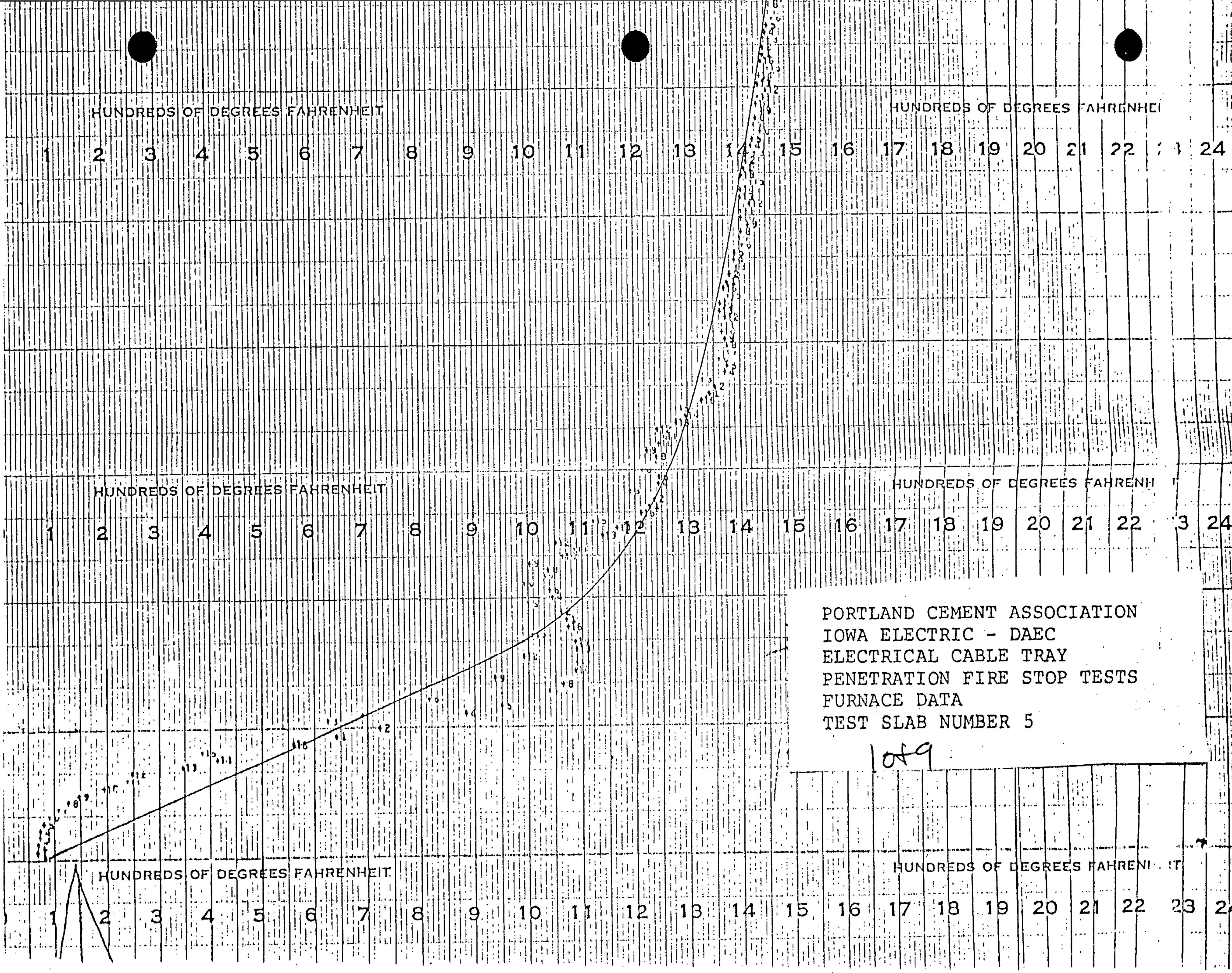
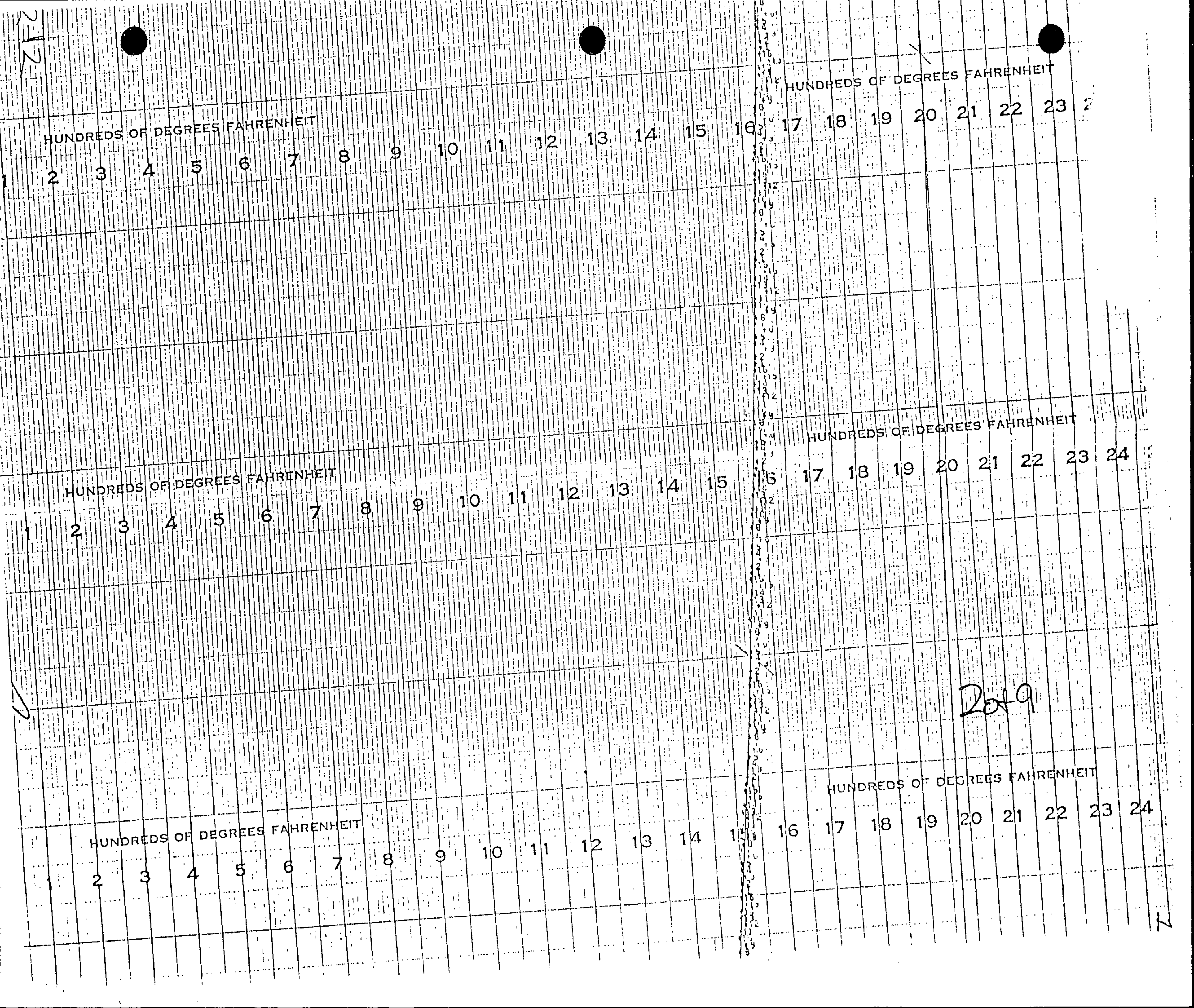
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-RP-2, Sht. 2/
WPD-RP-2, Sht. 4
Print No. 9
Thermocouple No. N/A
Thermocouple Location - Surface



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 5

1 of 9


212
HUNDREDS OF DEGREES FAHRENHEIT
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HUNDREDS OF DEGREES FAHRENHEIT
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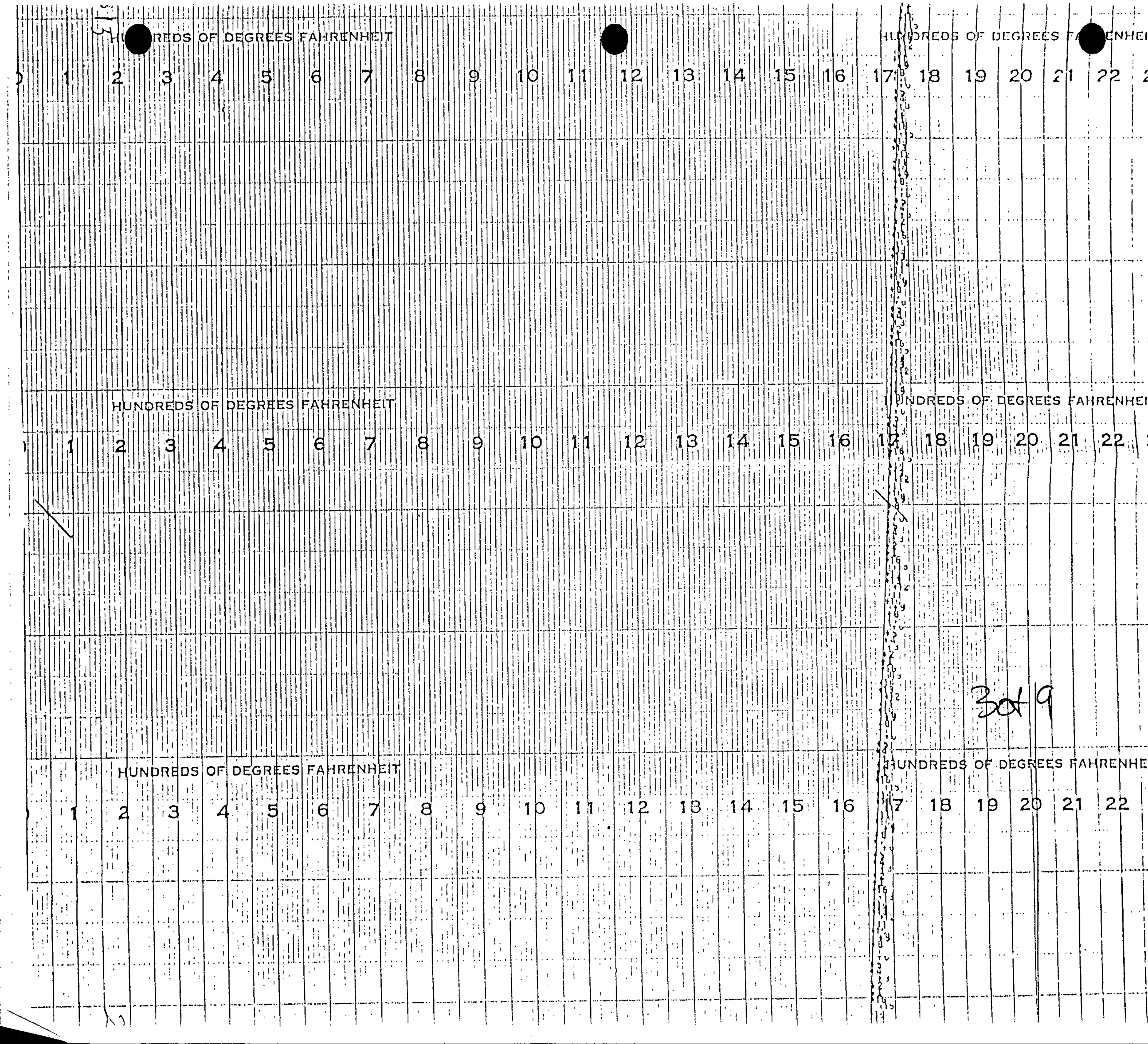
2of9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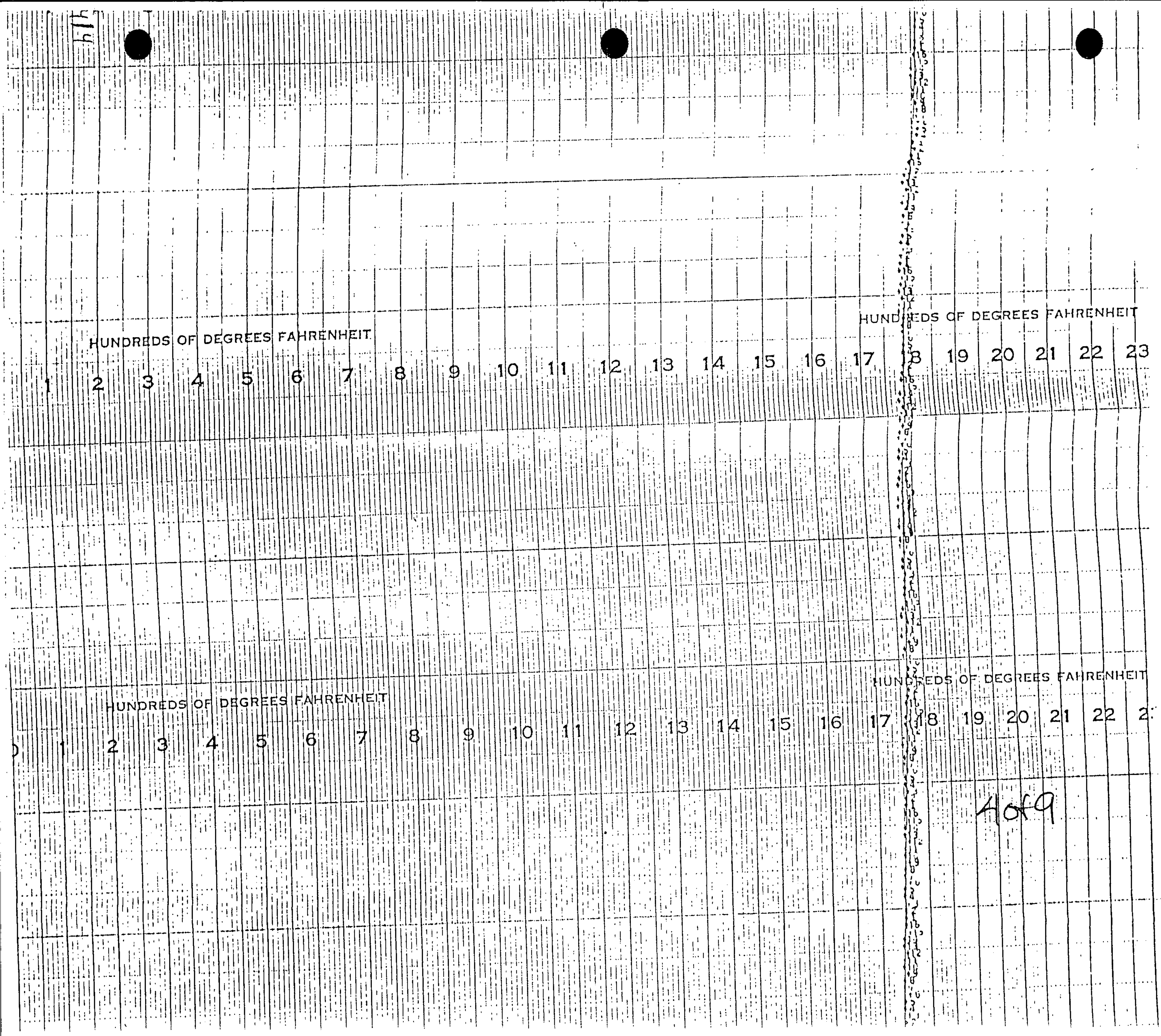
3 of 9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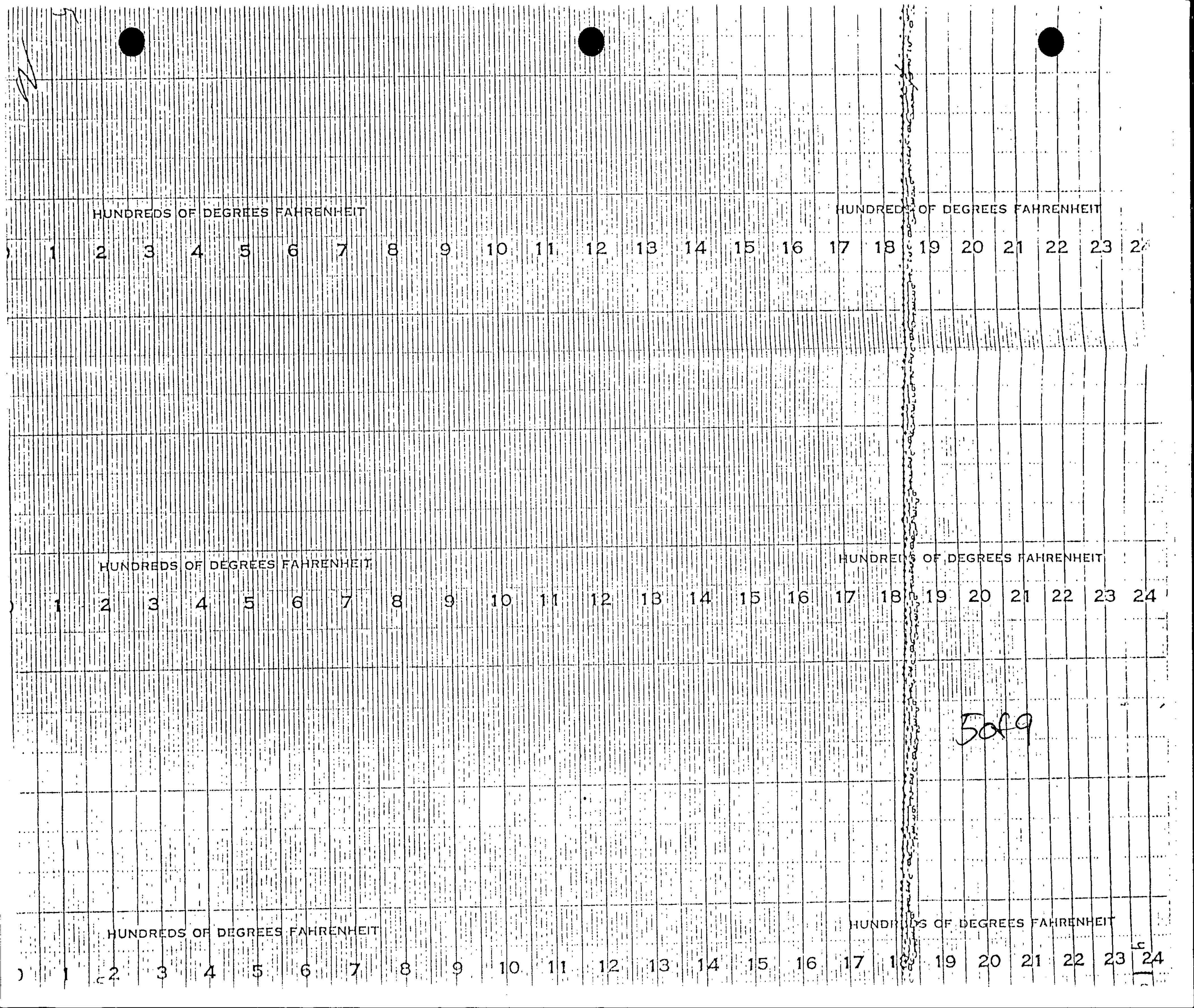
4of9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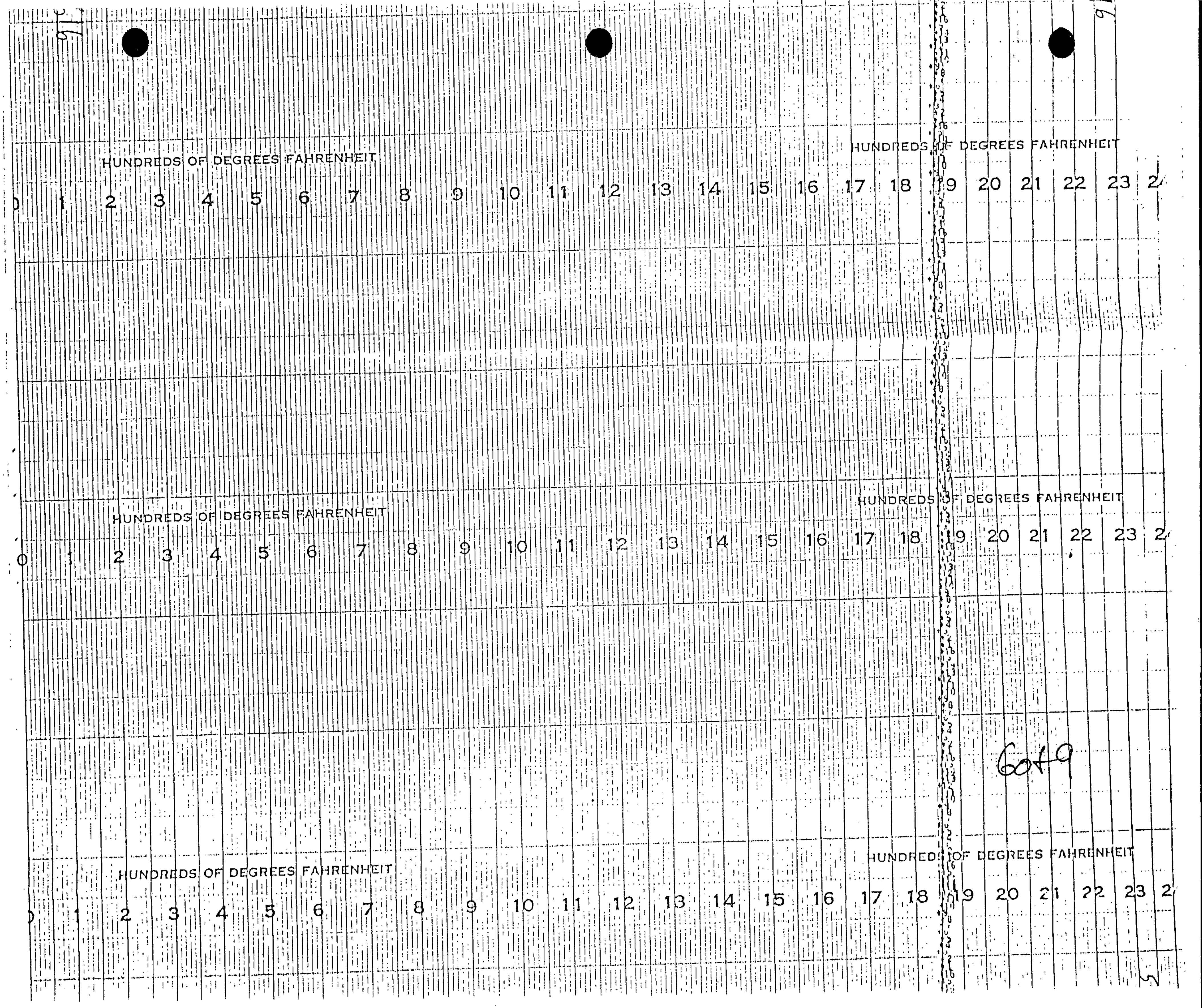
5 of 9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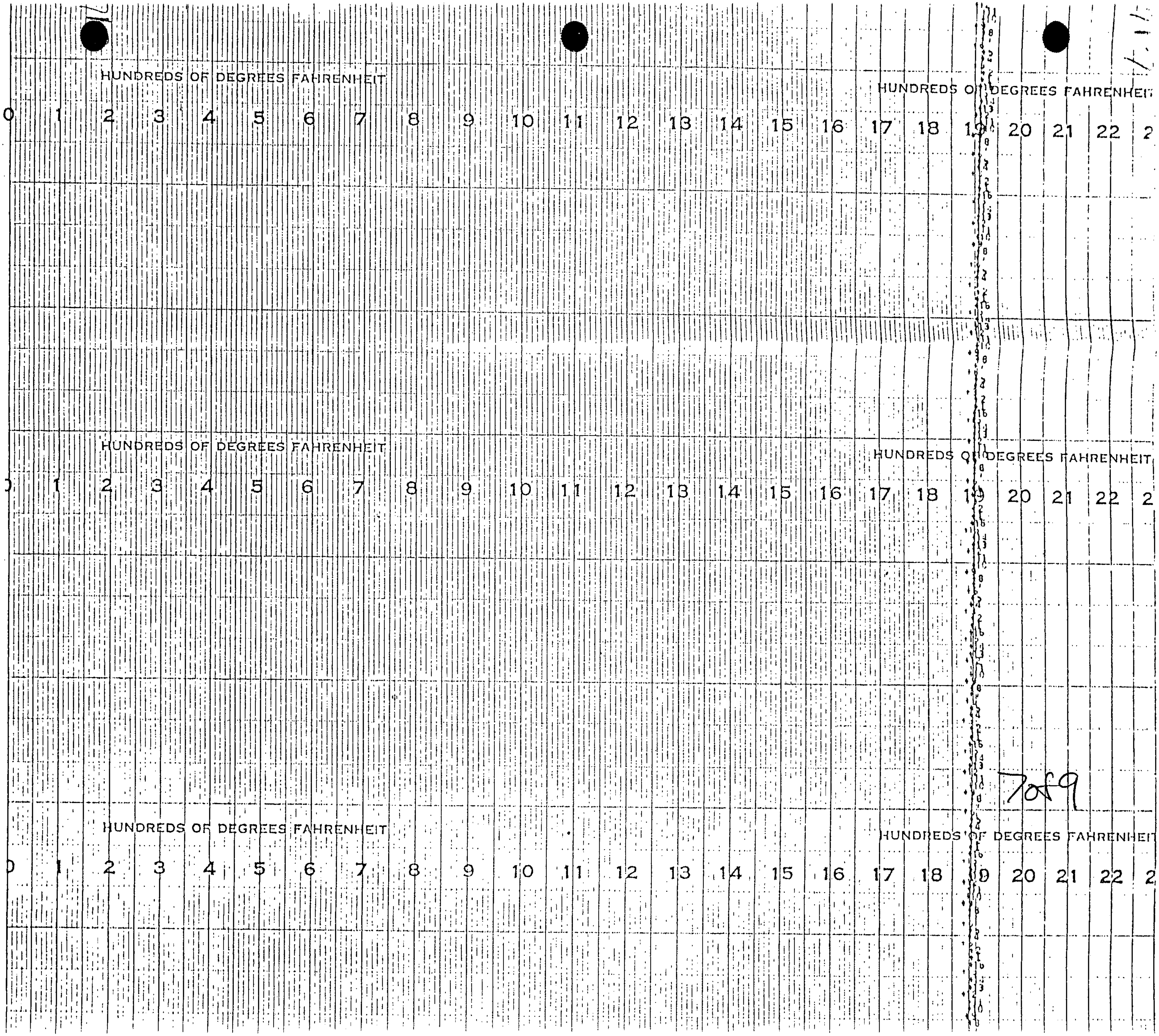
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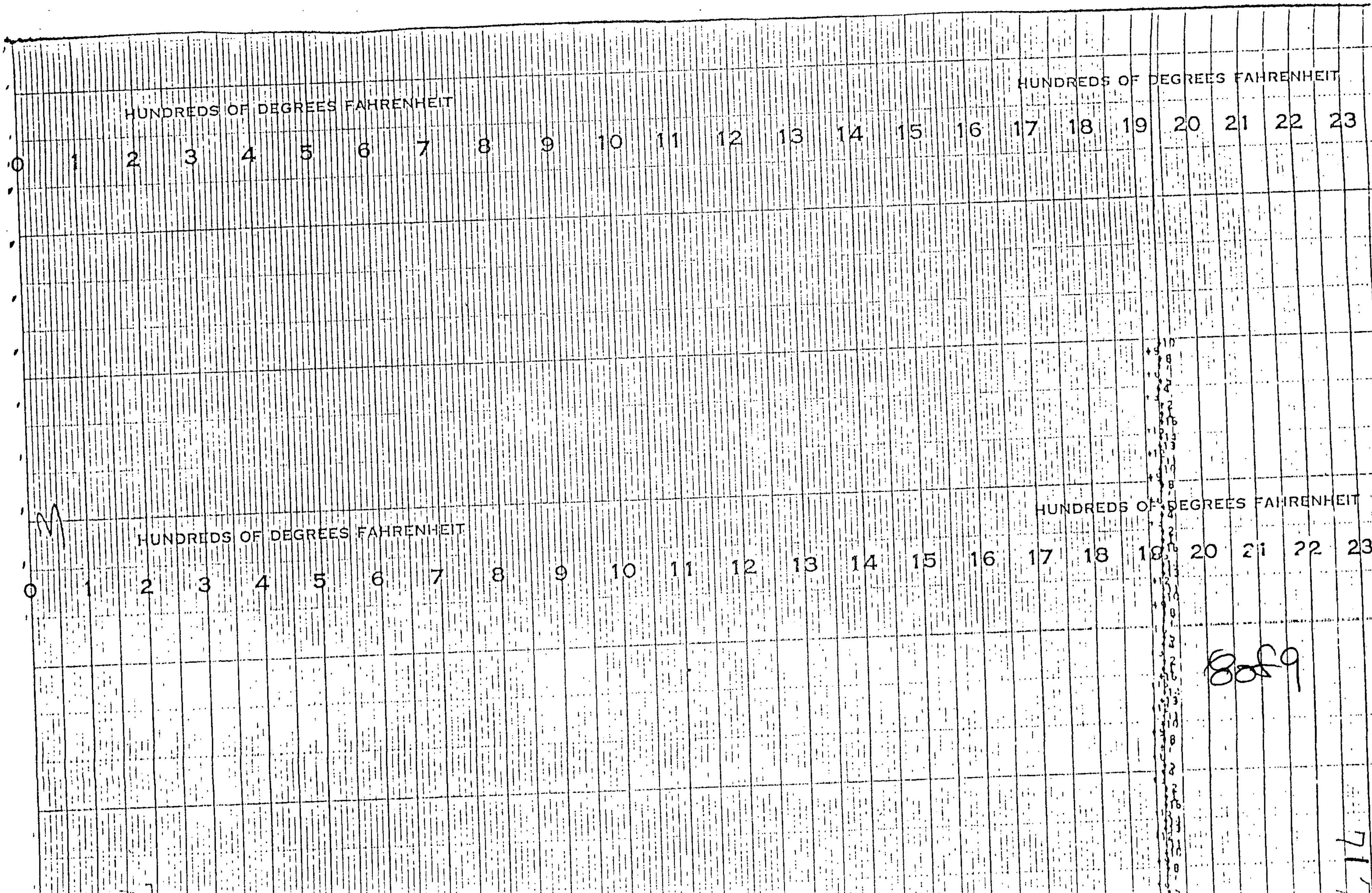
7of9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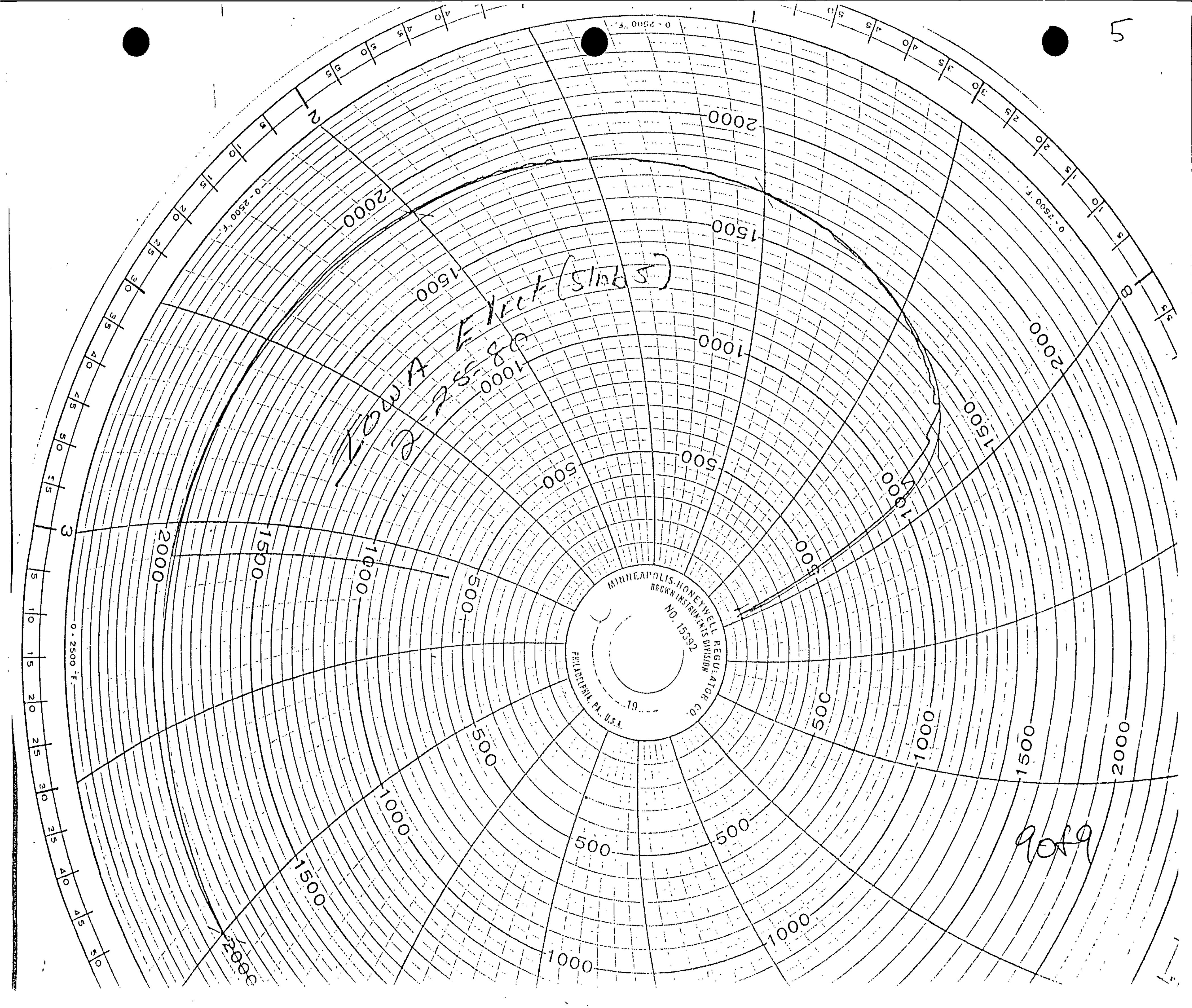
8 of 9

71

5


MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA. U.S.A.
19
0 - 2500 °F.
Iowa Elec
9 of 9

TEST SLAB NUMBER 6

DATE: 02/26/80

FIRE STOP DESIGNS TESTED: FPD-1
FPD-RP-1
FPD-RP-3
FPD-RP-4

CONTENTS:

- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

Test Witnessed by:

M. Gillen, PCA

Bob Chin, IEL&P

M. S. Abrams, PCA

CR4557

THERMOCOUPLE LOCATIONS ON IELP/EDS SPECIMEN NO. 6 (TO BE TESTED 2/26/80)

PENETRATION S1: FPD-1

T/C #1 - interior of cable bundle
T/C #2 - surface of cable bundle
T/C #3 - penetration surface

PENETRATION S2: FPD-RP-1

T/C #4 - on repair cable
T/C #5 - interior of cable bundle
T/C #6 - surface of cable bundle
T/C #7 - on 1-in. RS conduit
T/C #8 - penetration surface

PENETRATION S4: FPD-RP-3

T/C #18 - on repair cable
T/C #19 - interior of cable bundle
T/C #20 - surface of cable bundle
T/C #21 - penetration surface

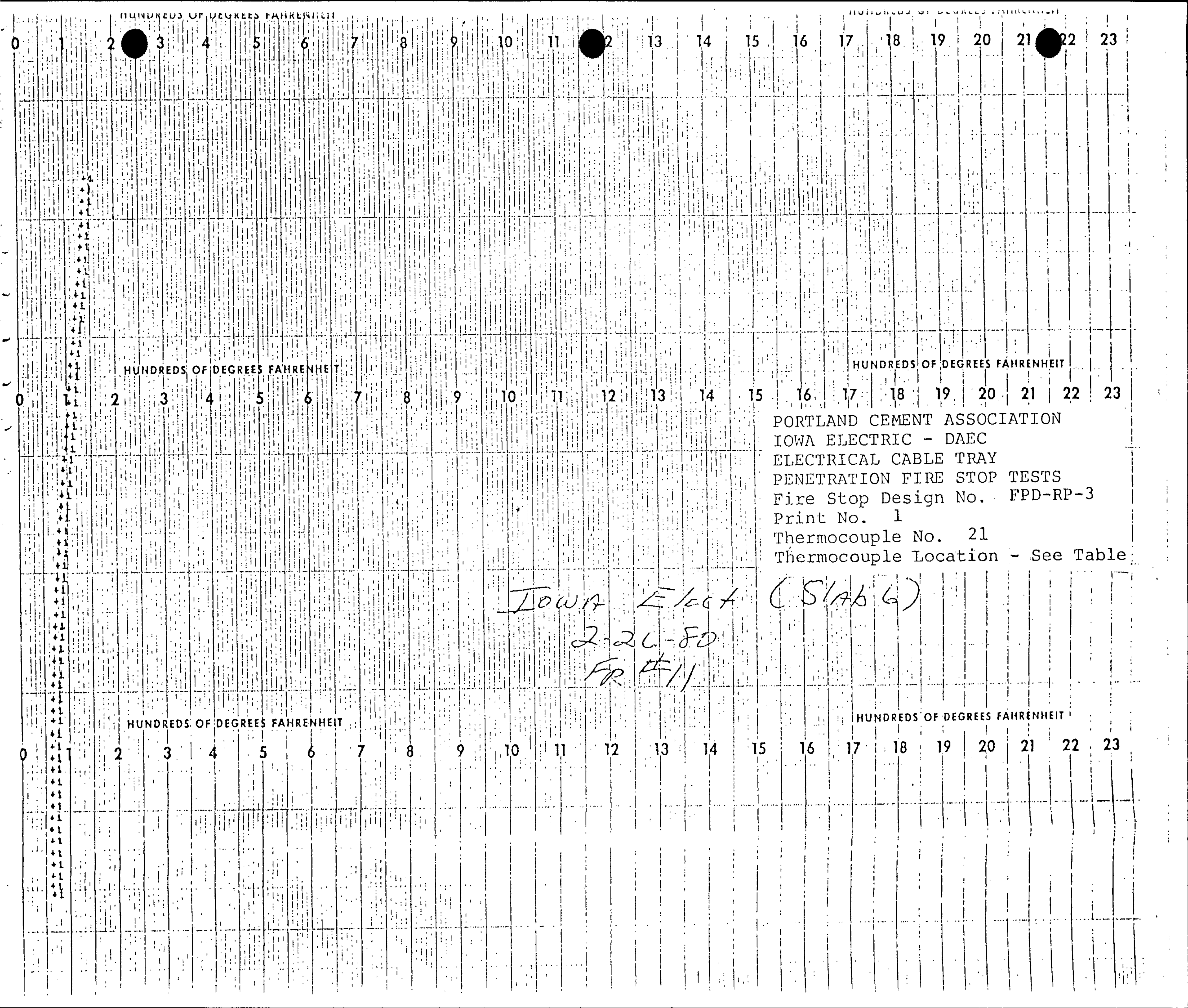
PENETRATION S5: FPD-RP-4

T/C #9 - on 1-in. RS conduit filled w/ kaowool & duxseal
T/C #10 - on cable in conduit " " " " "
T/C #11 - on 1-in. RS conduit filled w/ duxseal
T/C #12 - on cable in conduit " " " " "
T/C #13 - on 1-in. RS conduit filled w/ RTV
T/C #14 - on cable in conduit " " "
T/C #15 - on capped conduit filled w/ kaowool
T/C #16 - on cap fitted on conduit filled w/ kaowool (unexposed surfac
T/C #17 - on penetration surface

T/C # 22 - on concrete surface

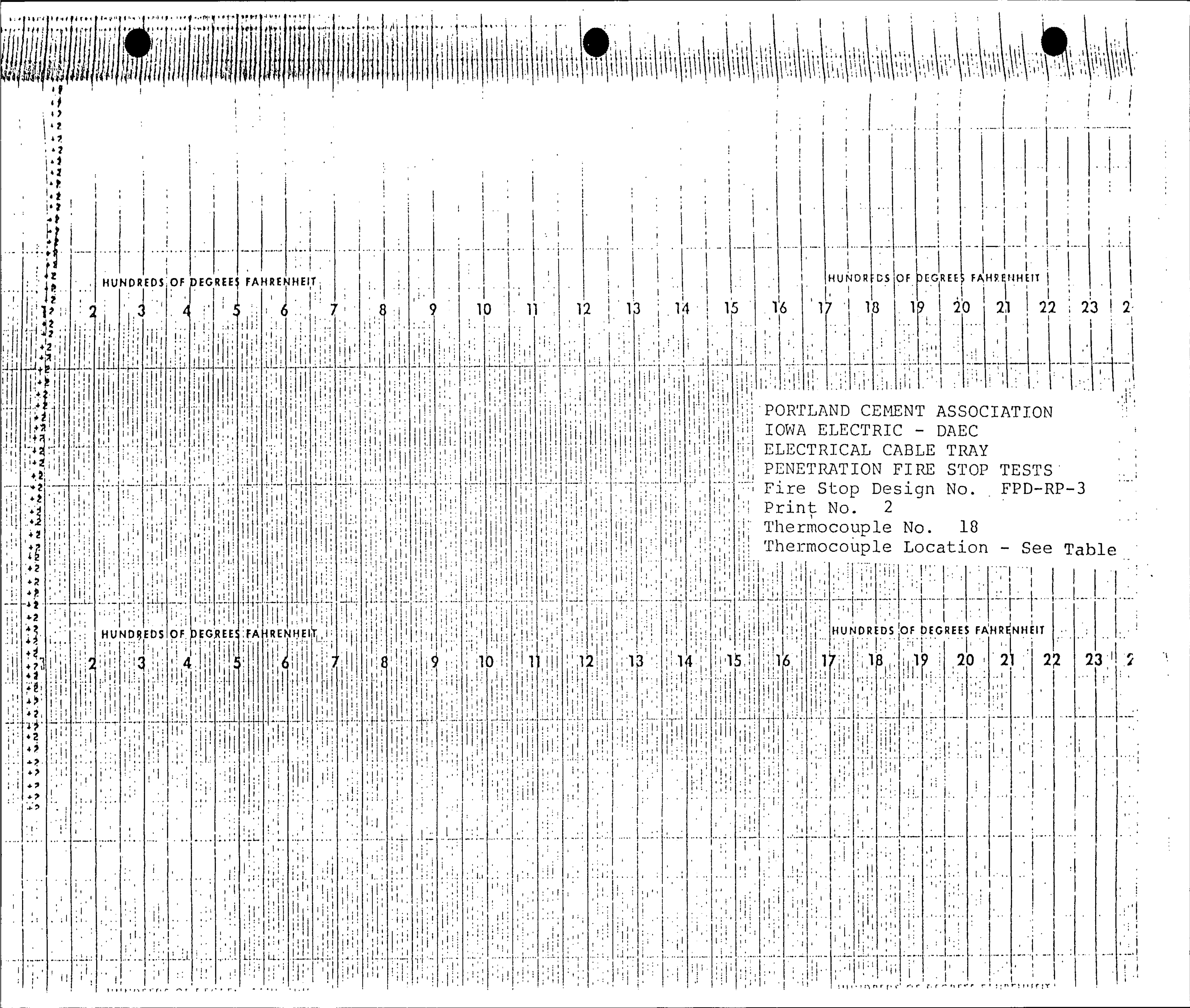
THERMOCOUPLE LOCATIONS - TEST 6

m.g.



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-3
Print No. 1
Thermocouple No. 21
Thermocouple Location - See Table

Iowa Elect (Slab 6)
2-26-80
FR #11



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-3
Print No. 2
Thermocouple No. 18
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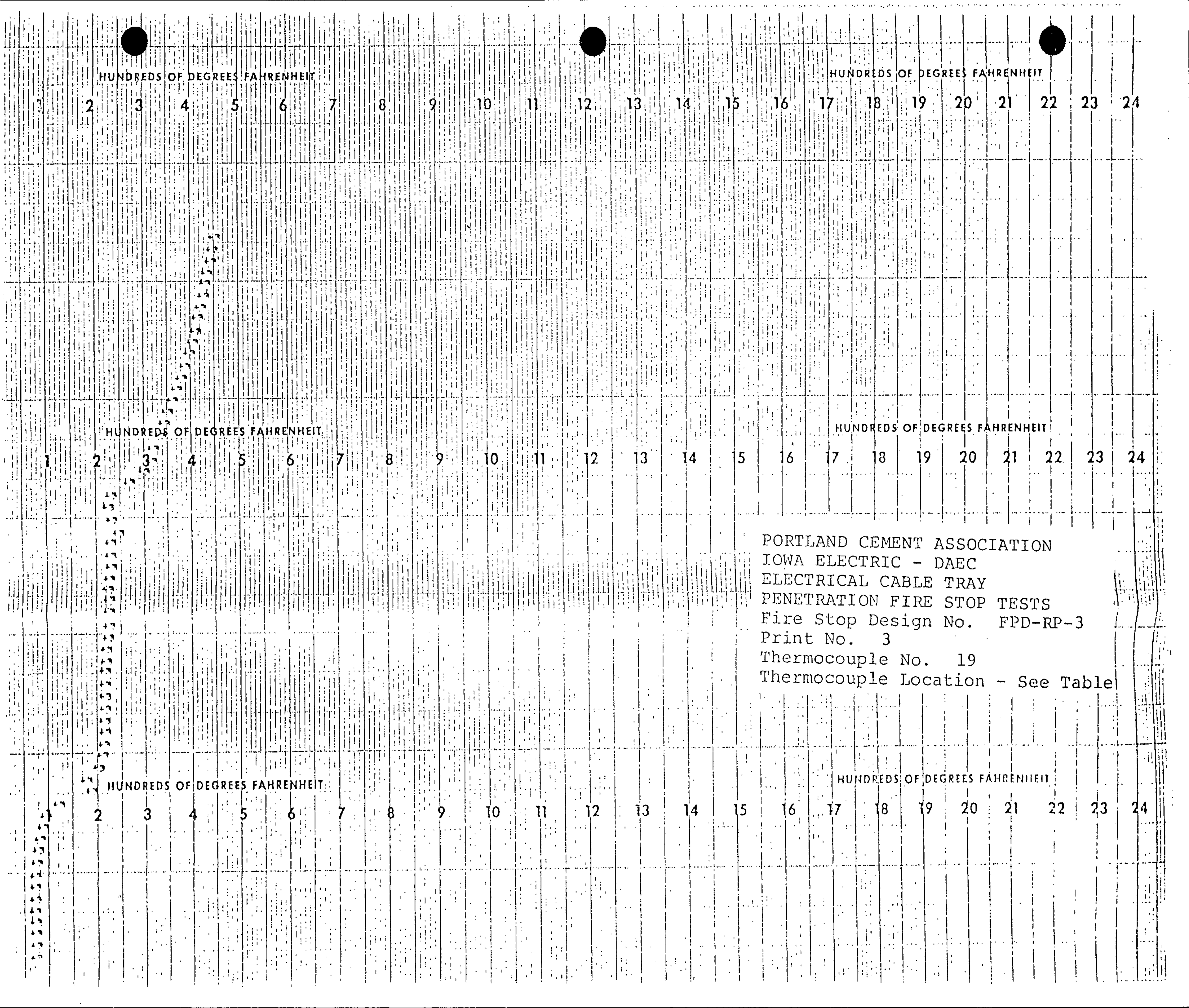
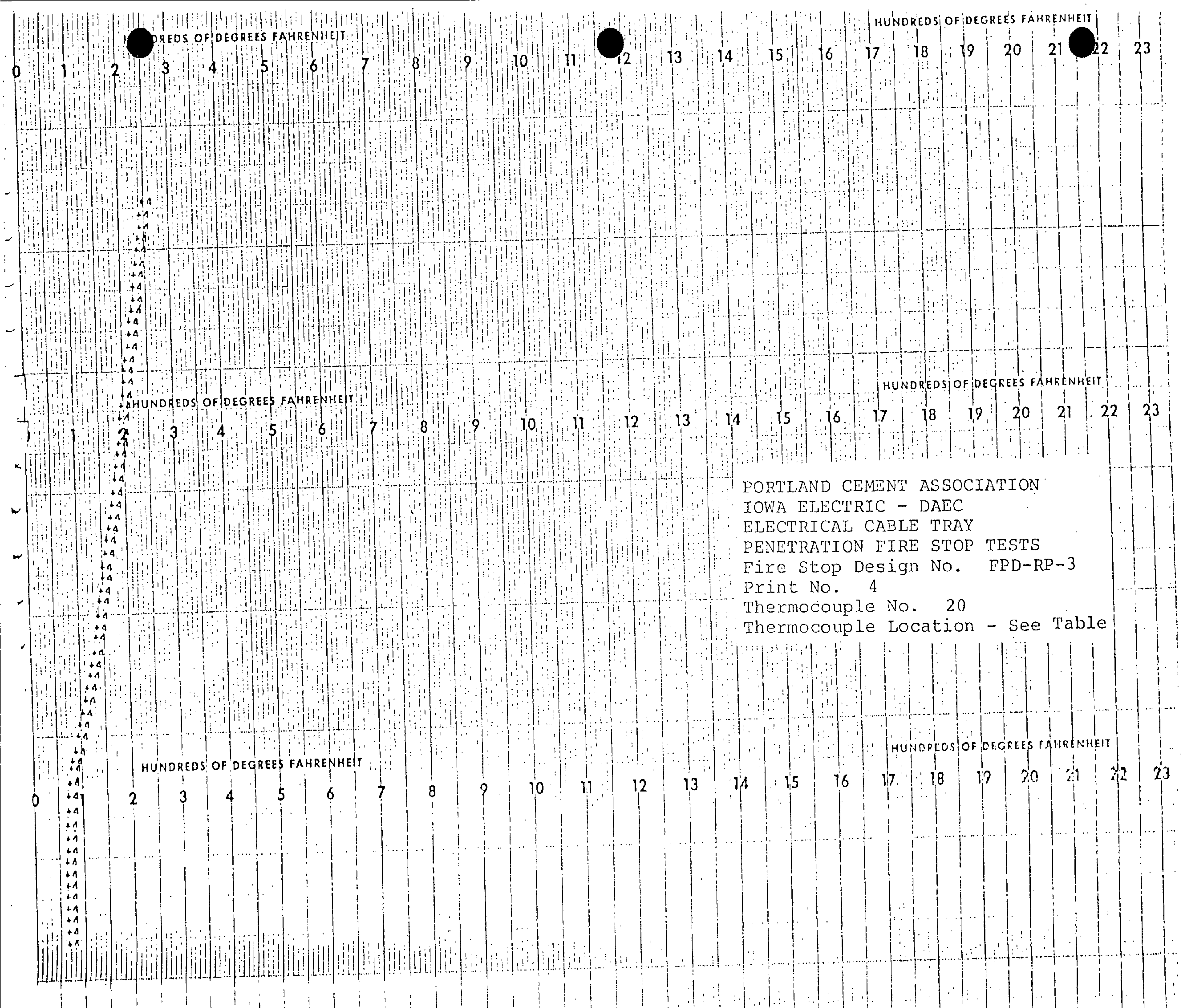


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-3
Print No. 3
Thermocouple No. 19
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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Fire Stop Design No. FPD-RP-3
Print No. 4
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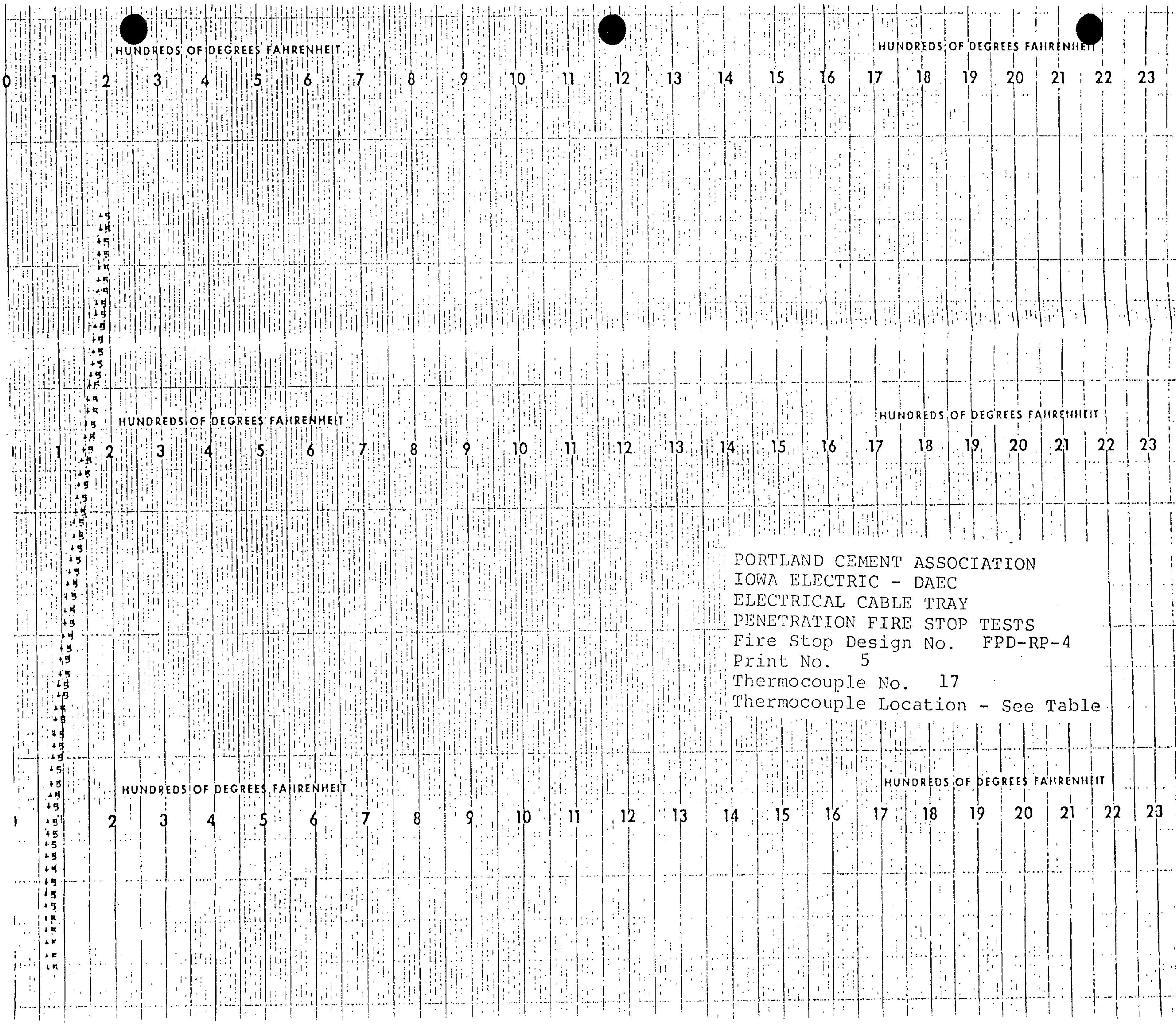
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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Fire Stop Design No. FPD-RP-4
Print No. 5
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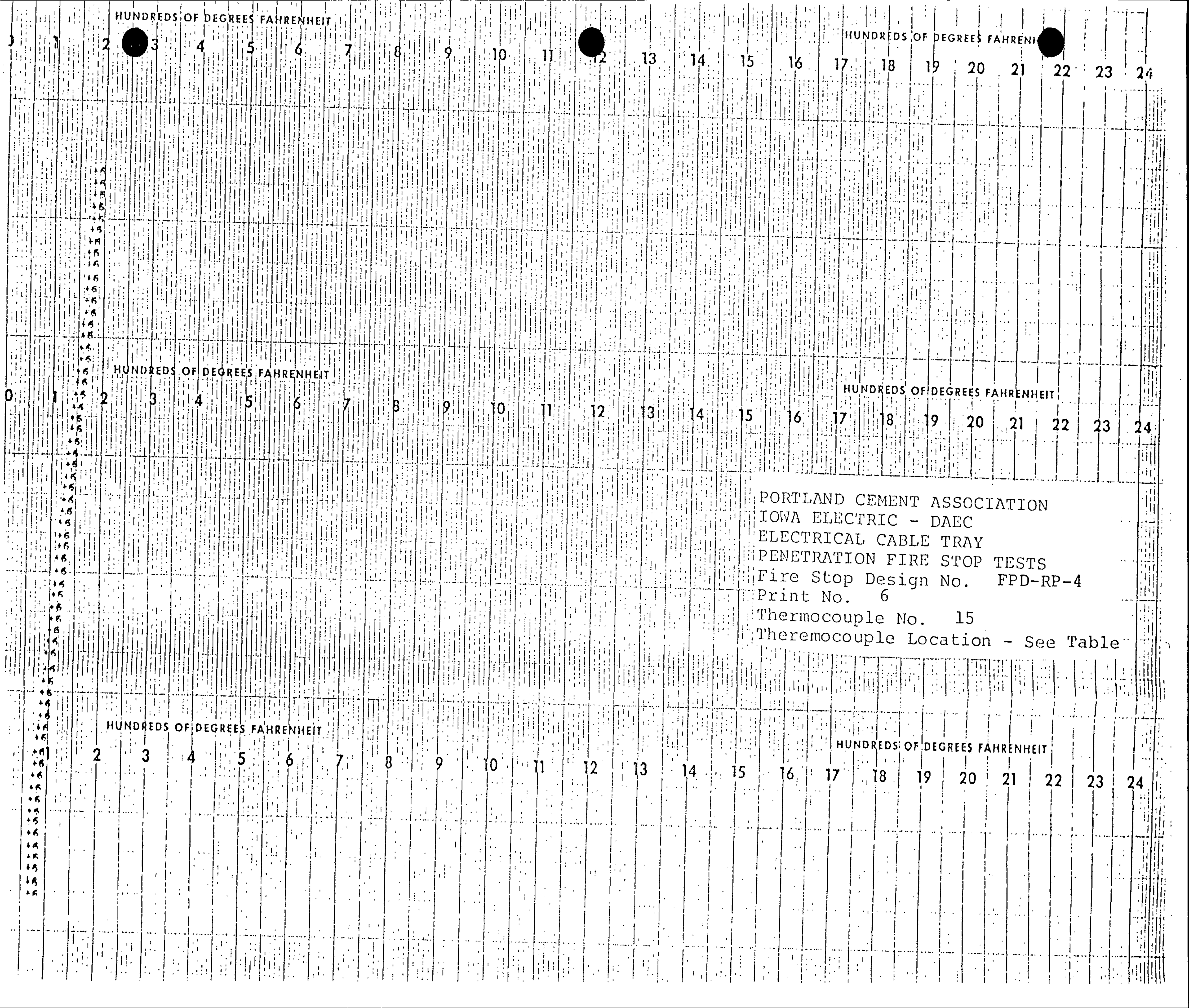
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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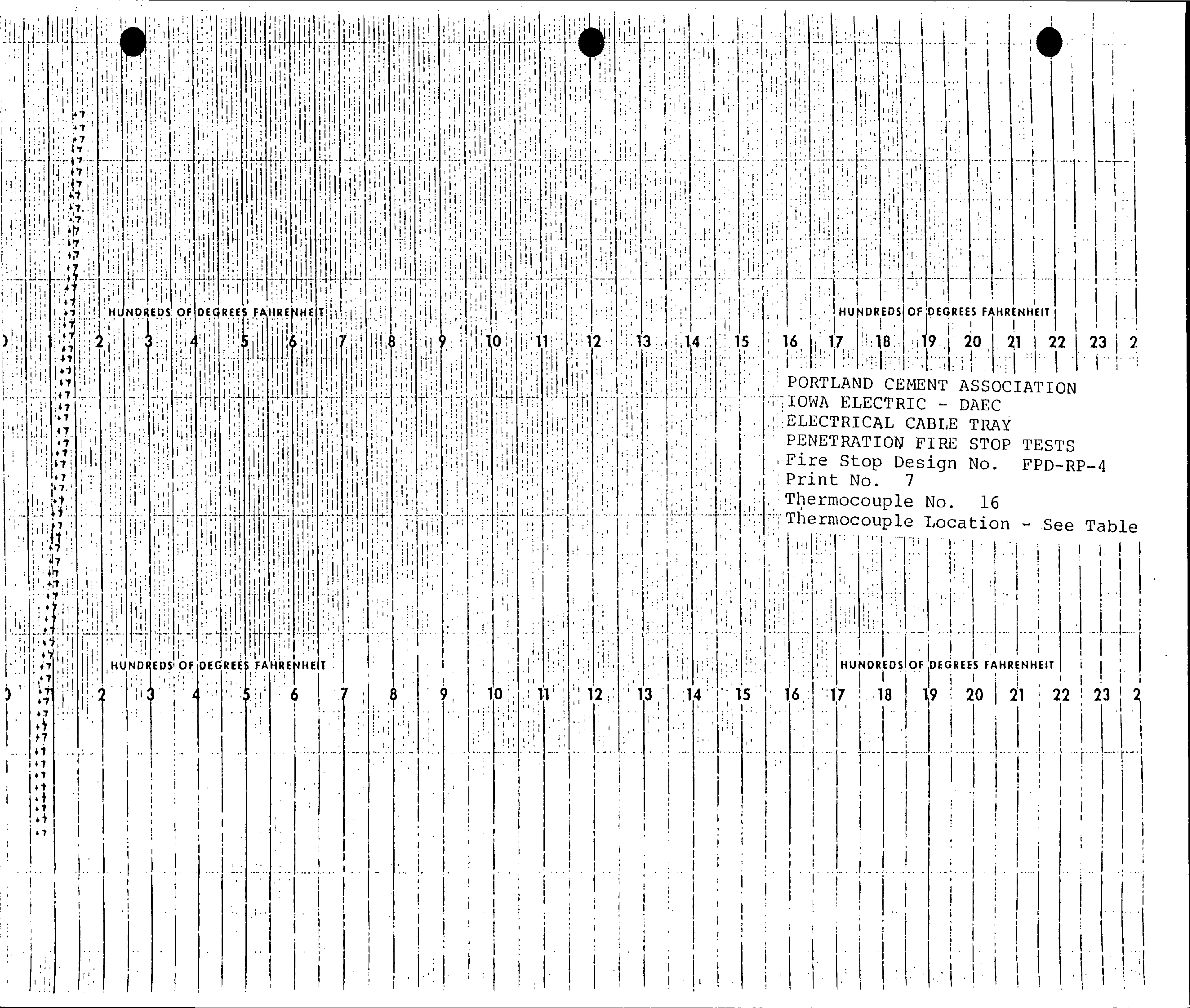
Theremocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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Fire Stop Design No. FPD-RP-4
Print No. 7
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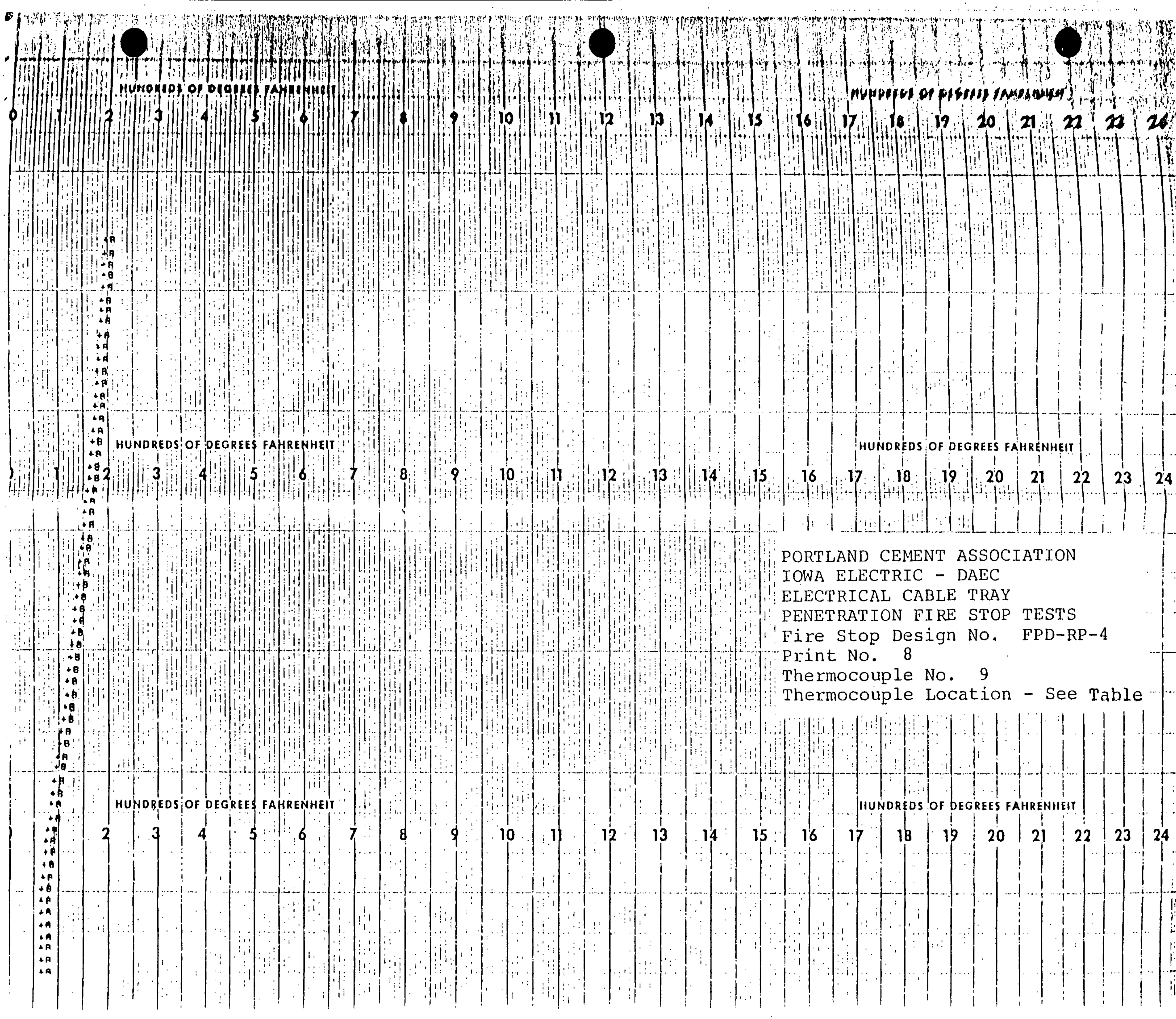
Thermocouple Location - See Table



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IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
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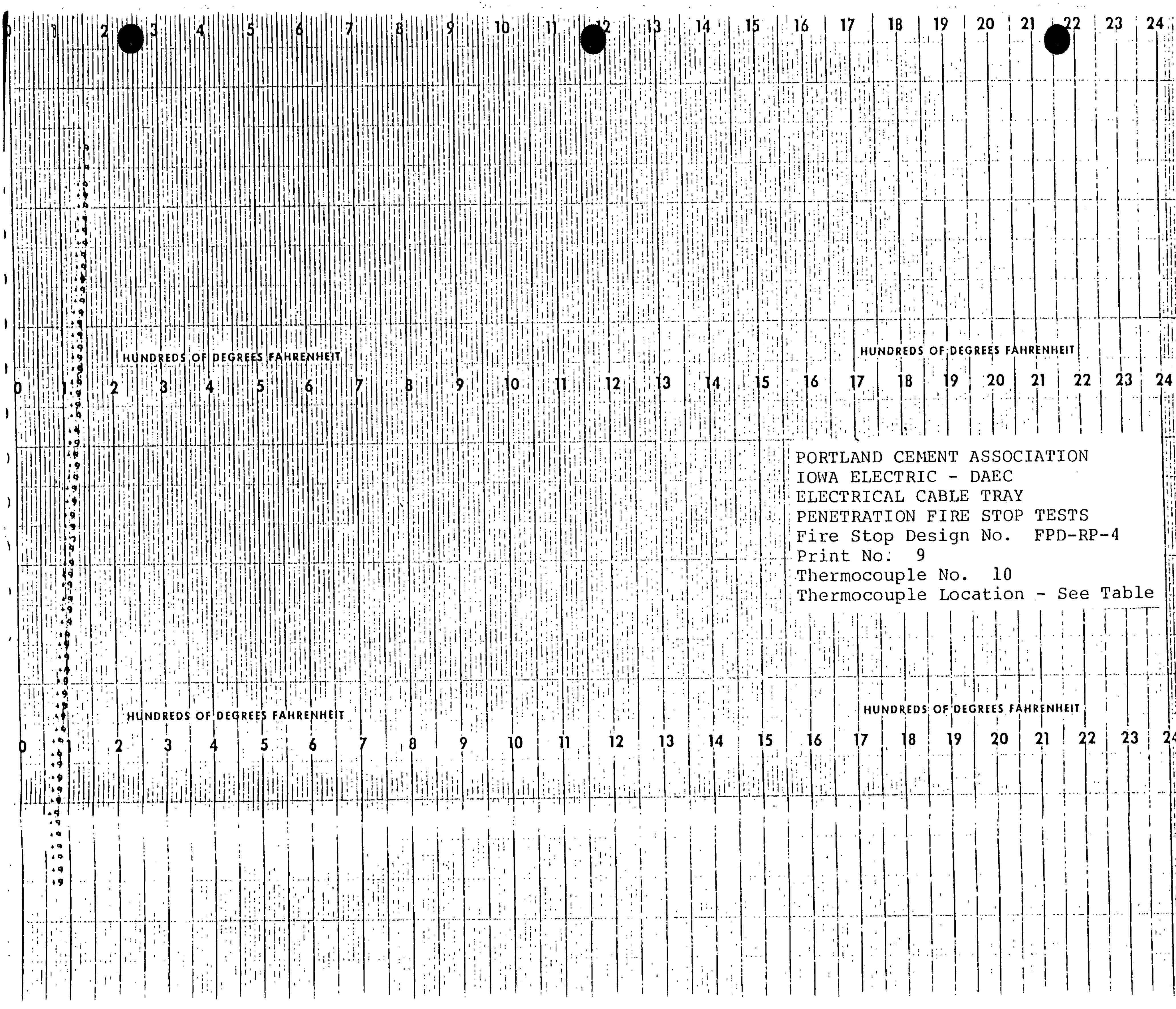
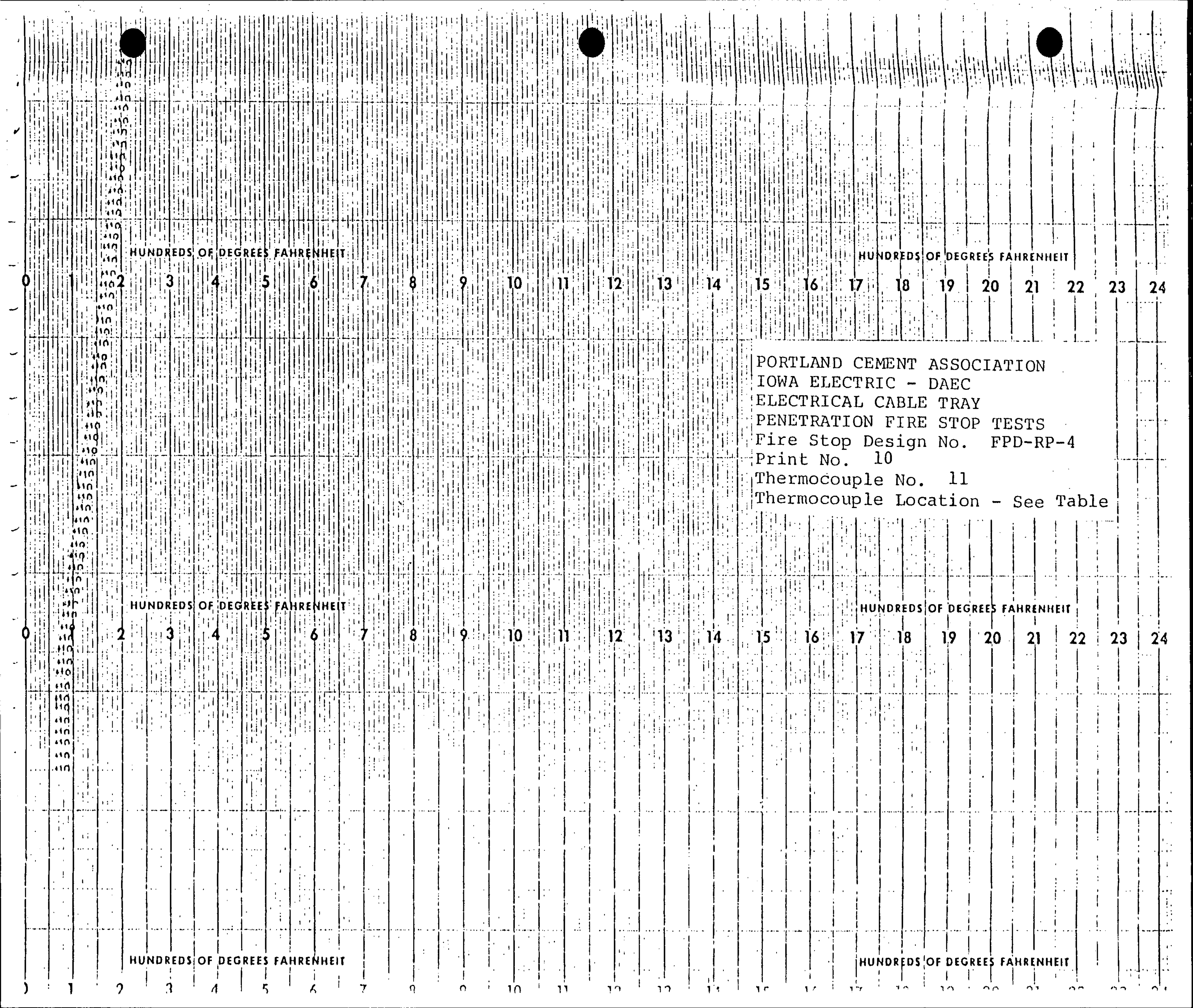
Print No. 8
Thermocouple No. 9
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-4
Print No. 9
Thermocouple No. 10
Thermocouple Location - See Table


HUNDREDS OF DEGREES FAHRENHEIT
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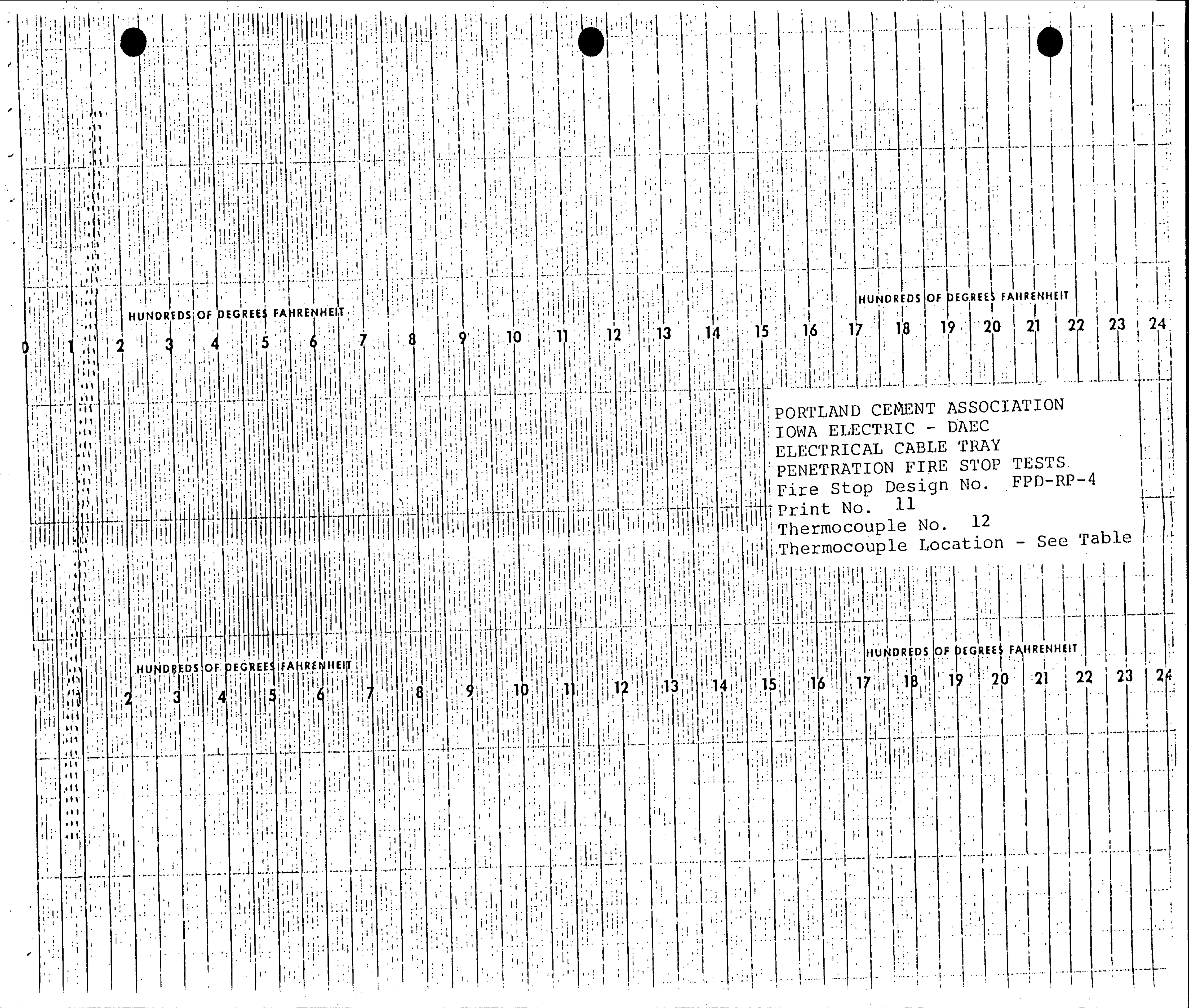
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-4
Print No. 10
Thermocouple No. 11
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-4
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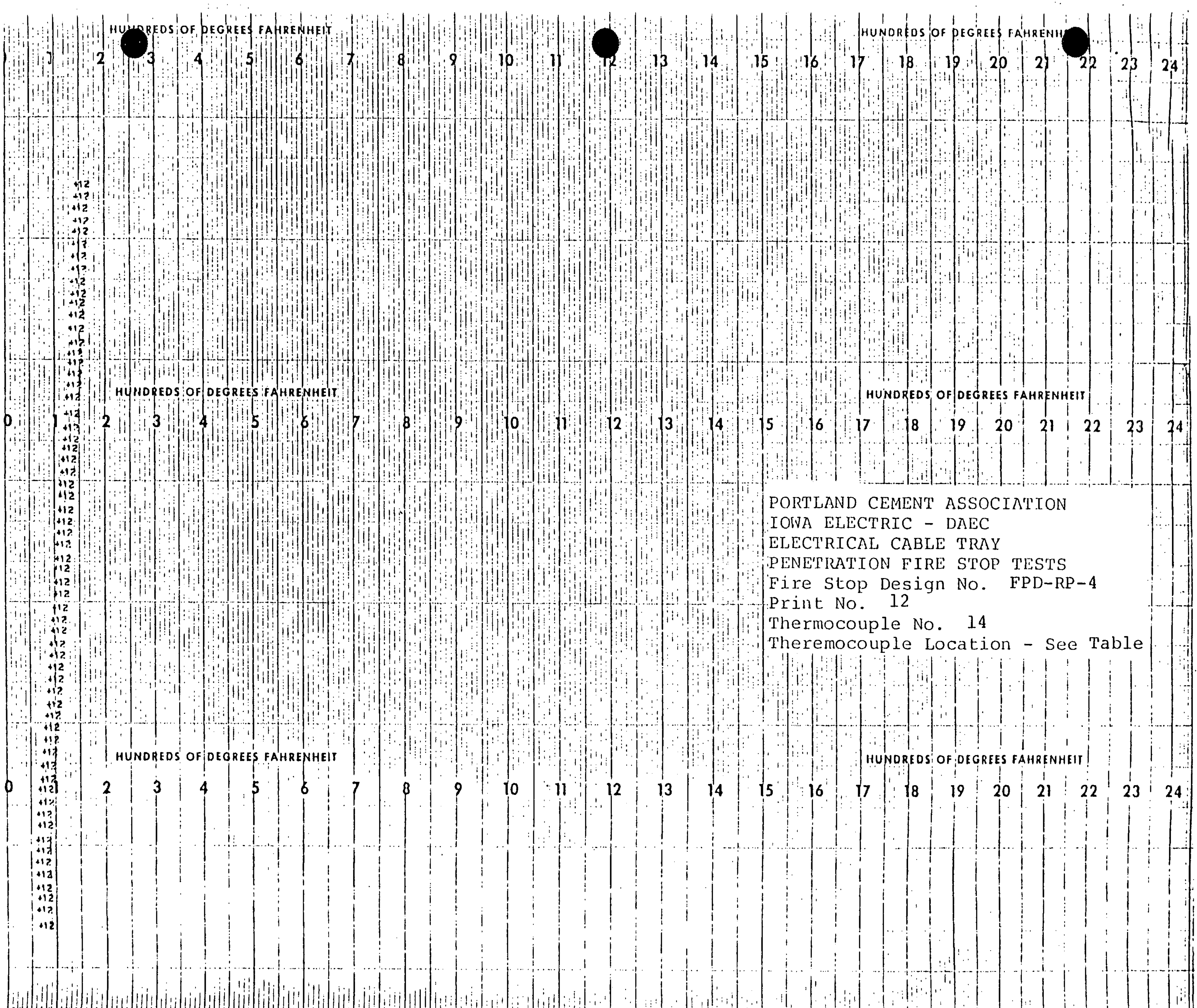
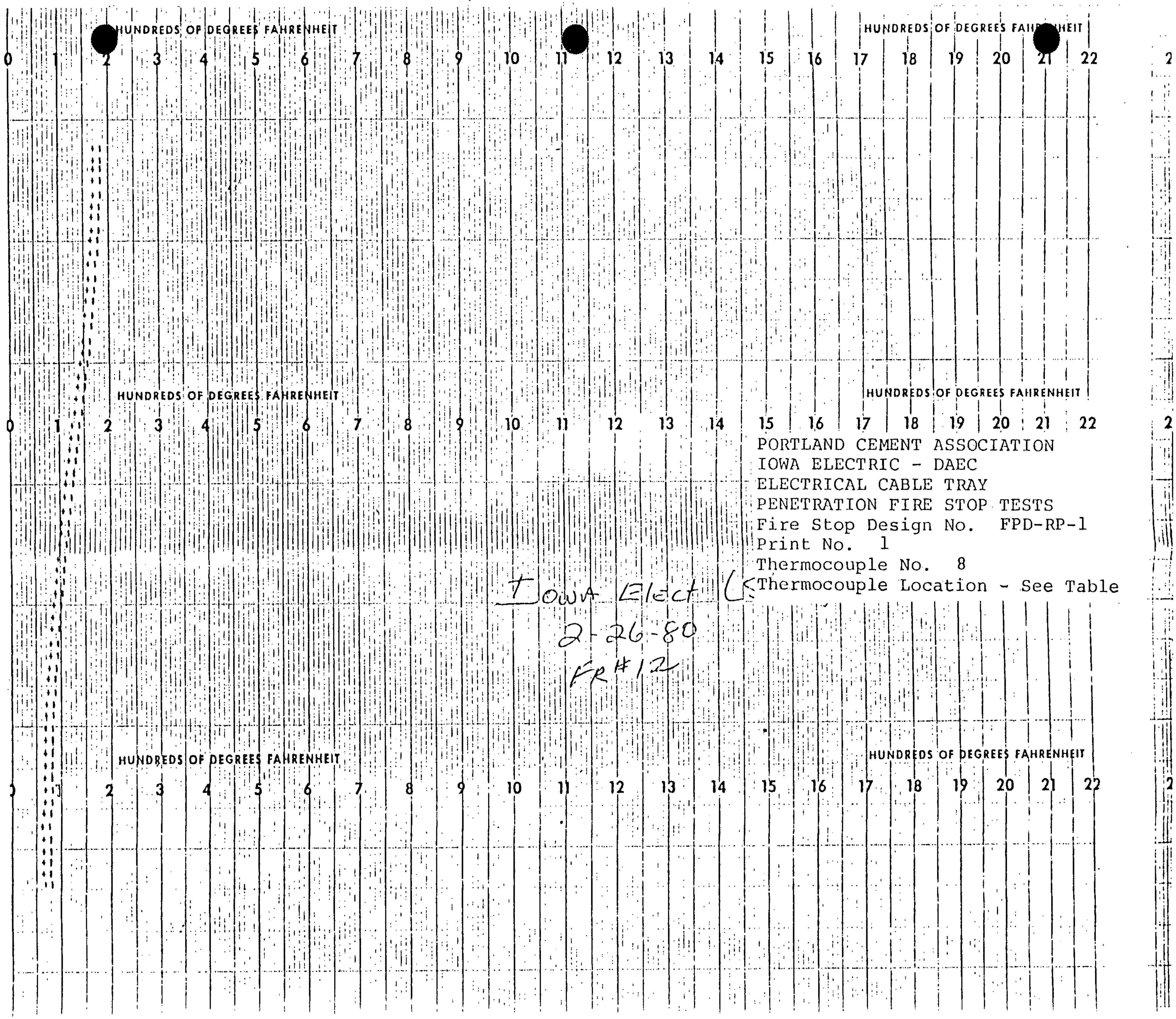
Thermocouple No. 12
Thermocouple Location - See Table

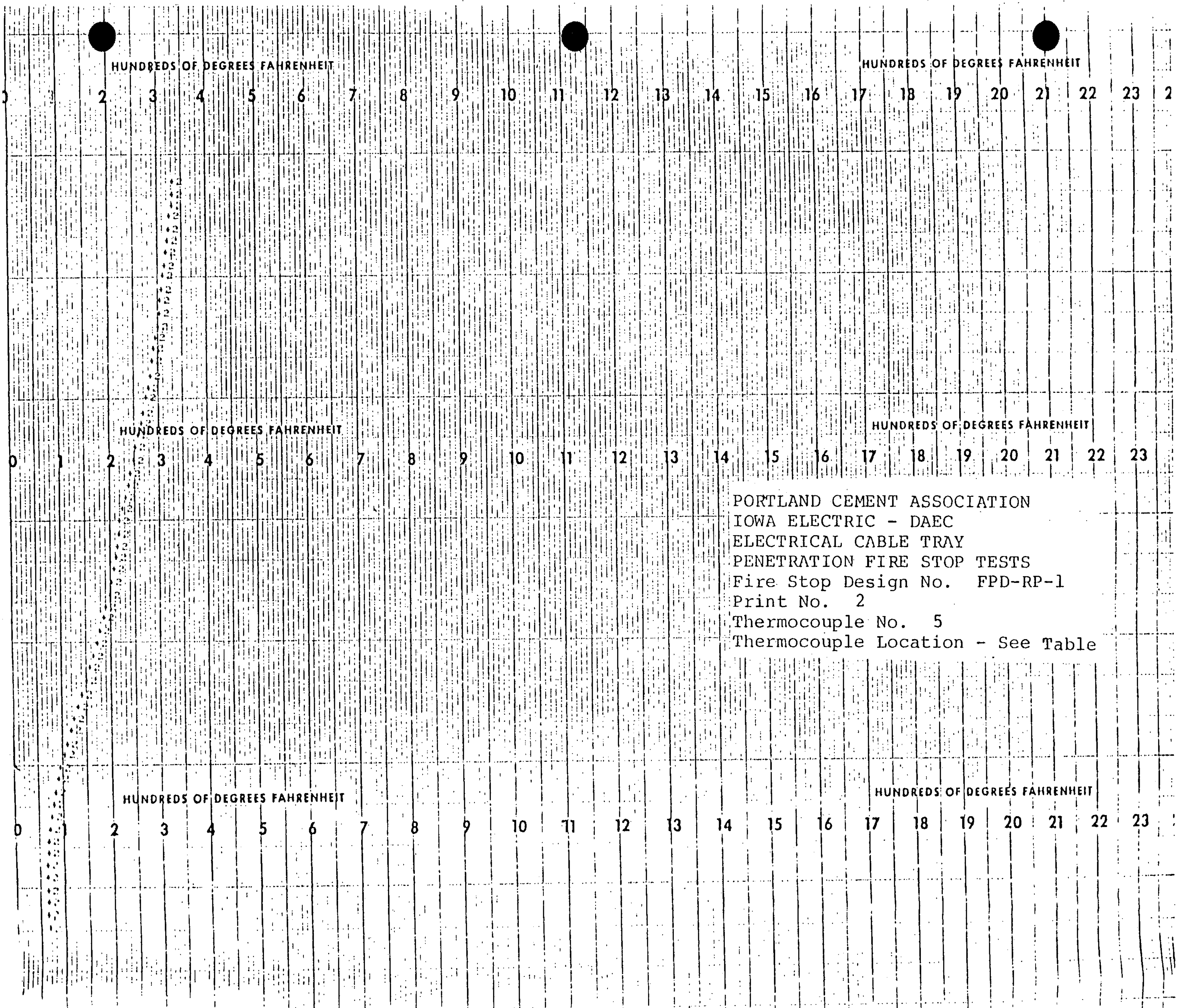


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-4
Print No. 12
Thermocouple No. 14
Theremocouple Location - See Table

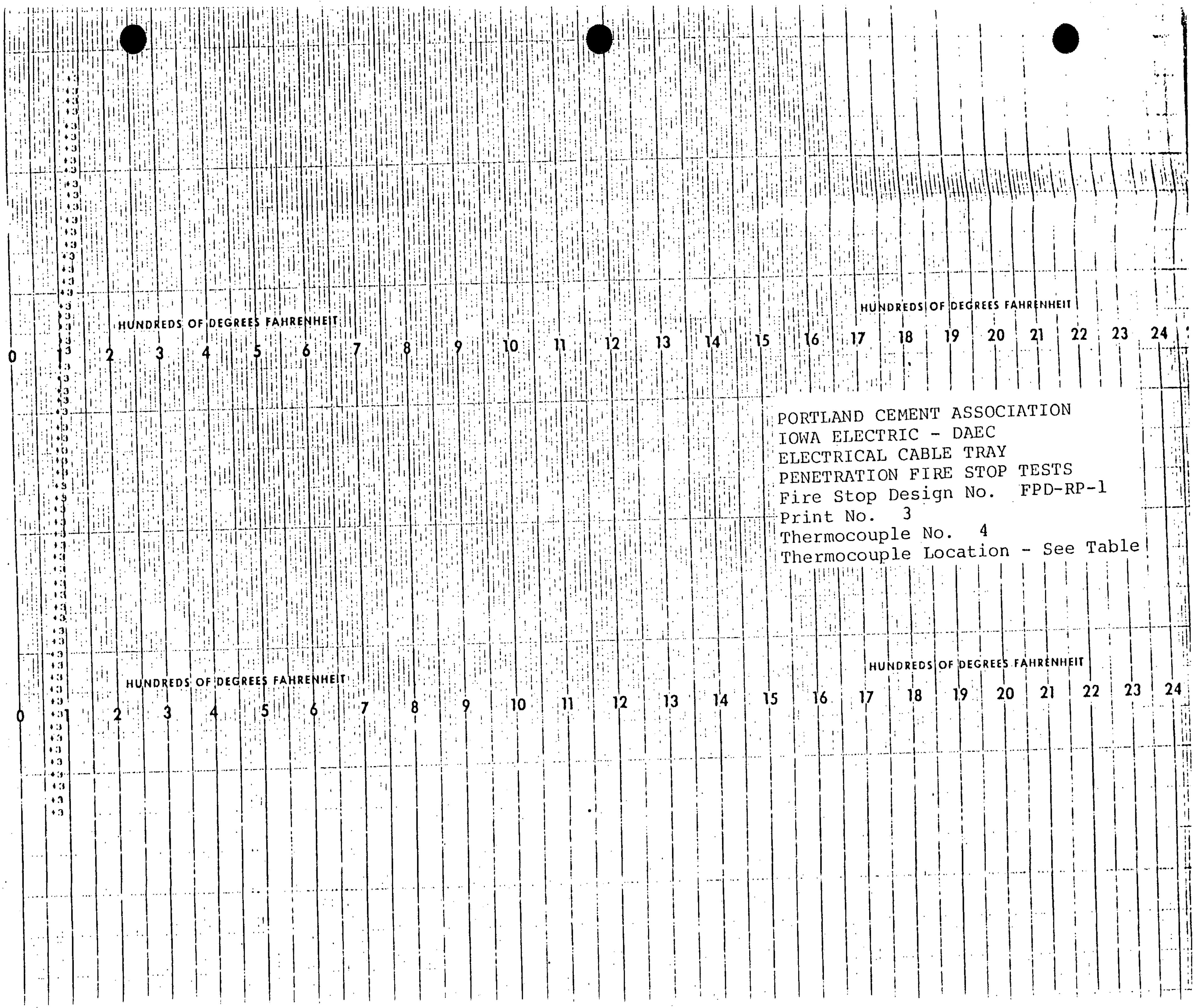


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-1
Print No. 1
Thermocouple No. 8
Thermocouple Location - See Table

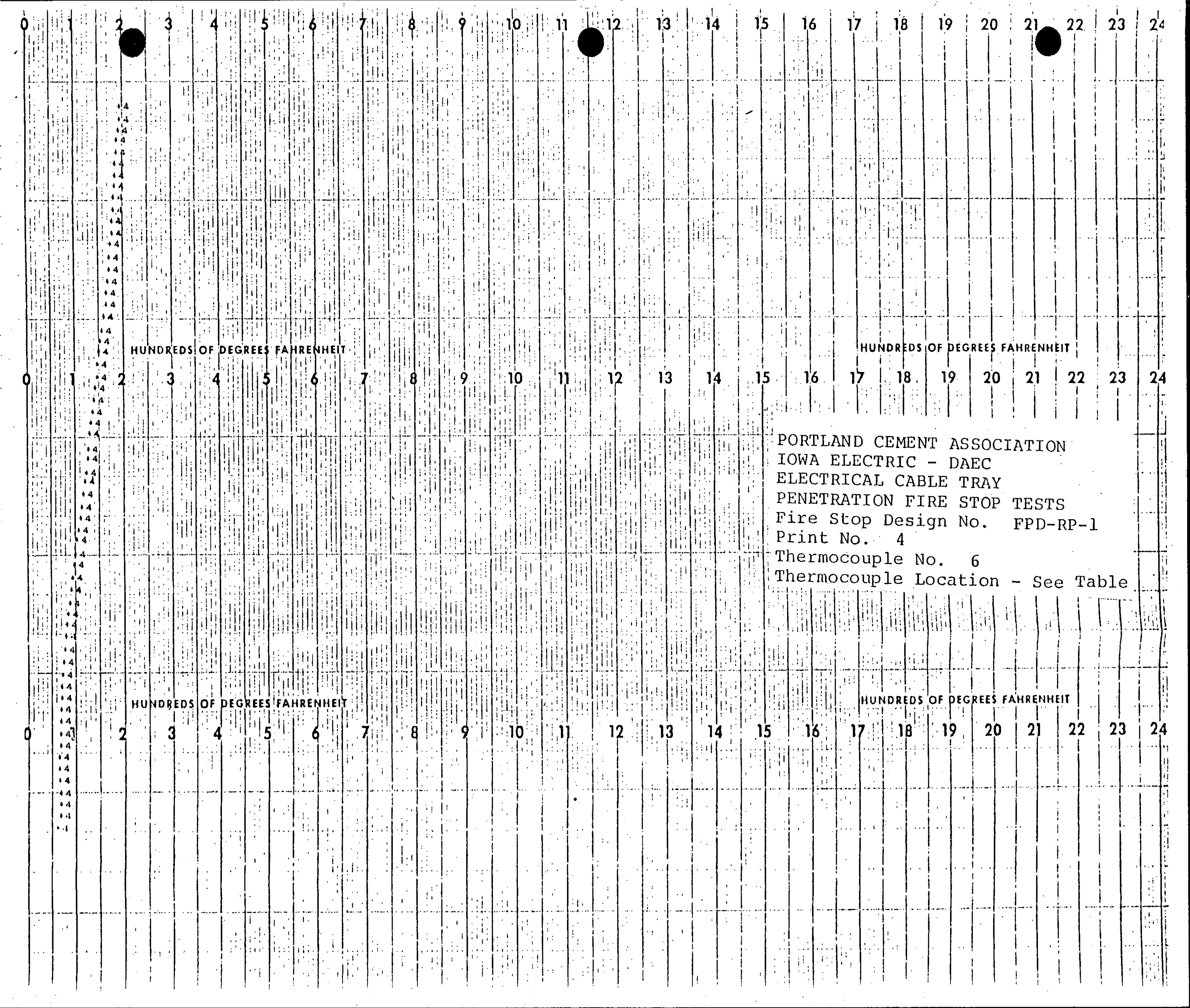
Iowa Elect Co
2-26-80
FR#12



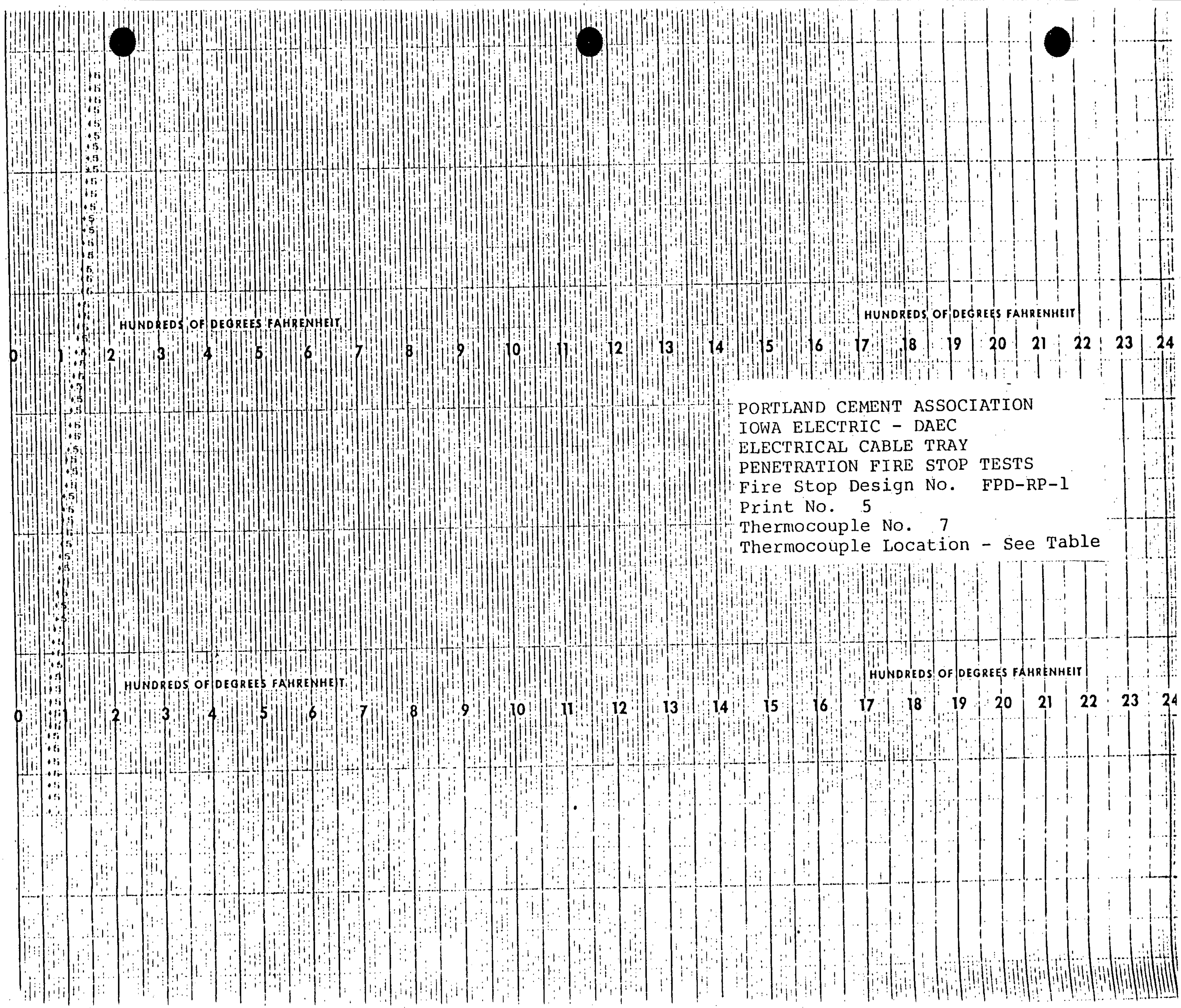
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-1
Print No. 2
Thermocouple No. 5
Thermocouple Location - See Table



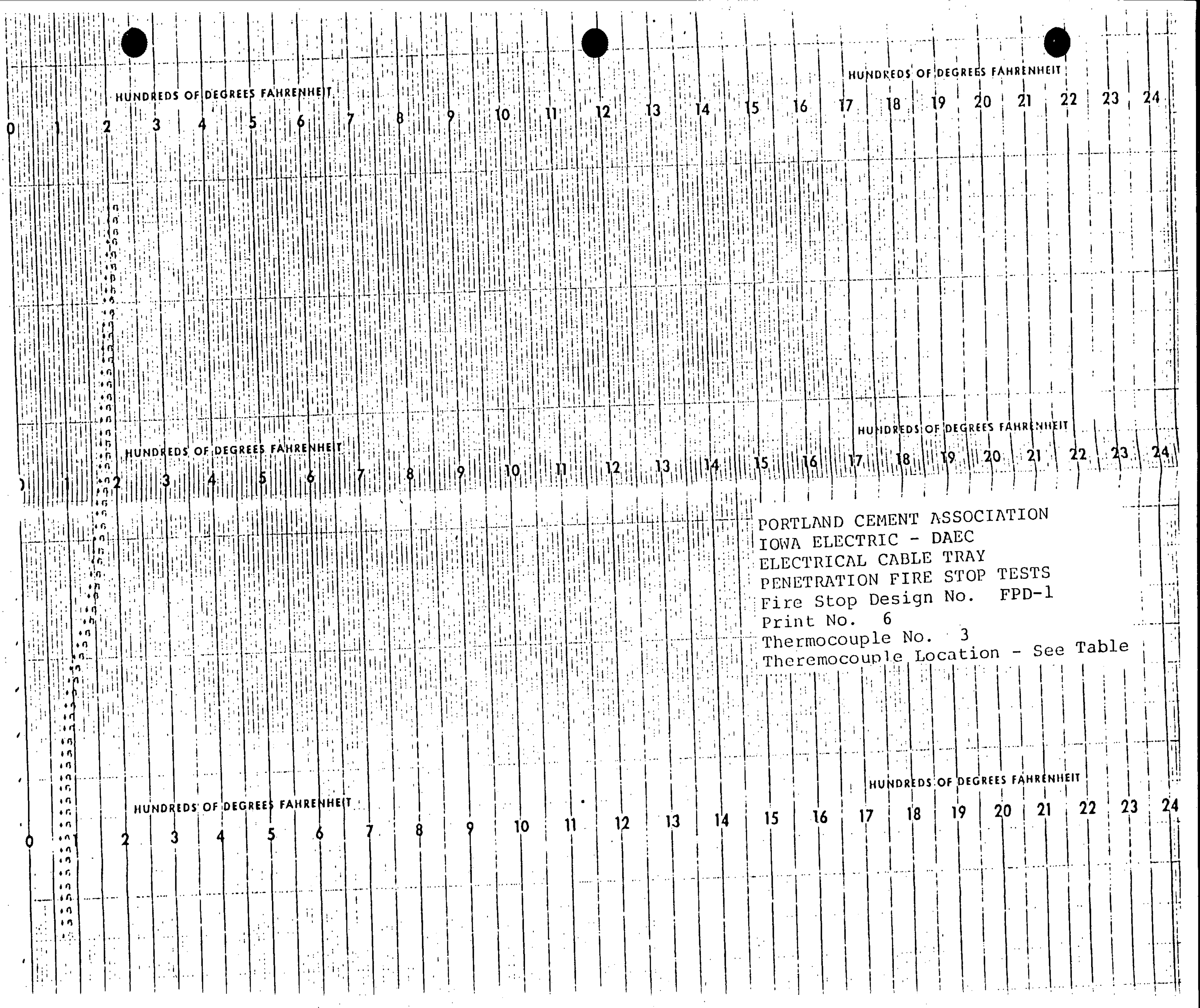
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-1
Print No. 3
Thermocouple No. 4
Thermocouple Location - See Table



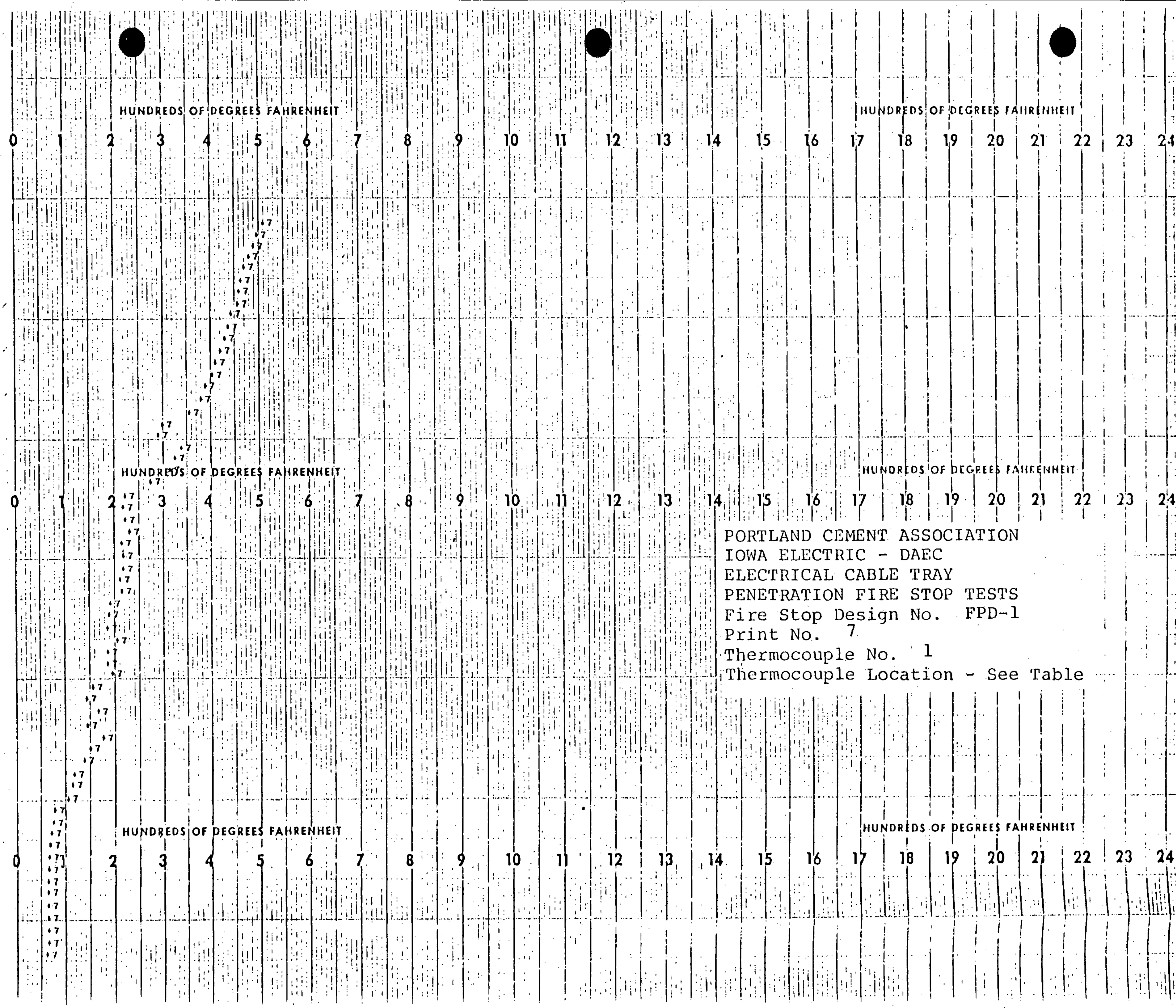
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-1
Print No. 4
Thermocouple No. 6
Thermocouple Location - See Table



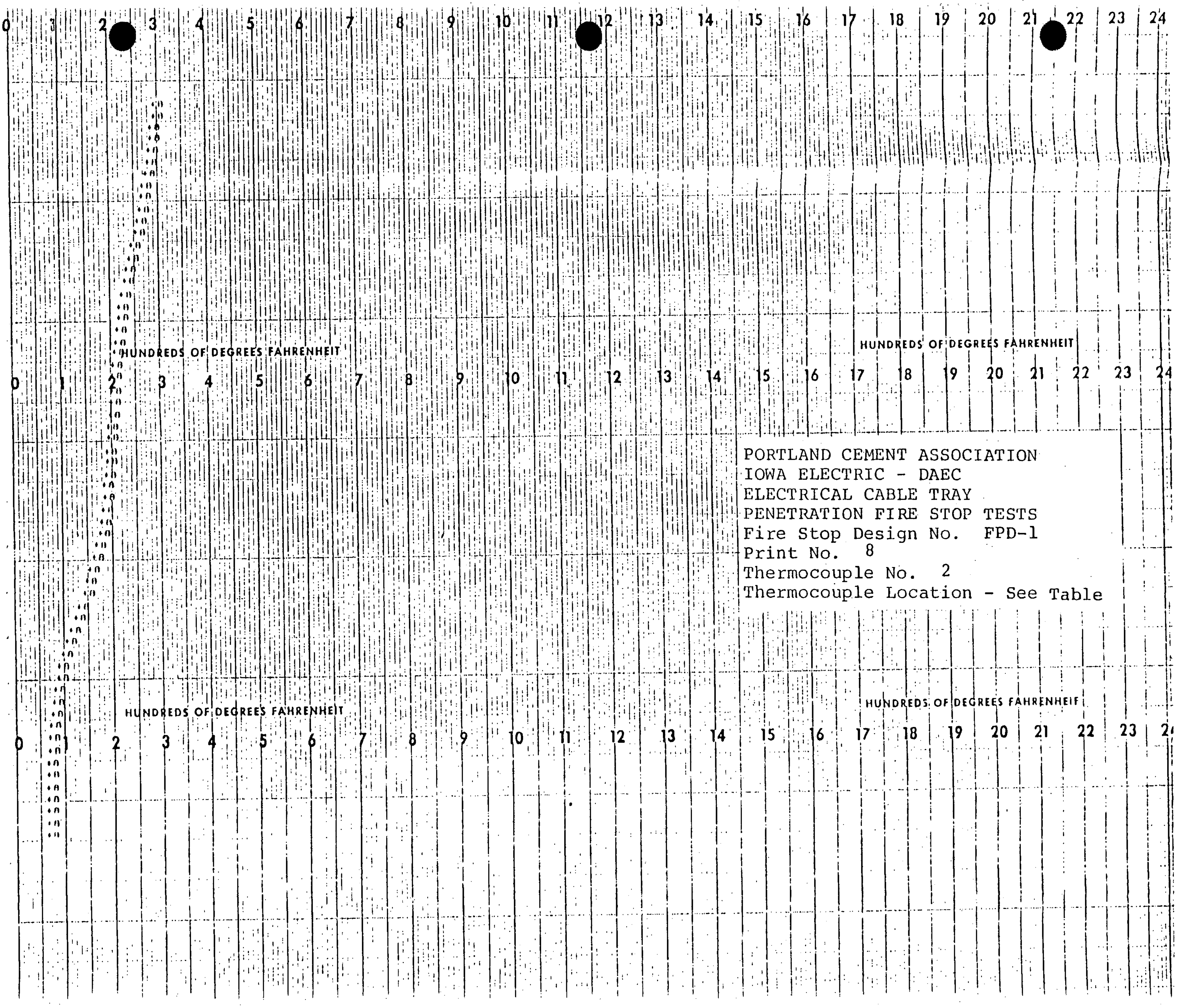
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-1
Print No. 5
Thermocouple No. 7
Thermocouple Location - See Table



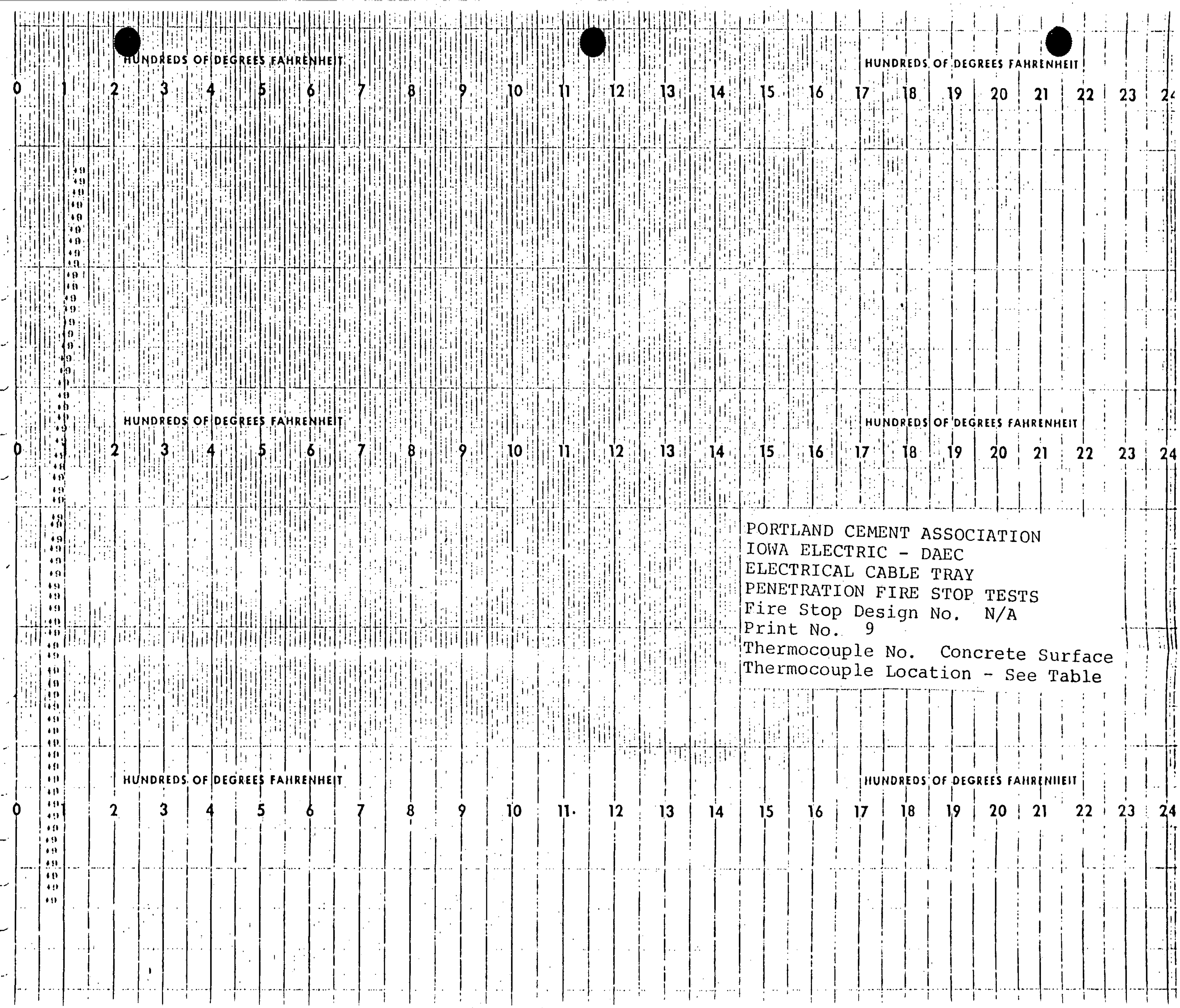
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-1
Print No. 6
Thermocouple No. 3
Theremocouple Location - See Table



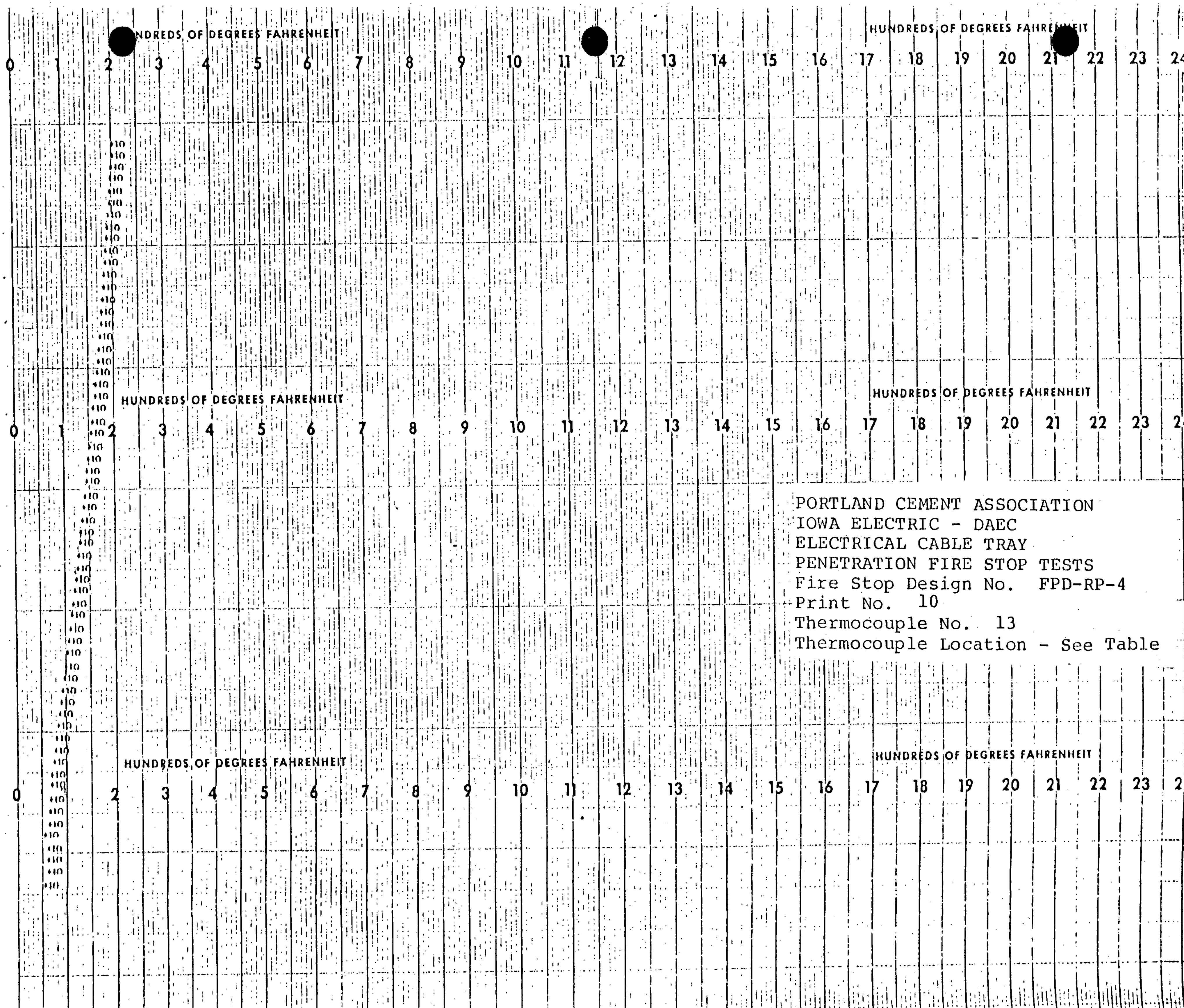
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-1
Print No. 7
Thermocouple No. 1
Thermocouple Location - See Table



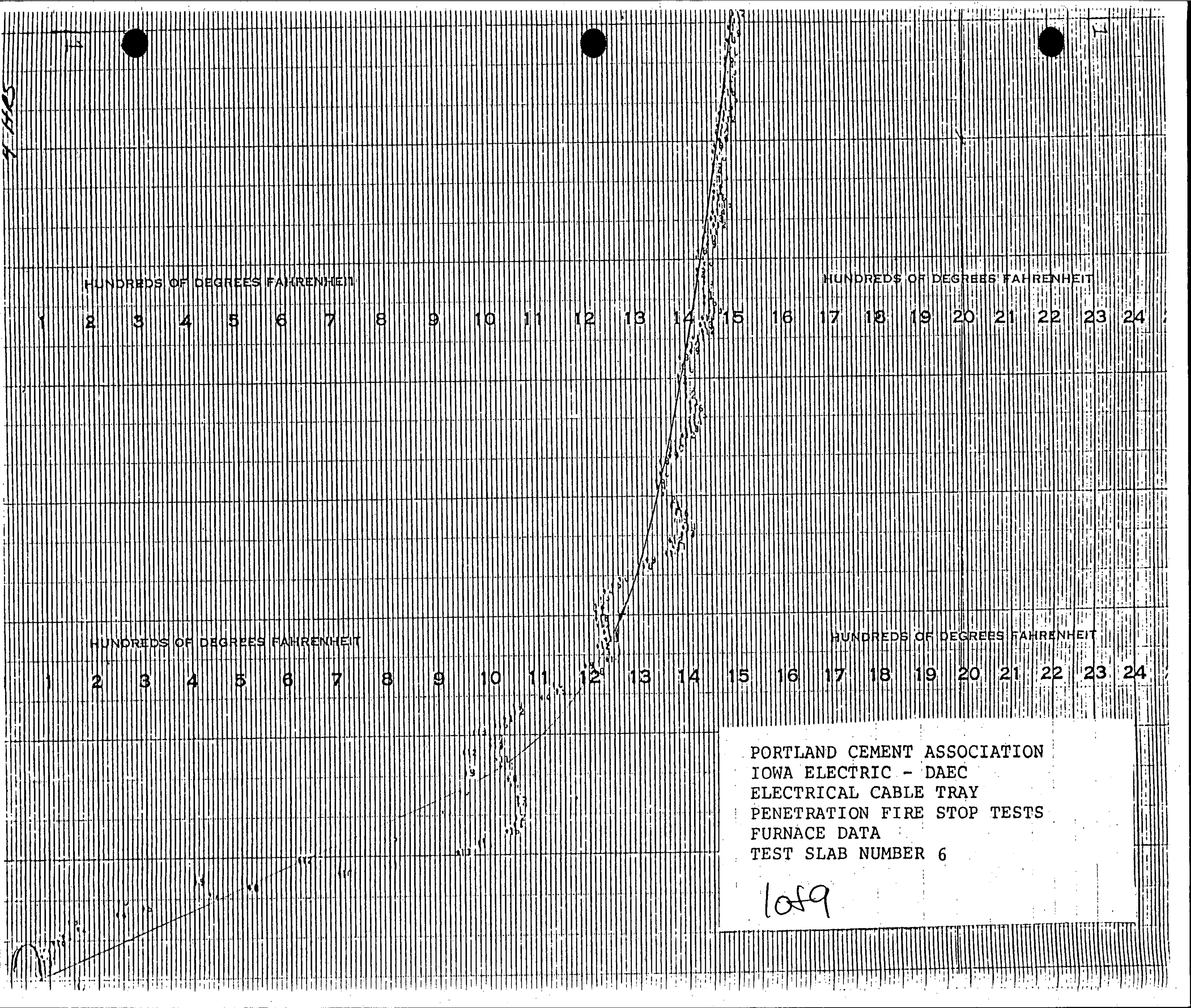
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-1
Print No. 8
Thermocouple No. 2
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. N/A
Print No. 9
Thermocouple No. Concrete Surface
Thermocouple Location - See Table

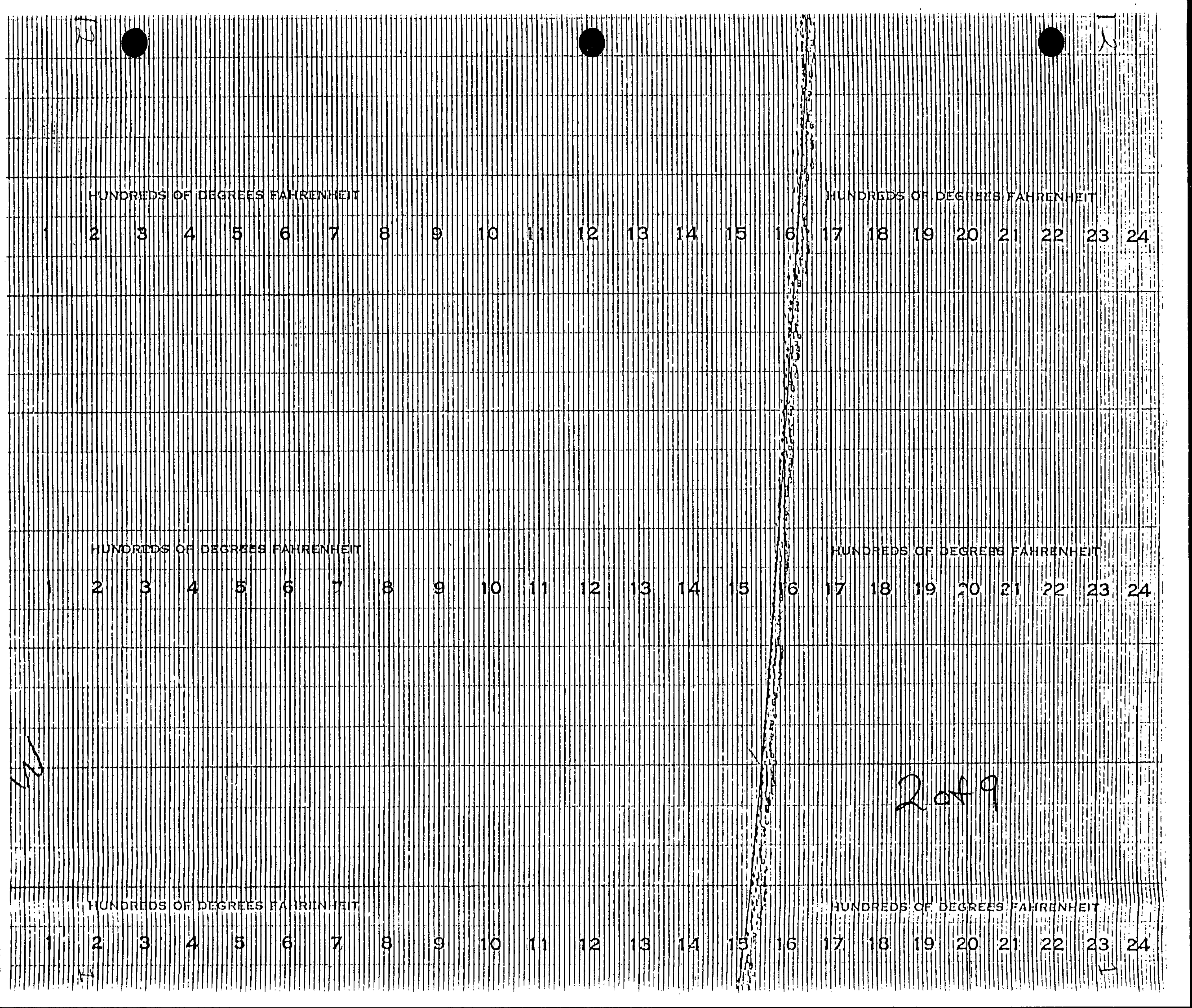


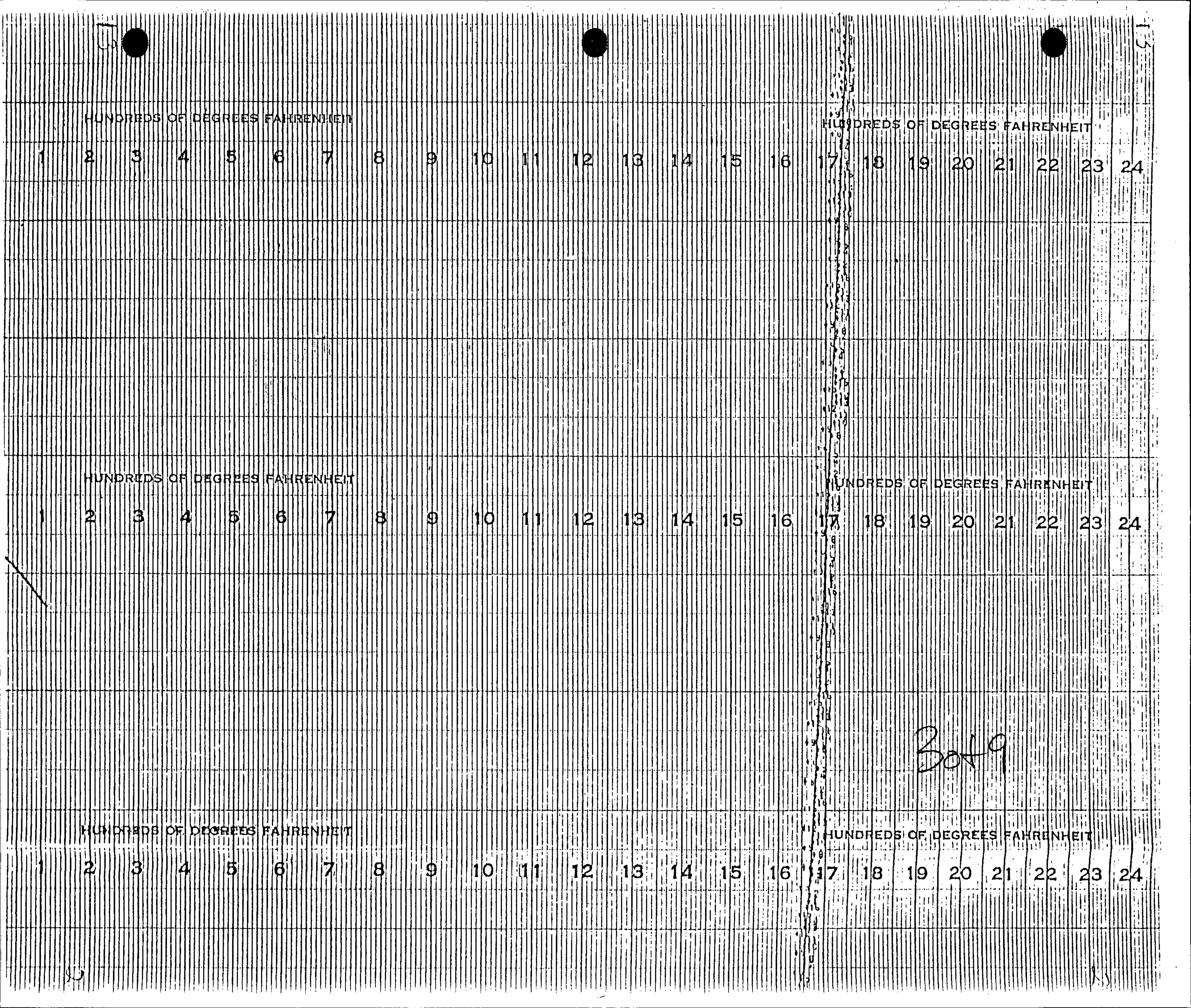
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-4
Print No. 10
Thermocouple No. 13
Thermocouple Location - See Table

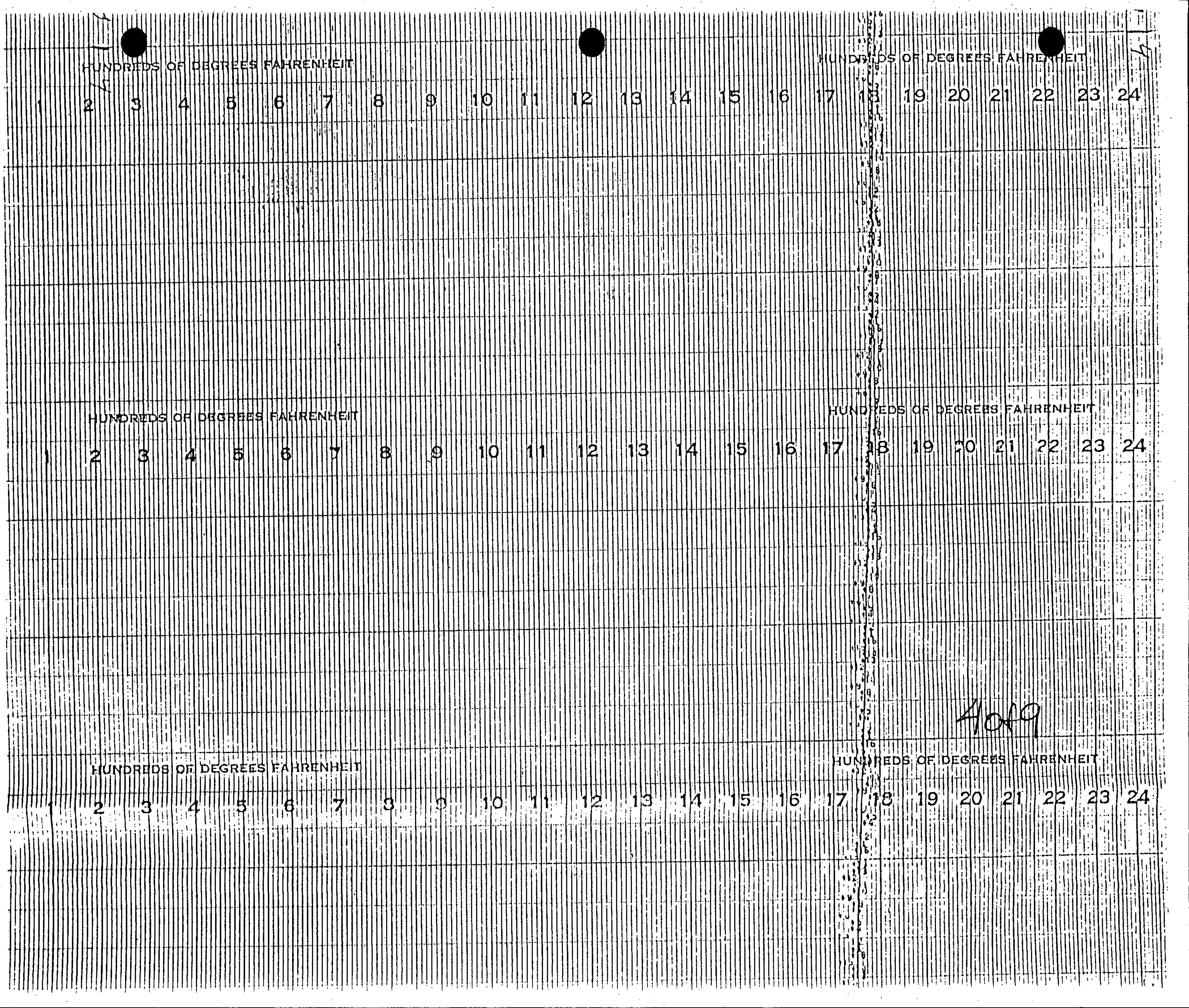


PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 6

1 of 9


HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
2 of 9


HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
3 of 9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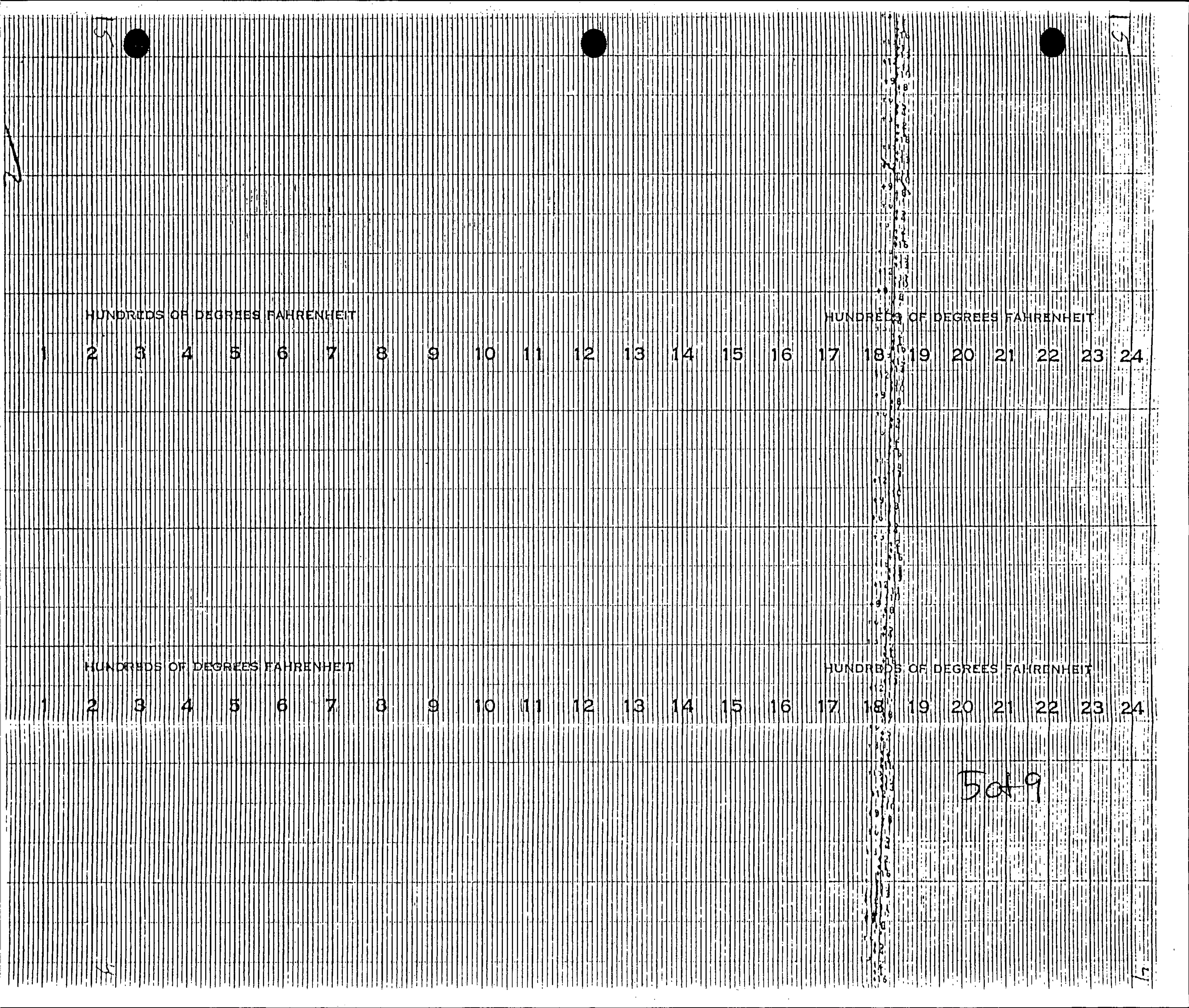
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
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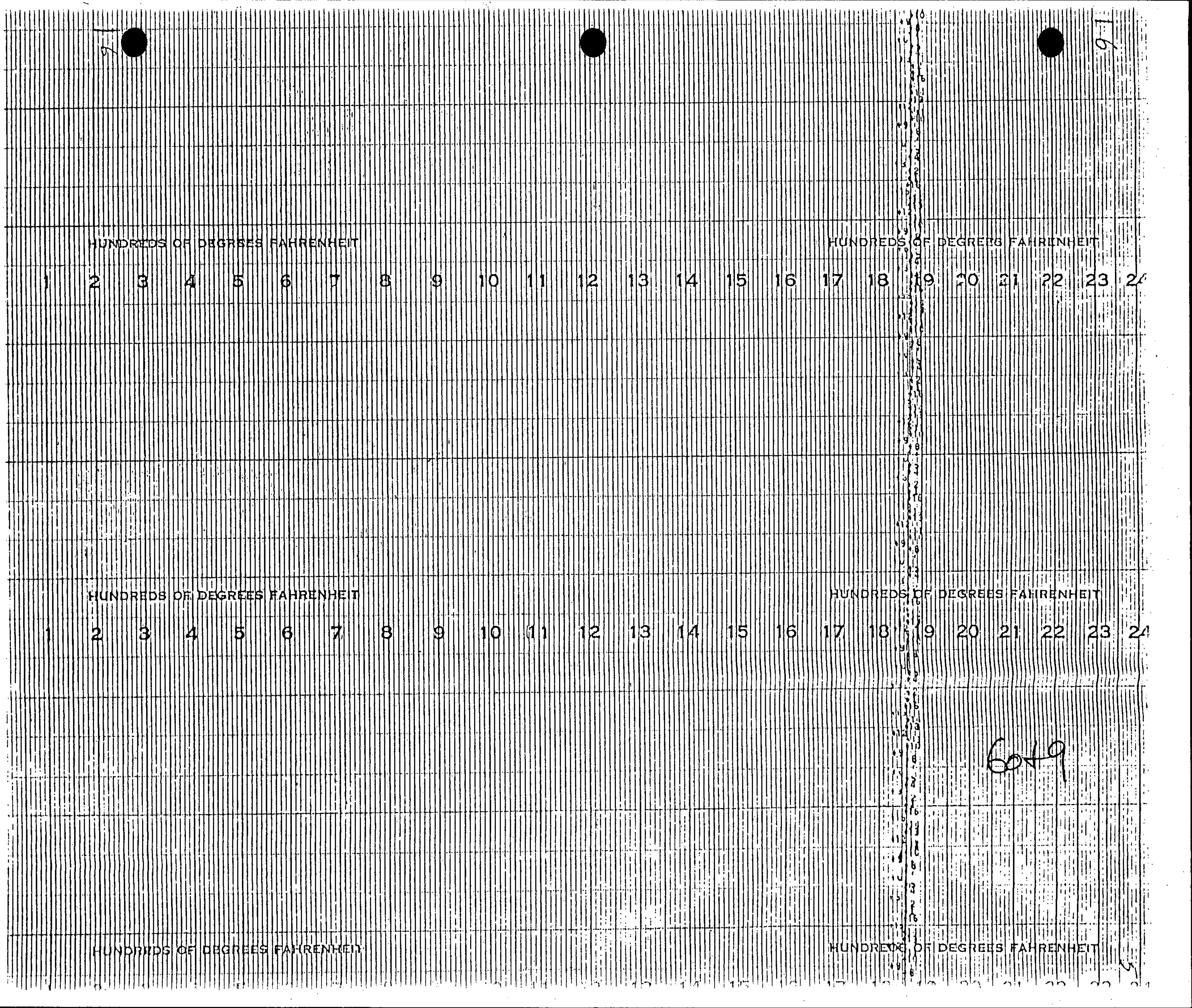
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
5 of 9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91
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
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HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
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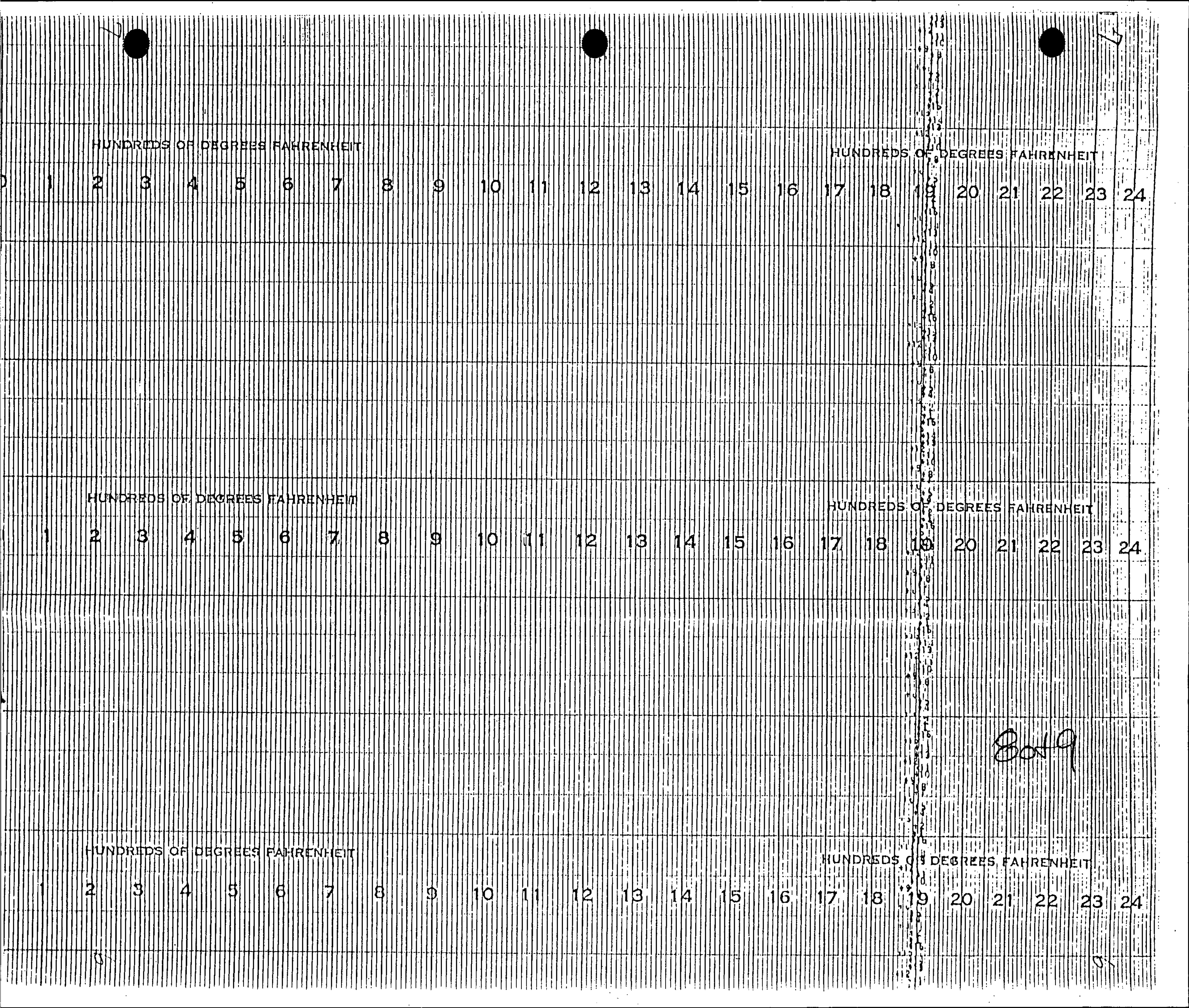
6049
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT


HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
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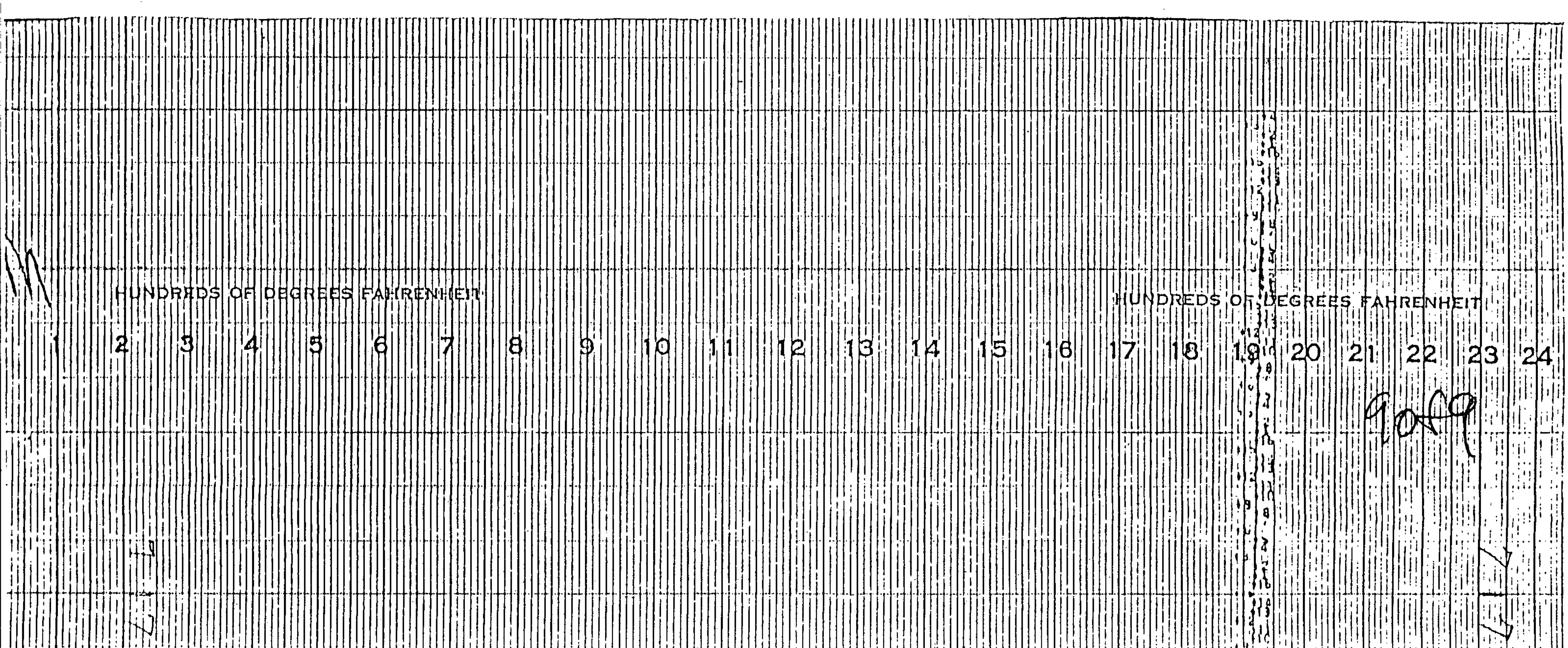
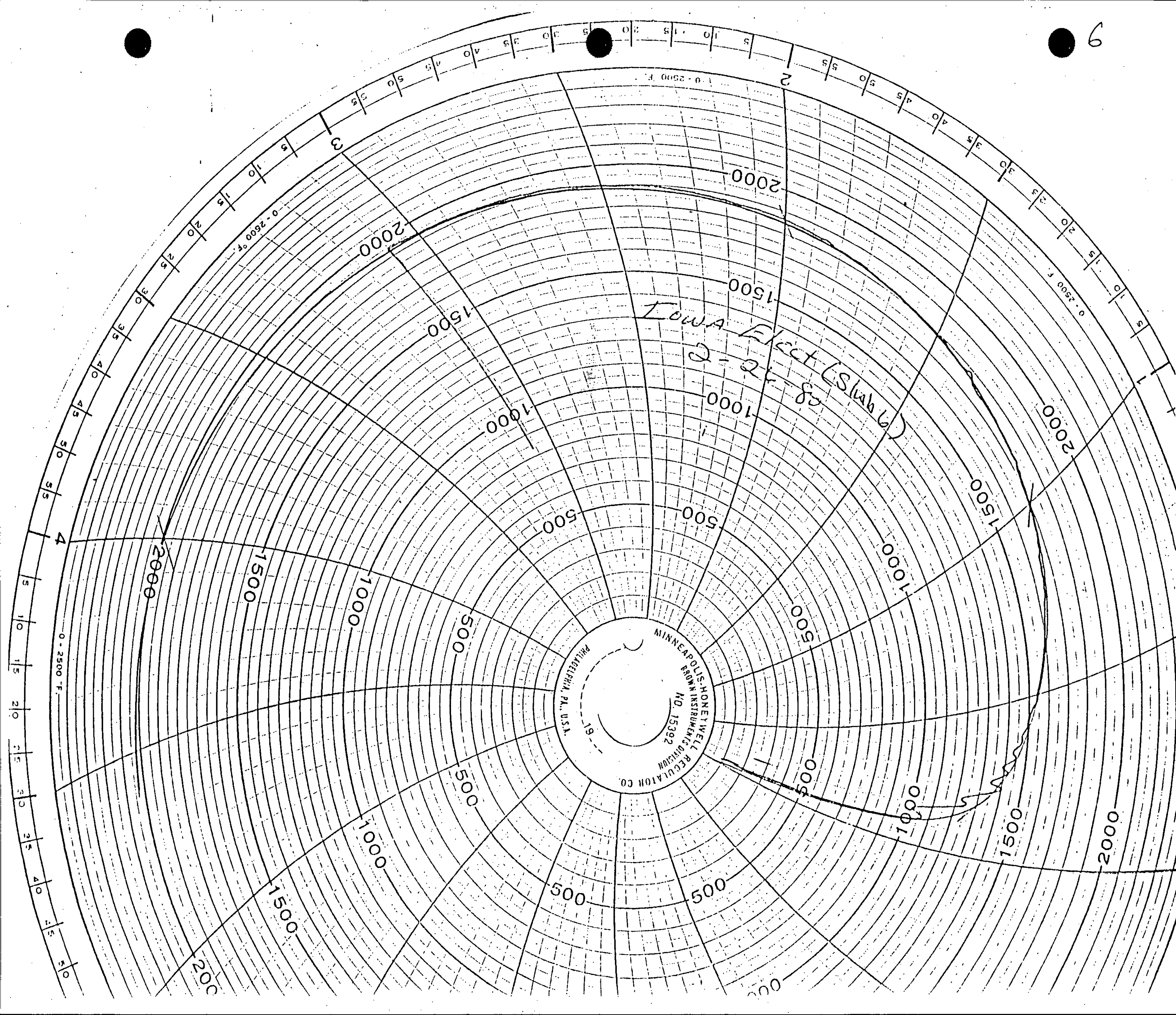
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
8 of 9
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
9 of 9

6


Iowa Elect (Slab 6)
2-24-83
MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA., U.S.A.
19
0 - 2500 °F.
500
1000
1500
2000

TEST SLAB NUMBER 7

DATE: 03/11/80

FIRE STOP DESIGNS TESTED: WPD-6
WPD-7
WPD-8
WPD-9
FPD-RP-2

CONTENTS:

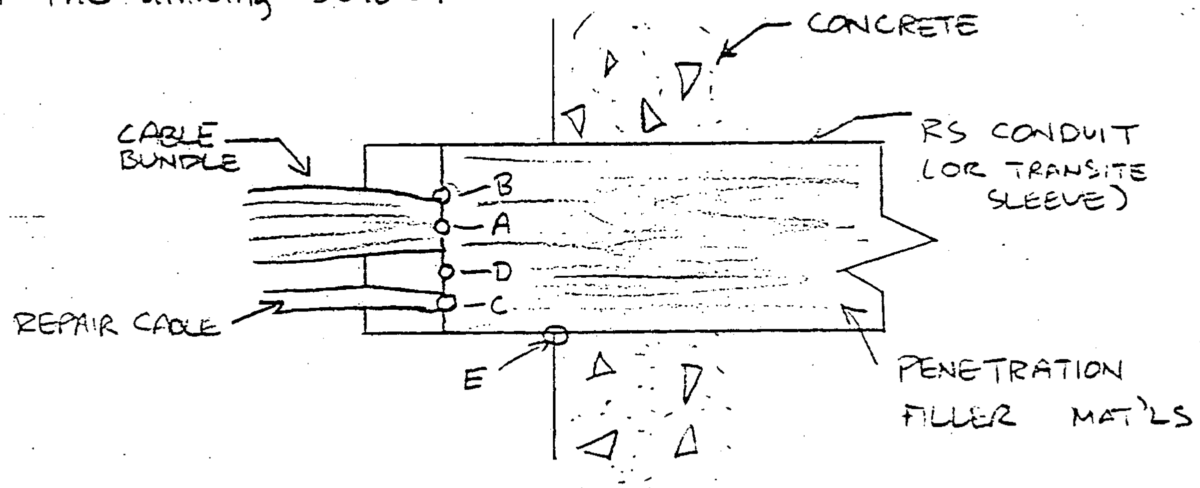
- THERMOCOUPLE LOCATIONS
- TEST PLOTS
- PLOT OF FURNACE ATMOSPHERE TEMPERATURE

Test Witnessed by:

M. Gillen, PCA

R. H. Hollenbacher, EDS

Thermocouples were installed in each penetration at a maximum of five locations: at Ⓐ in the interior of the cable bundle; at Ⓑ on the surface of the cable bundle; at Ⓒ on the repair cable; at Ⓓ on the unexposed surface of the penetration filler materials; and at Ⓔ on the conduit/concrete interface on the unexposed surface, as shown in the drawing below:



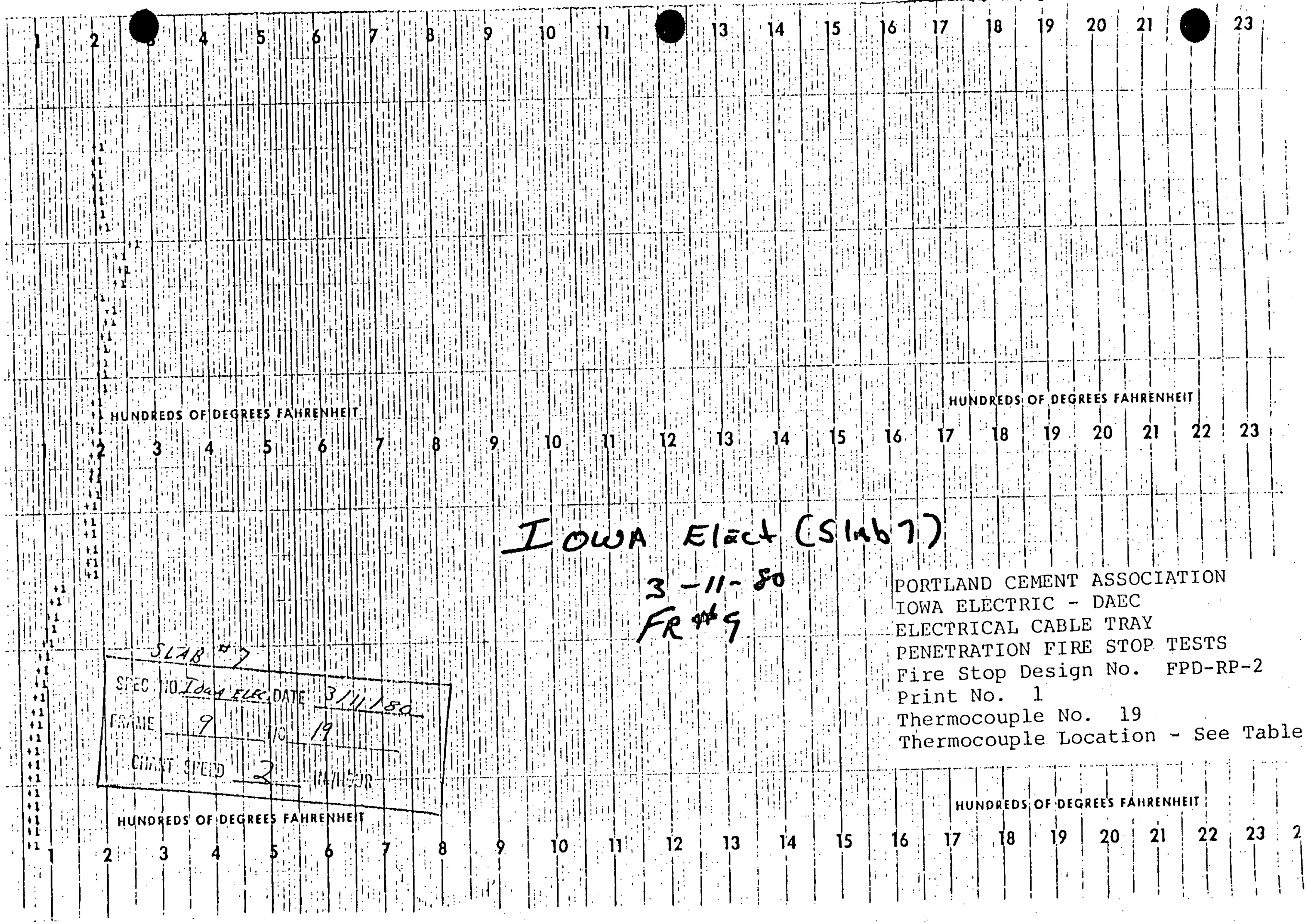
PENETRATION NUMBER	THERMOCOUPLE NO. AT LOCATION Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
S3	#19	#20	#21	#22	—
C13X	# 7	# 8	—	—	# 9
C18	#16	#17	—	—	#18
C25	# 1	# 2	—	—	# 3
C26	#10	# 11	—	—	# 12
C27	#26	#27	—	—	#28
C28	# 4	# 5	—	—	# 6
C29	# 13	# 14	—	—	# 15
C30	# 23	# 24	—	—	# 25

ON SURFACE OF CONCRETE: T/C # 29

THERMOCOUPLE LOCATIONS - TEST 7

SLAB 7

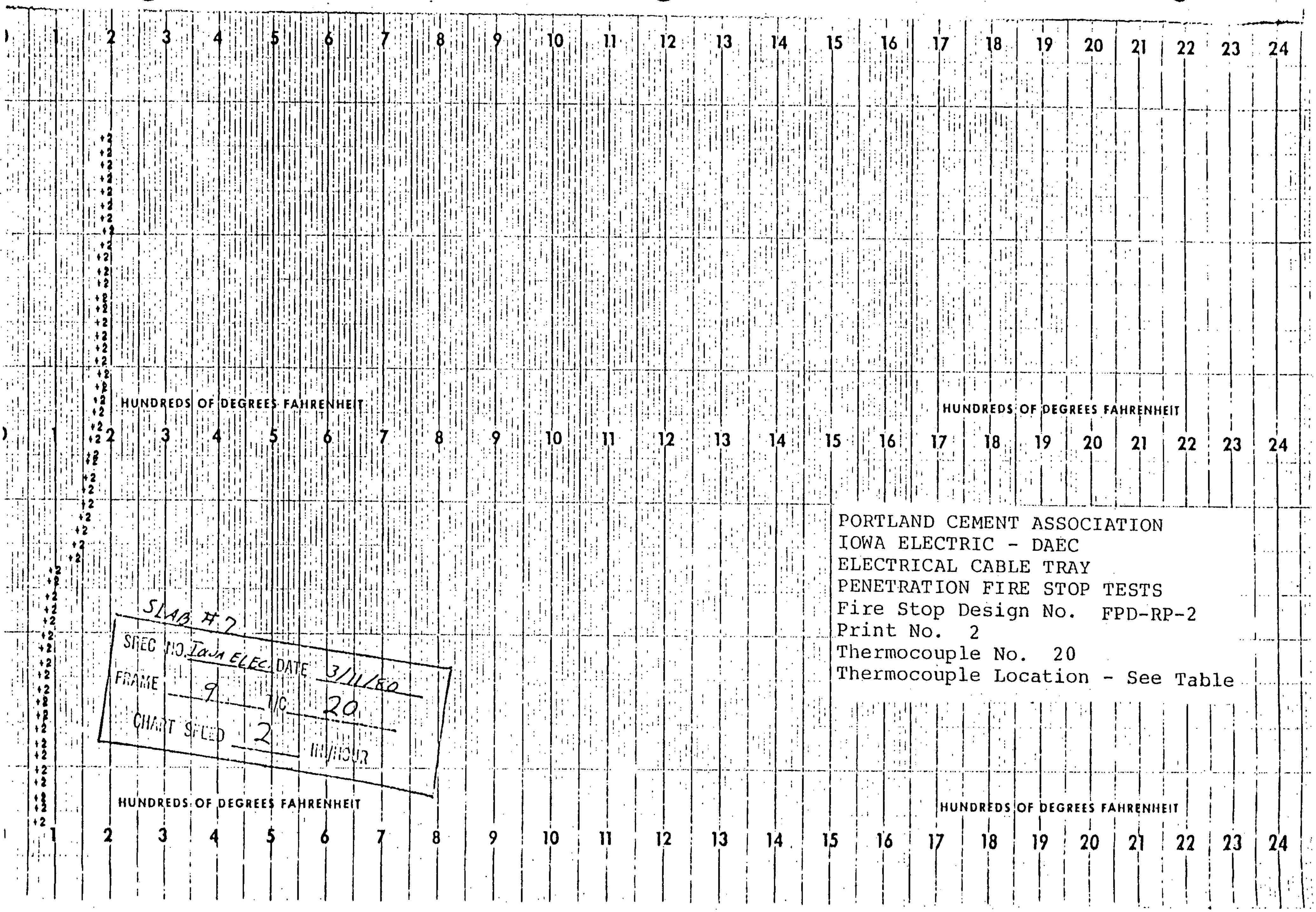
CONSTRUCTION DESIGN Nº	FIRE STOP DESIGN Nº
S3	FPD-RP-2
C13X	WPD-6
C18	WPD-18
C25	WPD-9
C26	WPD-9
C27	WPD-8
C28	WPD-6



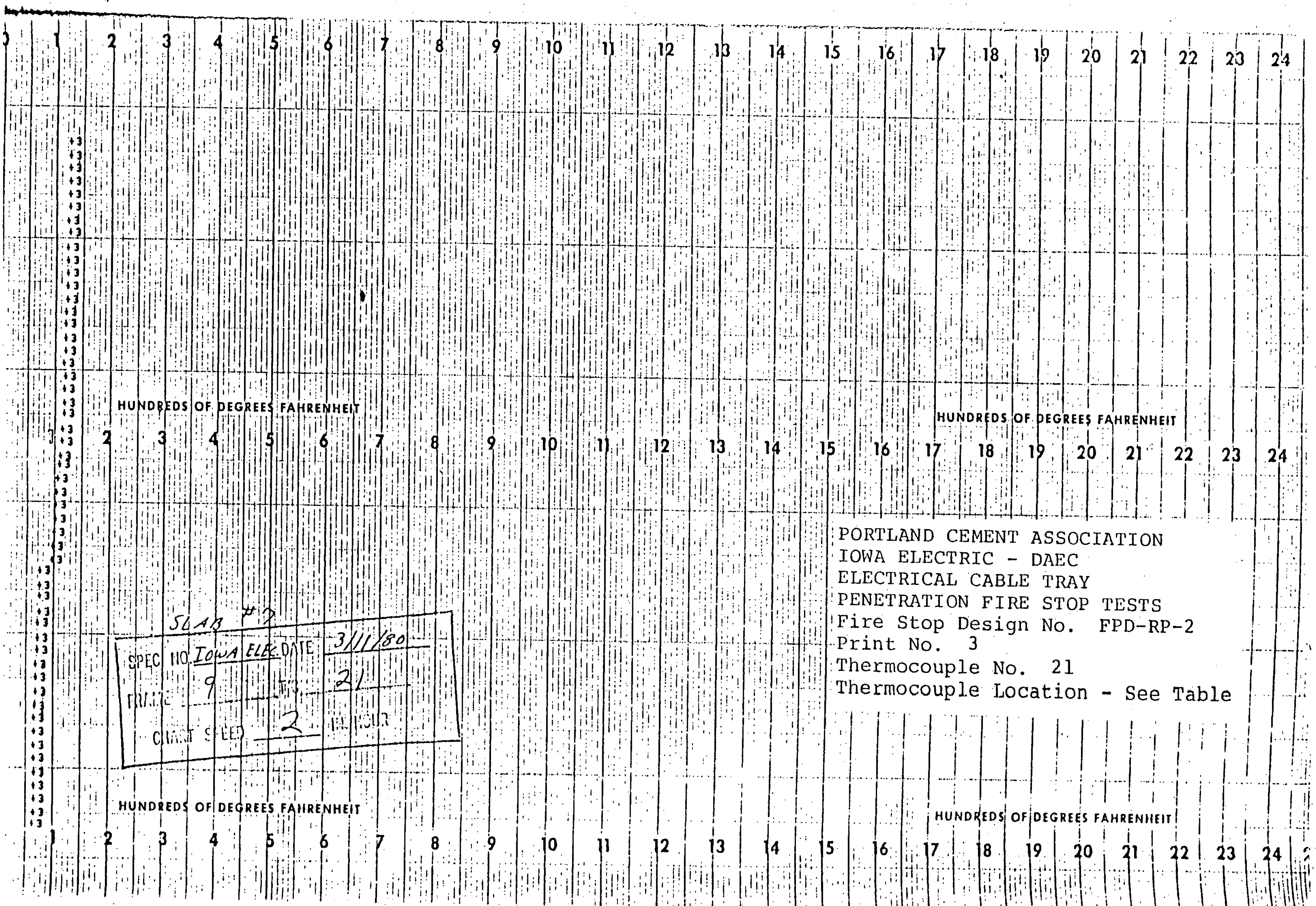
IOWA Elect (Slab 7)
3-11-80
FR #9

SLAB #7
SPEC NO Iowa Elec DATE 3/11/80
FRAME 9 TO 19
CHART SPEED 2

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-2
Print No. 1
Thermocouple No. 19
Thermocouple Location - See Table



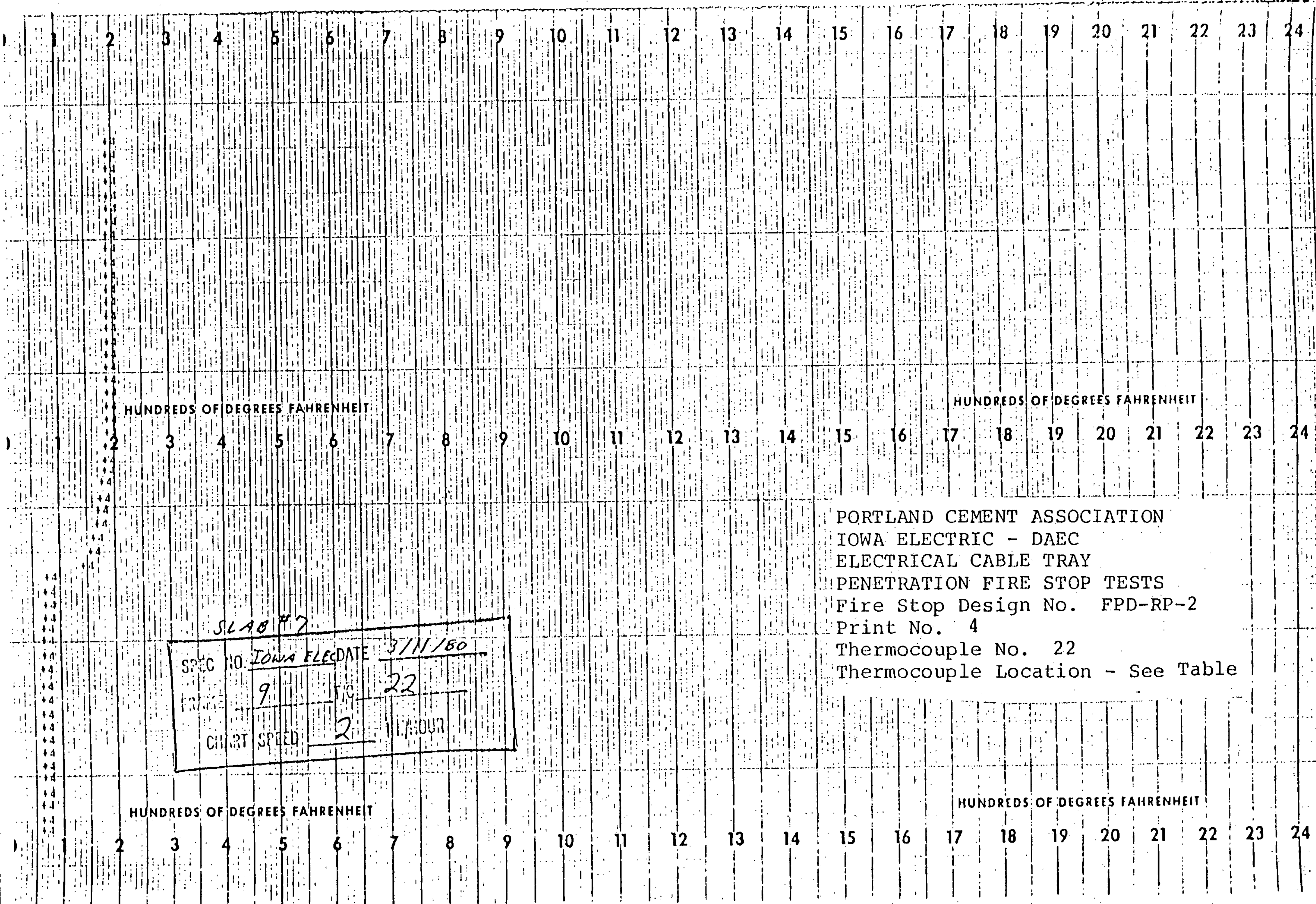
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-2
Print No. 2
Thermocouple No. 20
Thermocouple Location - See Table



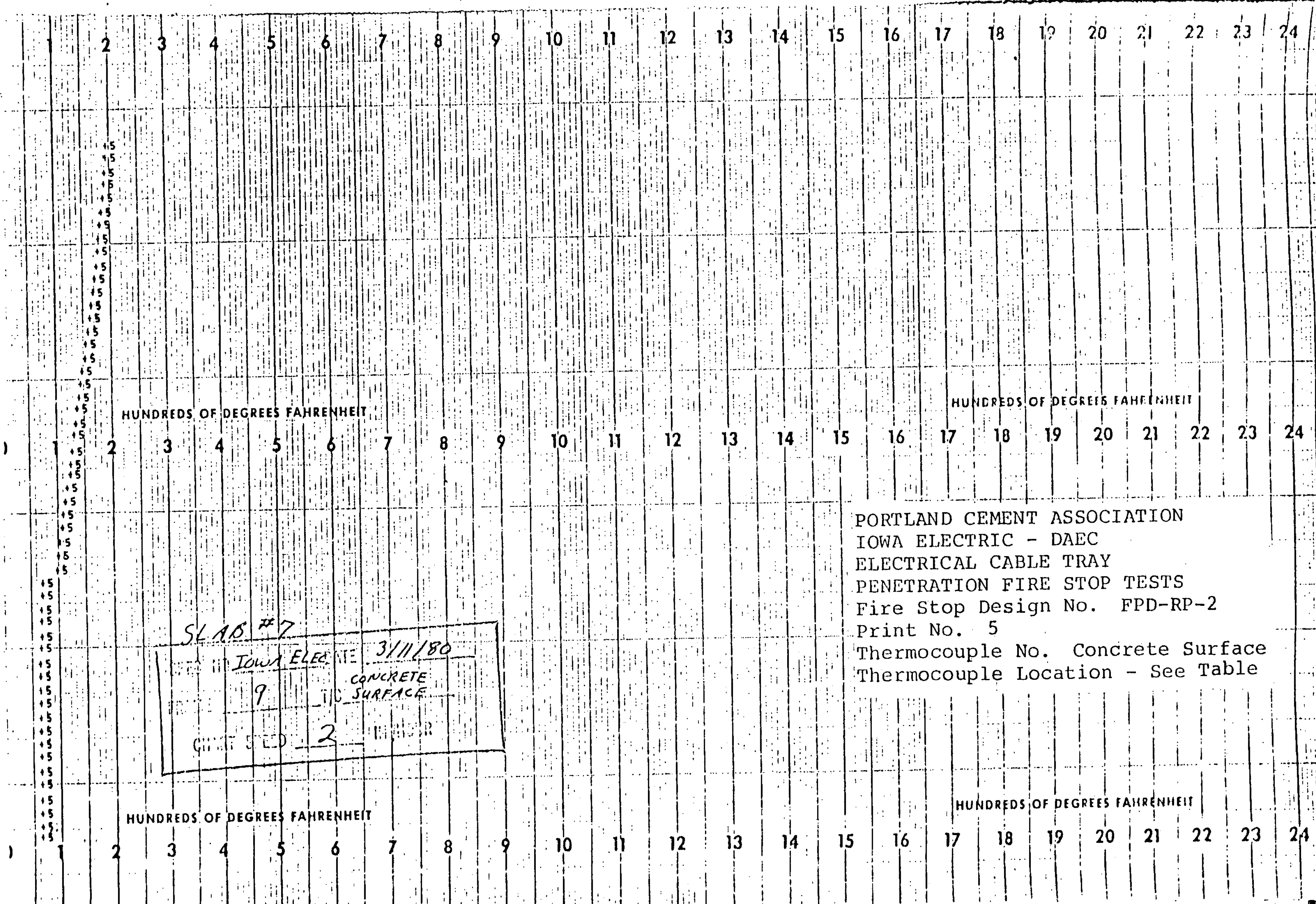
SLAB #2

SPEC NO. Iowa ELEC. DATE 3/11/80
FRAME 9 TO 21
CHART SPEED 2 IN/HOUR

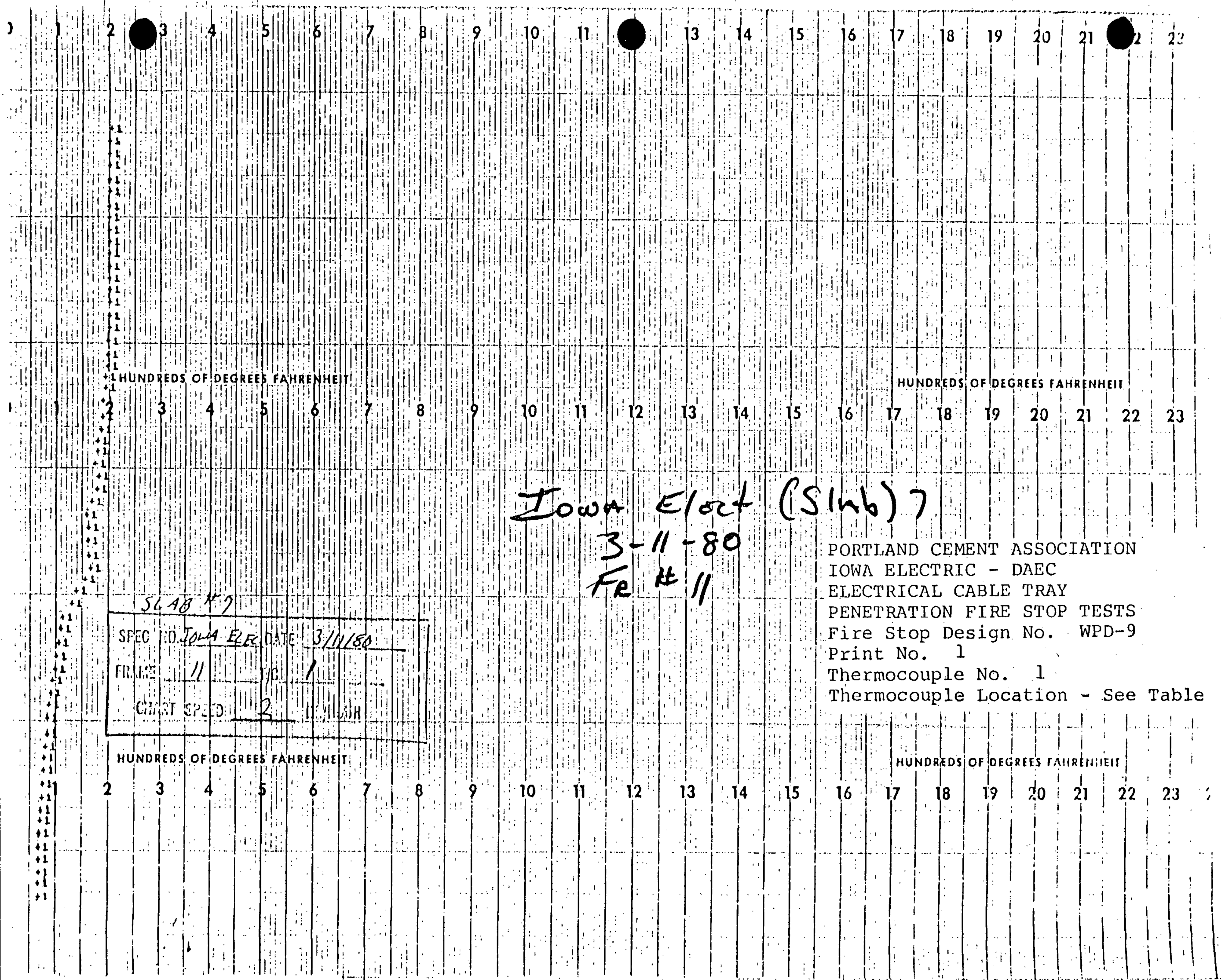
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-2
Print No. 3
Thermocouple No. 21
Thermocouple Location - See Table



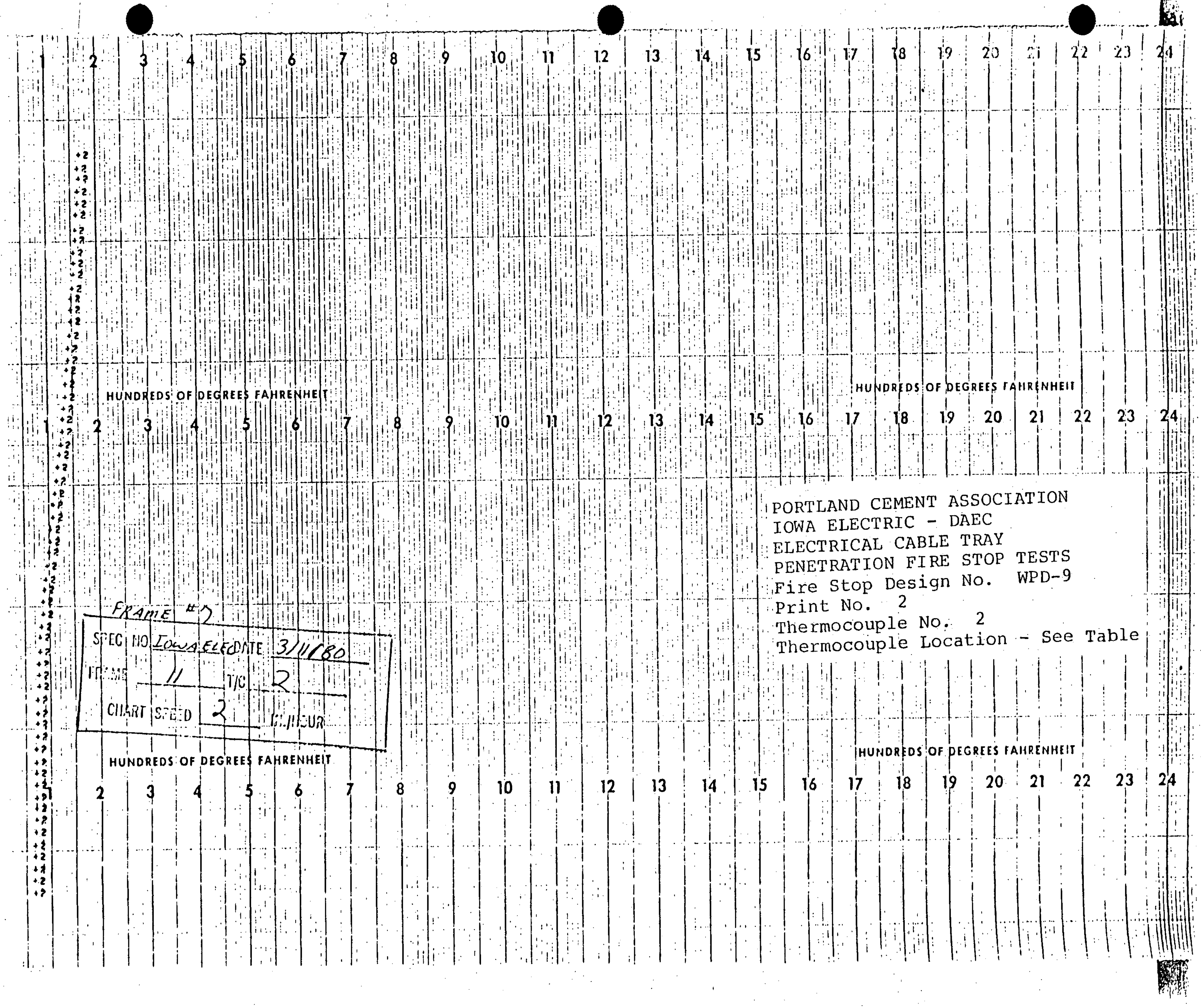
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-2
Print No. 4
Thermocouple No. 22
Thermocouple Location - See Table



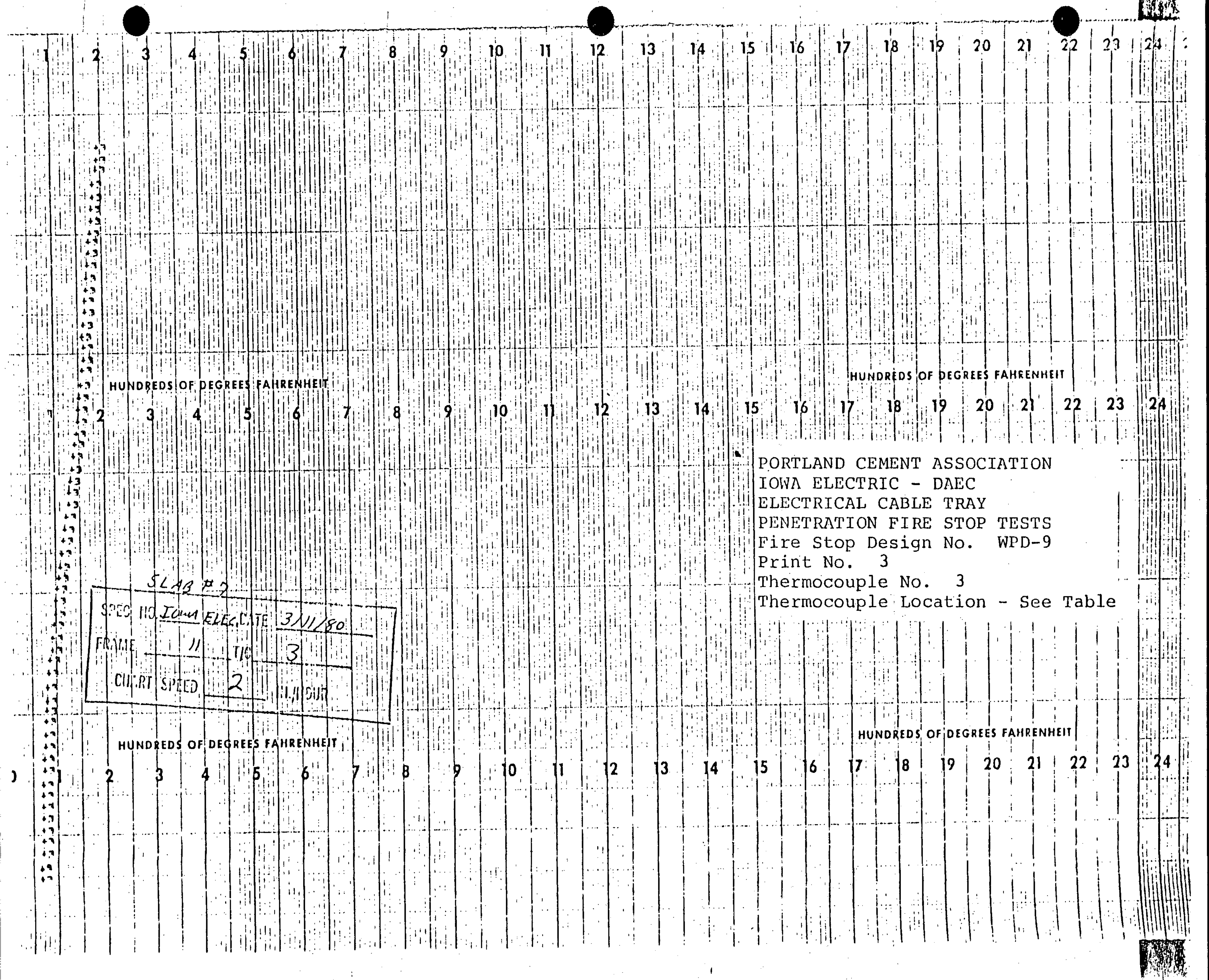
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. FPD-RP-2
Print No. 5
Thermocouple No. Concrete Surface
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 1
Thermocouple No. 1
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 2
Thermocouple No. 2
Thermocouple Location - See Table



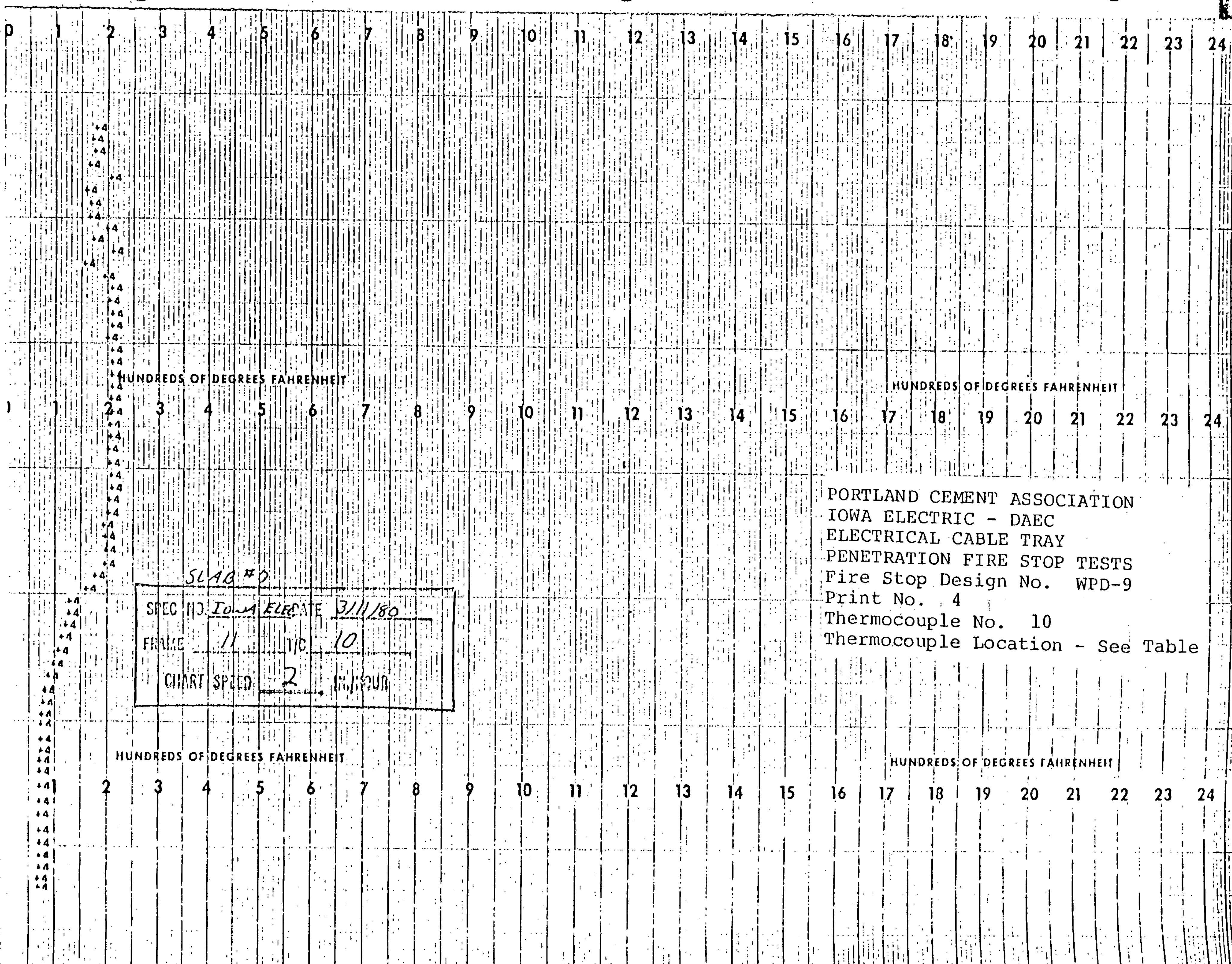
SLAB #2

SPEC NO. Iowa Elec DATE 3/11/80

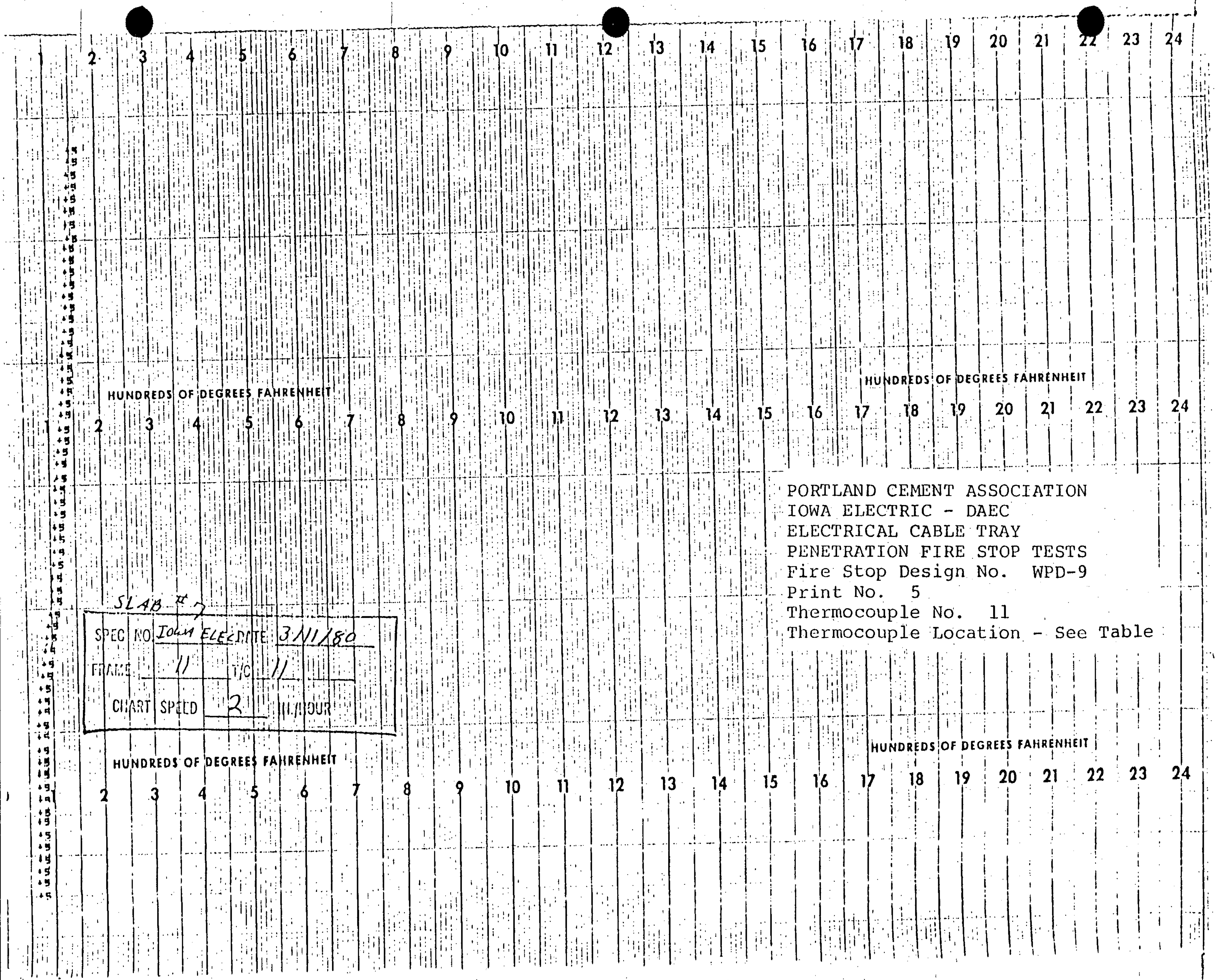
FRAME 11 T/C 3

CHART SPEED 2 IN/HOUR

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 3
Thermocouple No. 3
Thermocouple Location - See Table



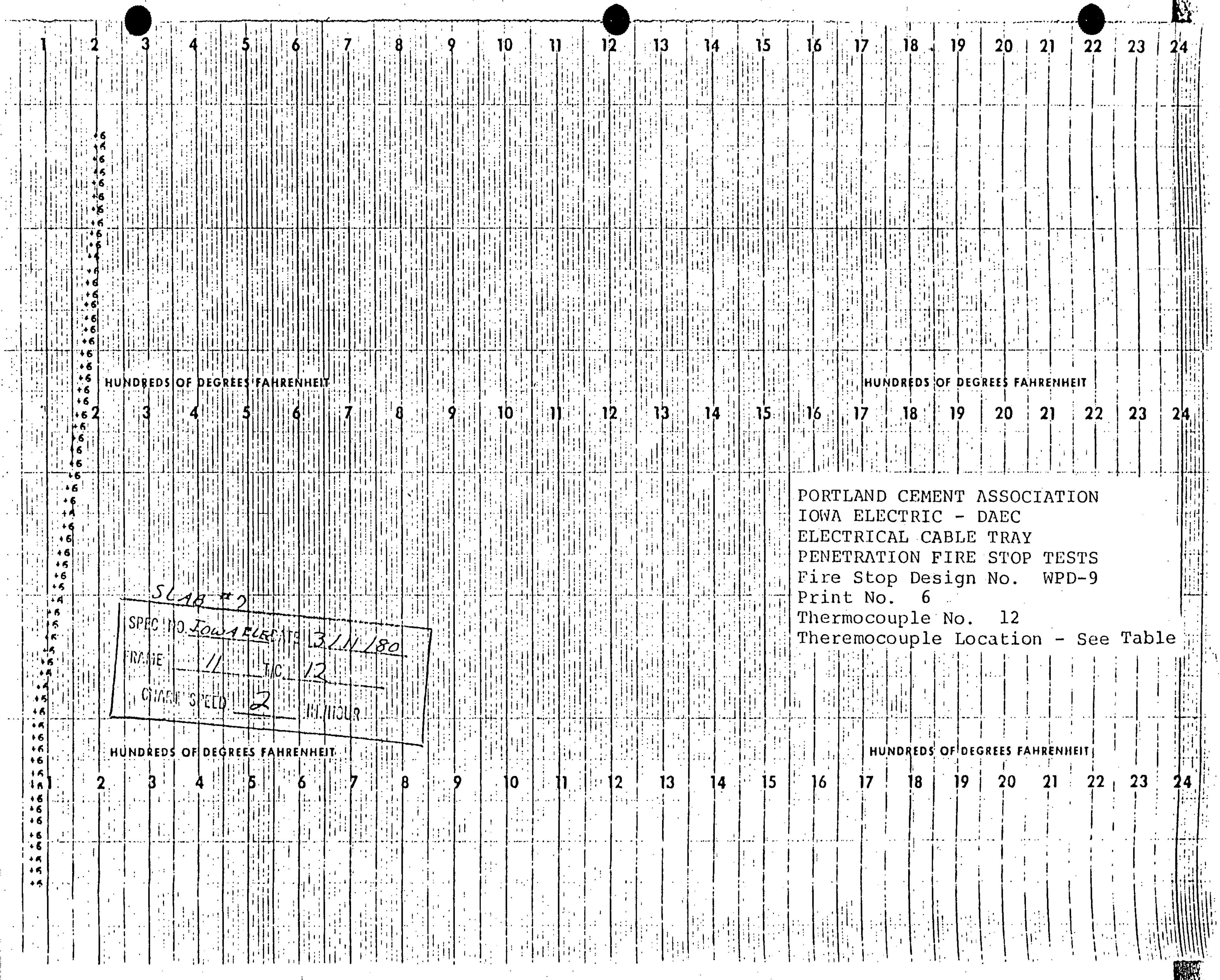
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 4
Thermocouple No. 10
Thermocouple Location - See Table



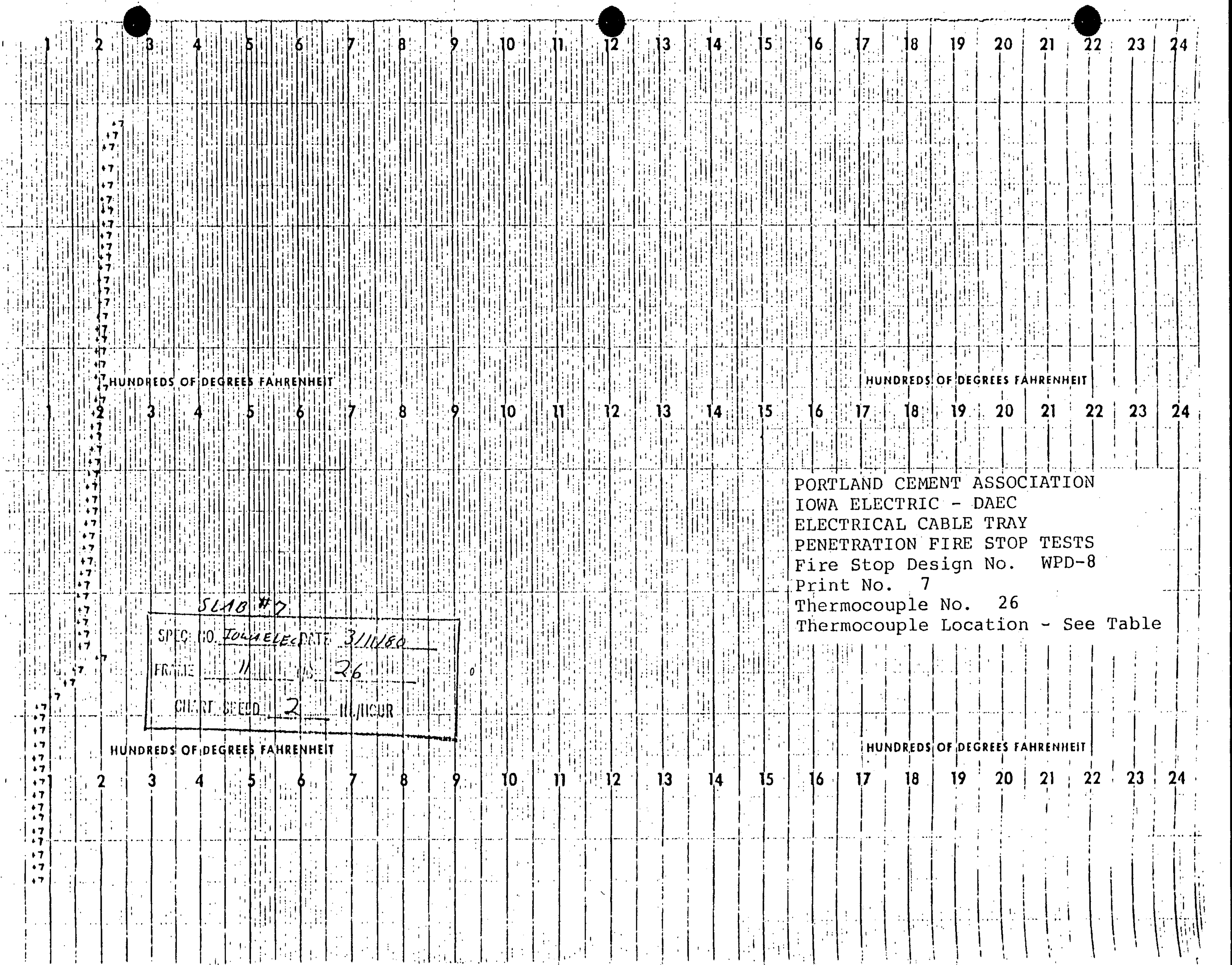
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 5
Thermocouple No. 11
Thermocouple Location - See Table

SLAB #7

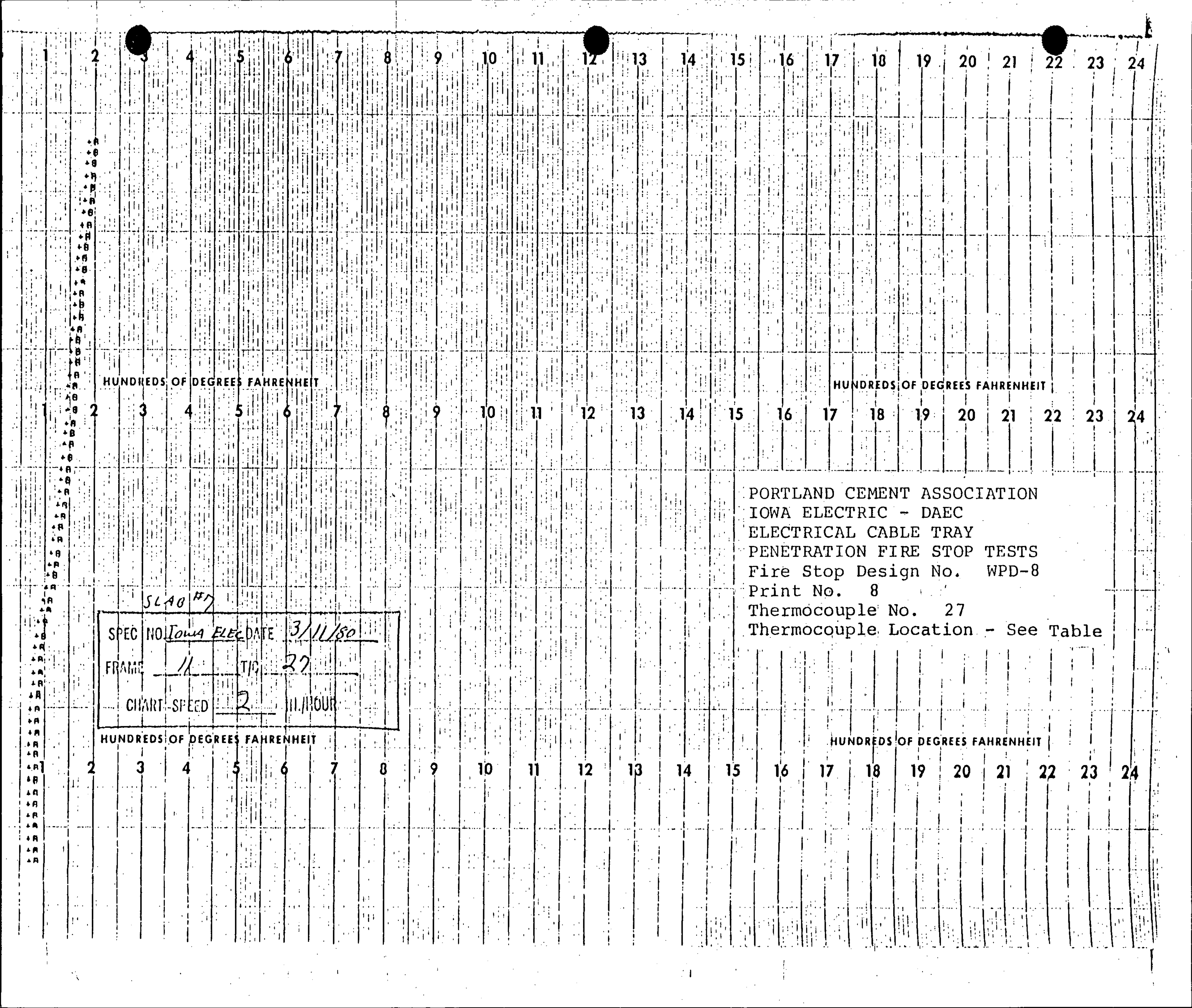
SPEC NO Iowa Elec DATE 3/11/80
FRAME 11 T/C 11
CHART SPEED 2 IN/HOUR



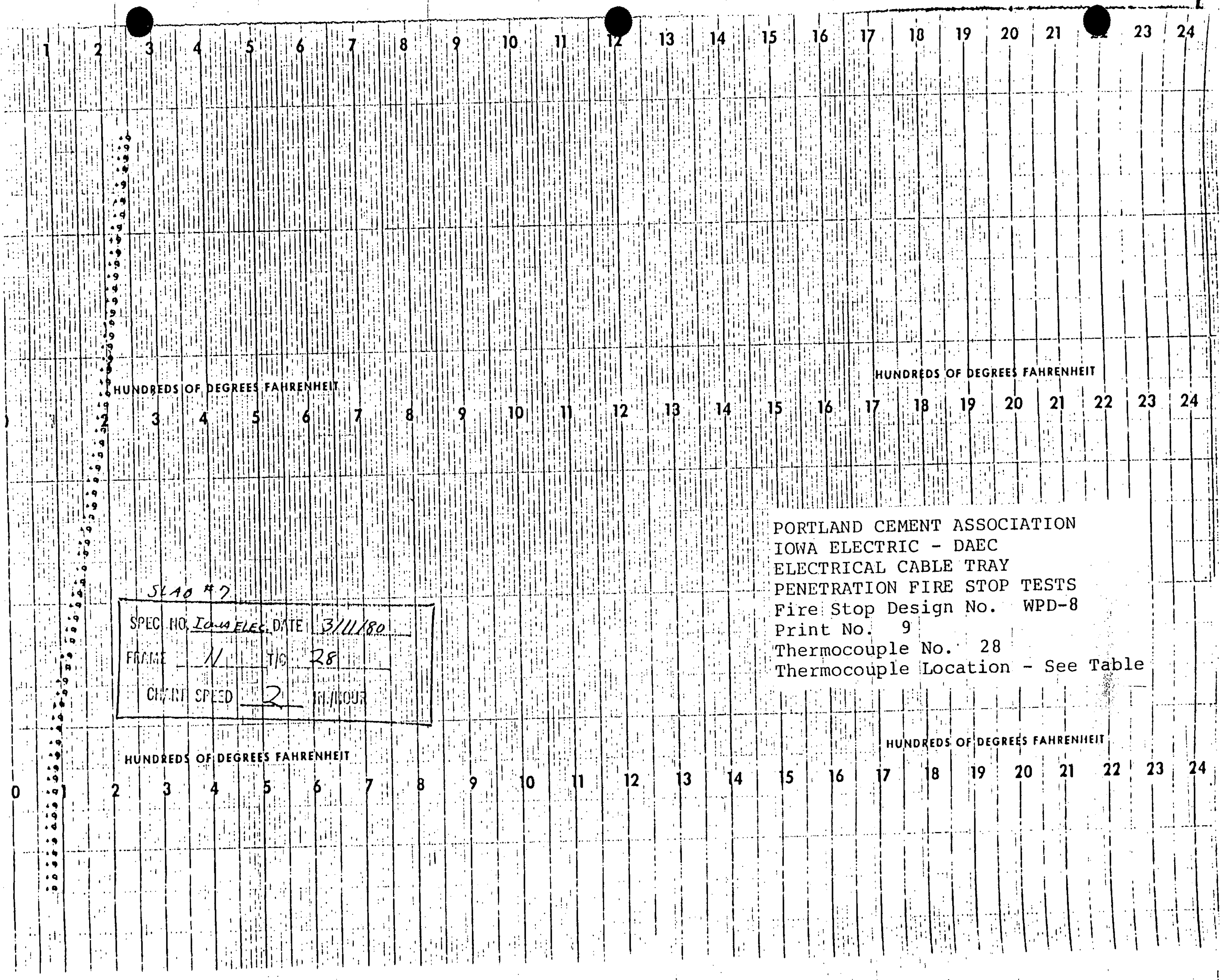
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-9
Print No. 6
Thermocouple No. 12
Theremocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-8
Print No. 7
Thermocouple No. 26
Thermocouple Location - See Table



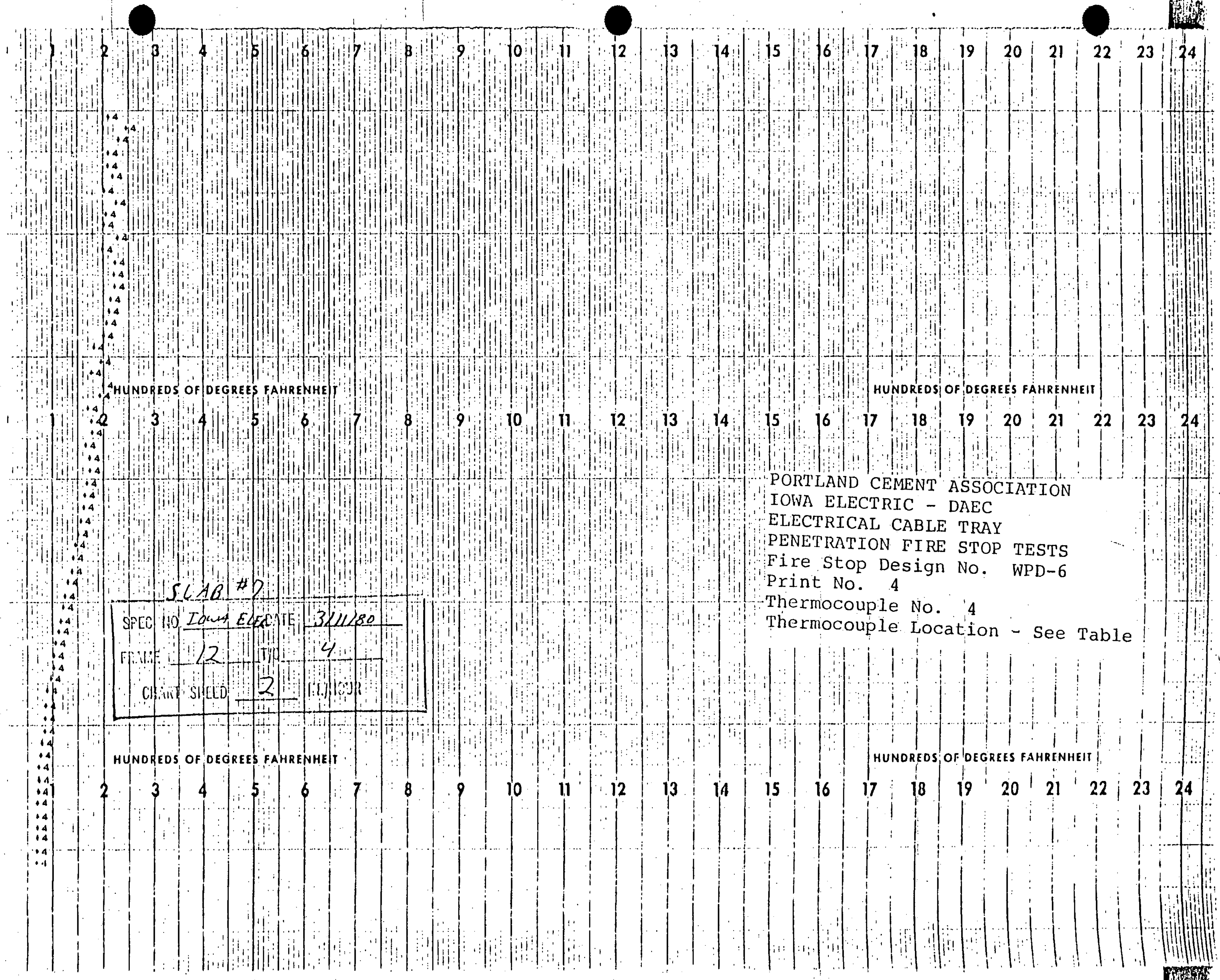
HUNDREDS OF DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
SLAB #7
SPEC NO Iowa Elec DATE 3/11/80
FRAME 11 T/C 27
CHART SPEED 2 IN/HOUR
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-8
Print No. 8
Thermocouple No. 27
Thermocouple Location - See Table



SLAB #2

SPEC NO. Iowa Elec. DATE 3/11/80
FRAME N T/C 28
CHART SPEED 2 IN/HOUR

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-8
Print No. 9
Thermocouple No. 28
Thermocouple Location - See Table



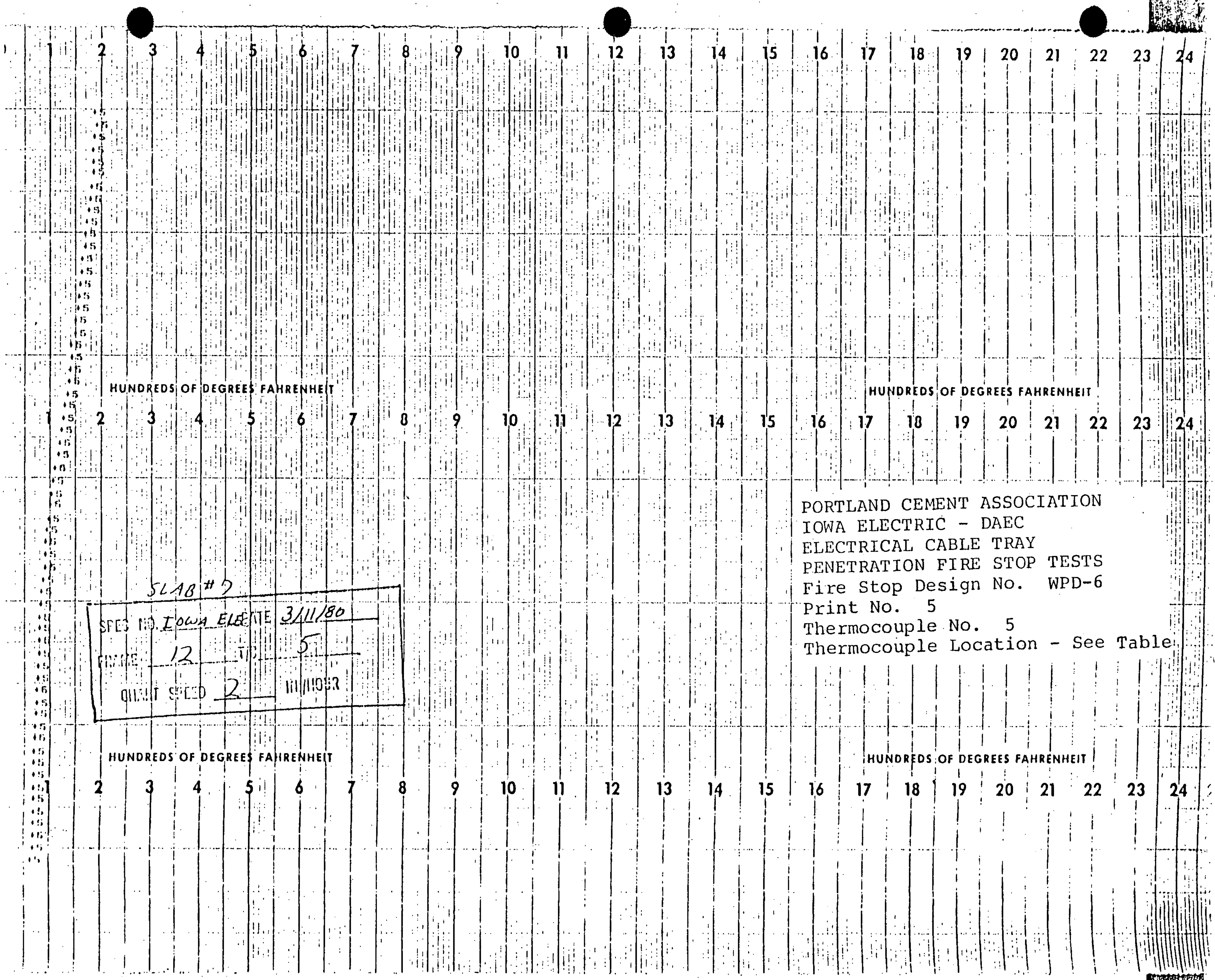
SLAB #7

SPEC NO. Iowa Elec DATE 3/11/80

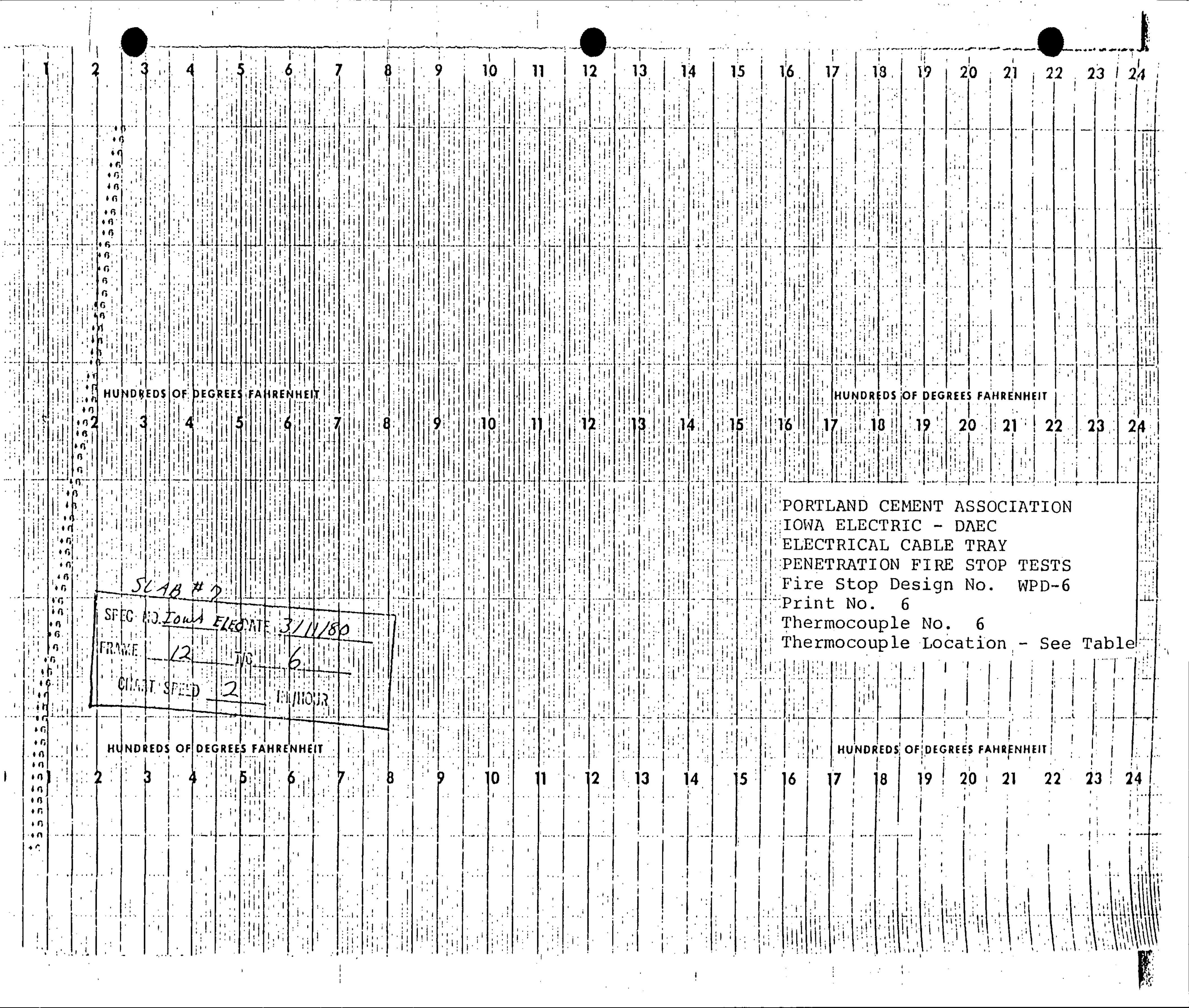
FRAME 12 T/C 4

CHART SPEED 2 IN/HOUR

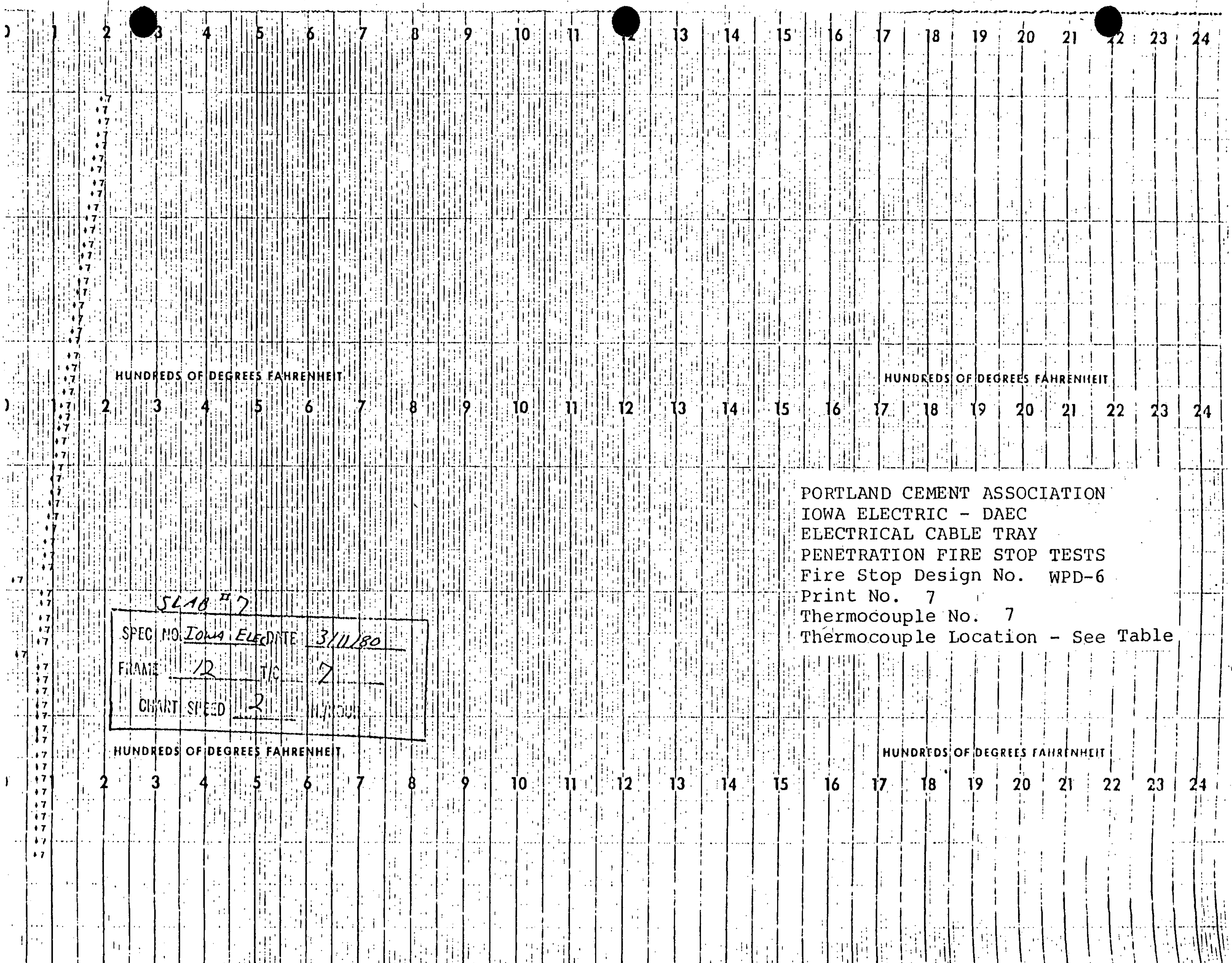
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 4
Thermocouple No. 4
Thermocouple Location - See Table



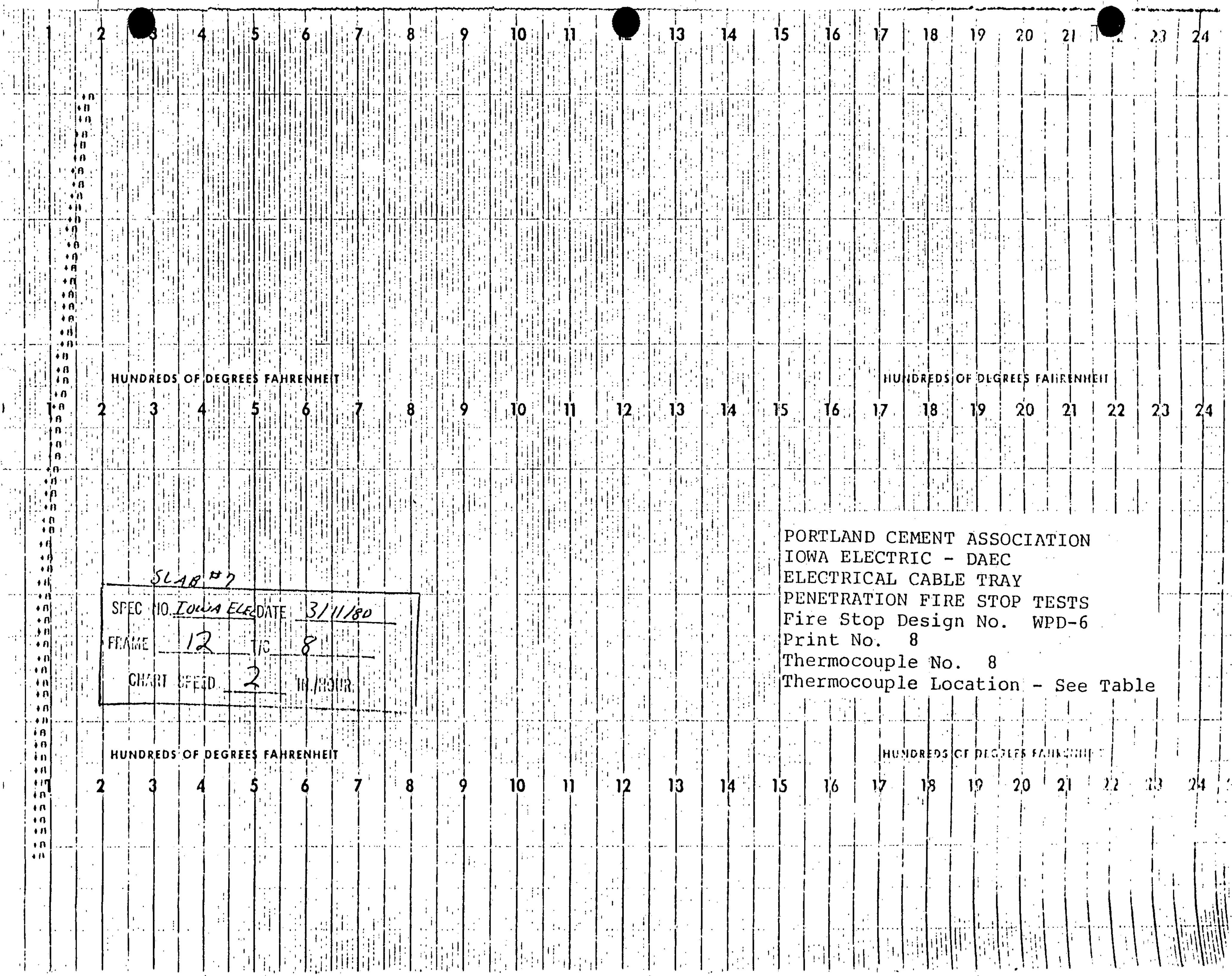
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 5
Thermocouple No. 5
Thermocouple Location - See Table



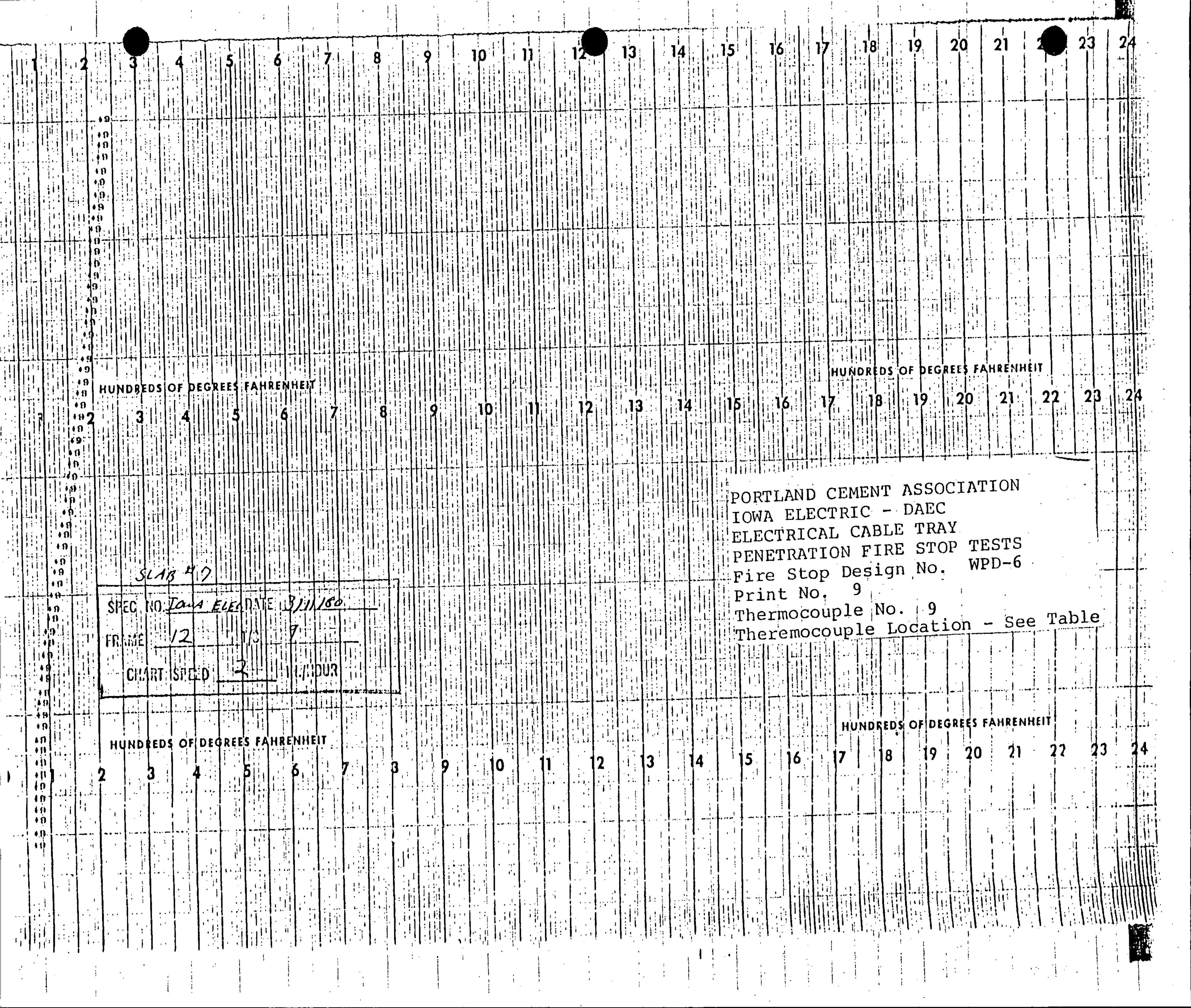
PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 6
Thermocouple No. 6
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 7
Thermocouple No. 7
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 8
Thermocouple No. 8
Thermocouple Location - See Table



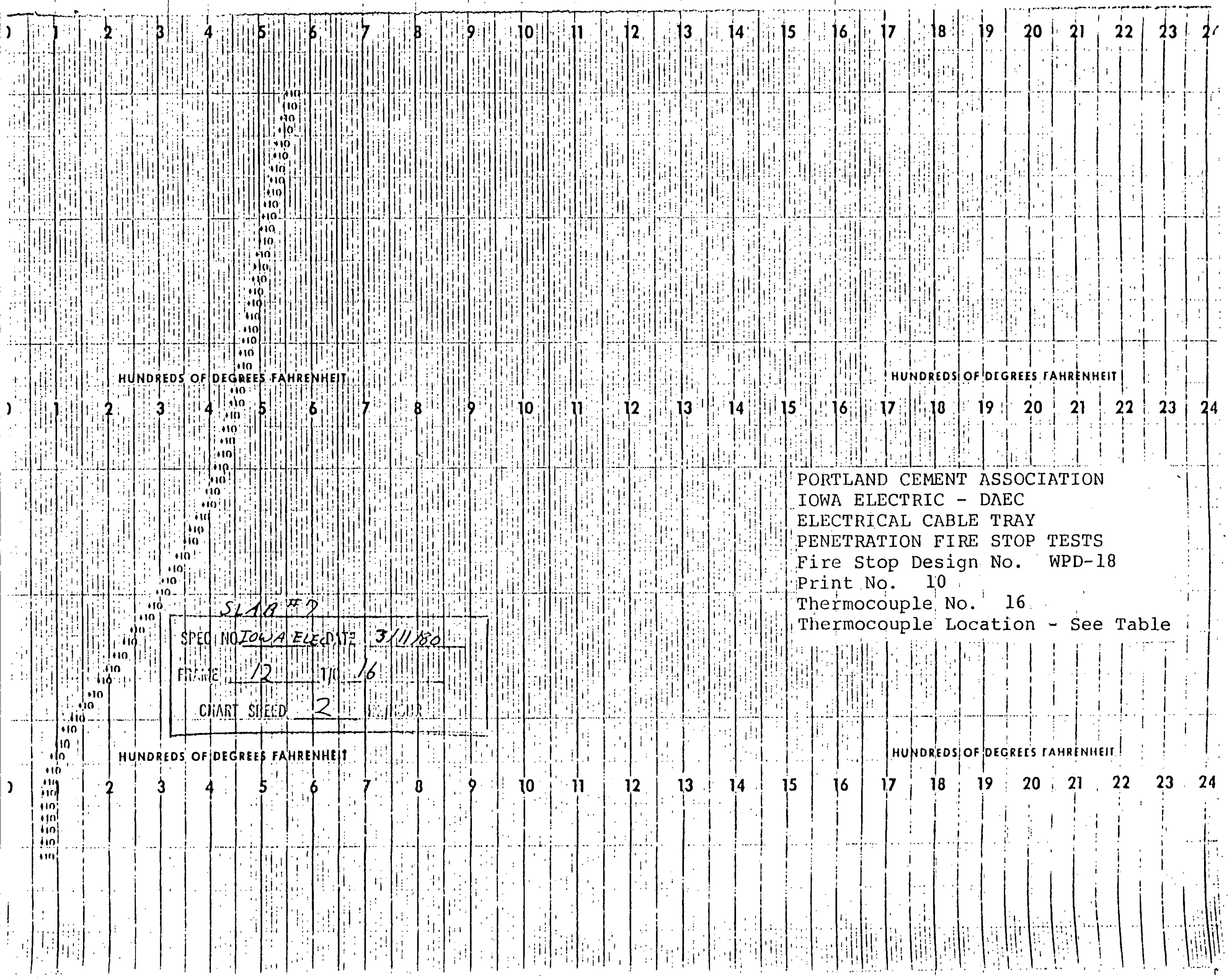
SLAB 47

SPEC NO. Iowa Elec DATE 3/11/80

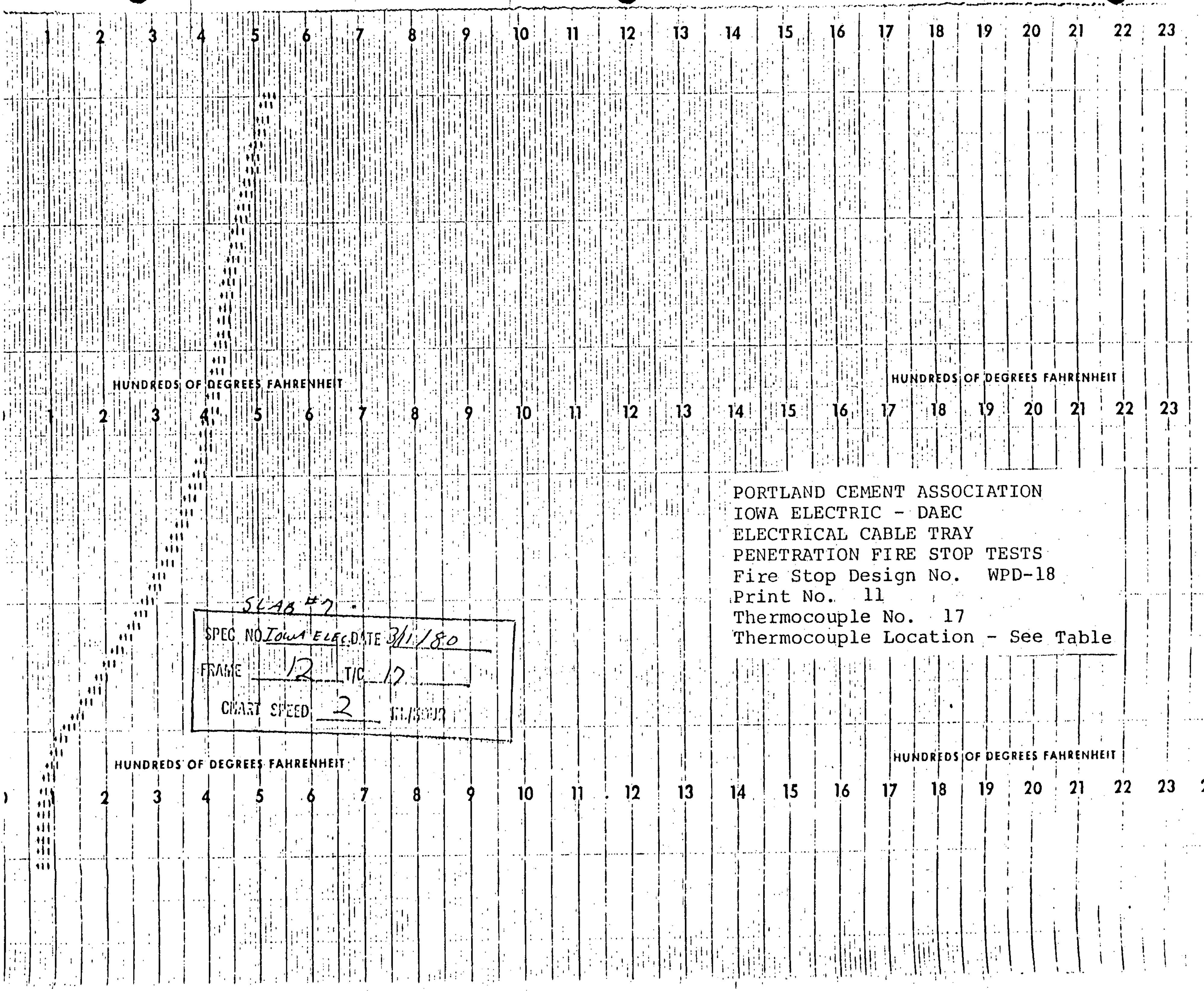
FRAME 12 T/C 9

CHART SPEED 2 IN/HOUR

PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-6
Print No. 9
Thermocouple No. 9
Theremocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
Fire Stop Design No. WPD-18
Print No. 10
Thermocouple No. 16
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
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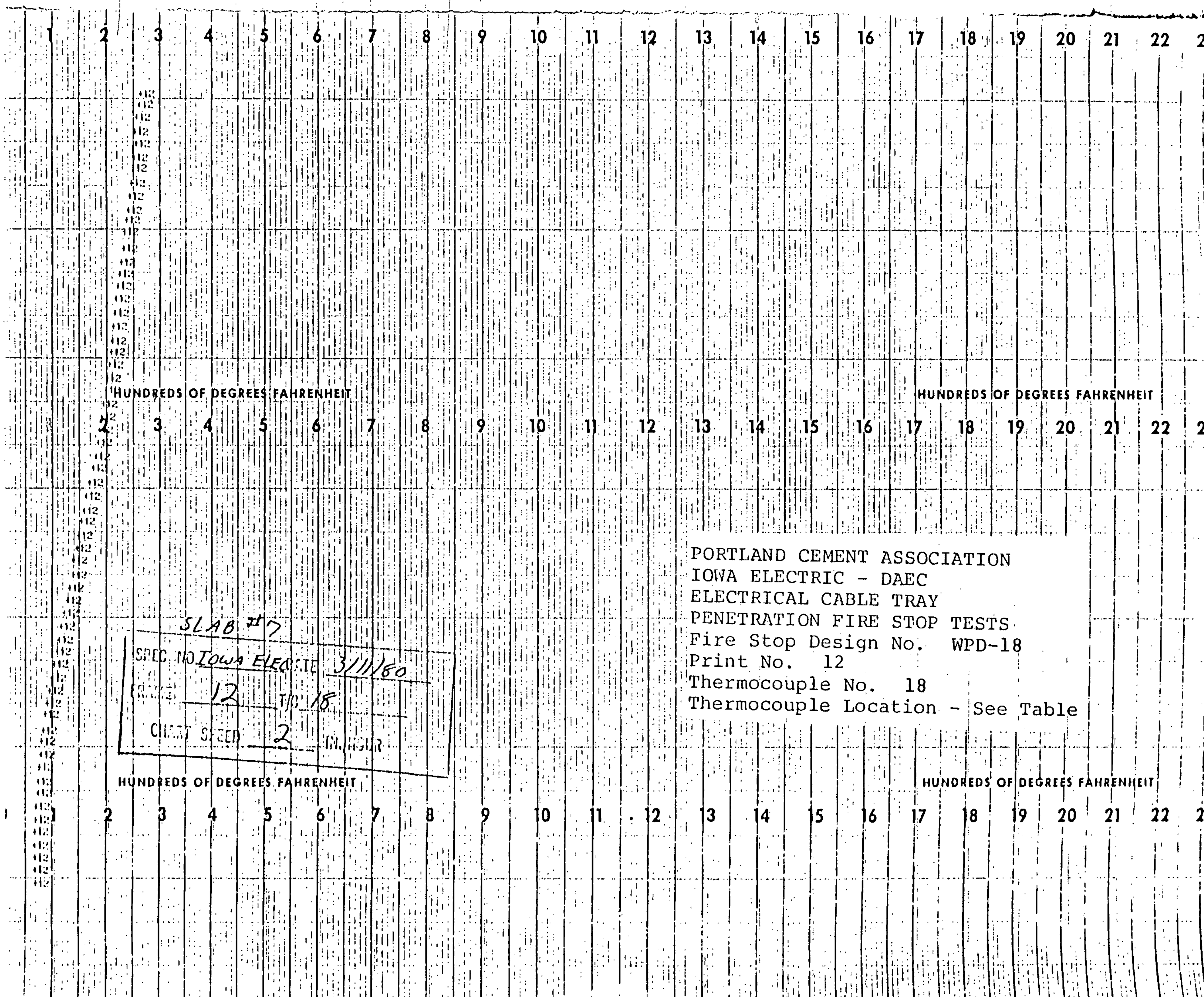
Thermocouple No. 17
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
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PENETRATION FIRE STOP TESTS
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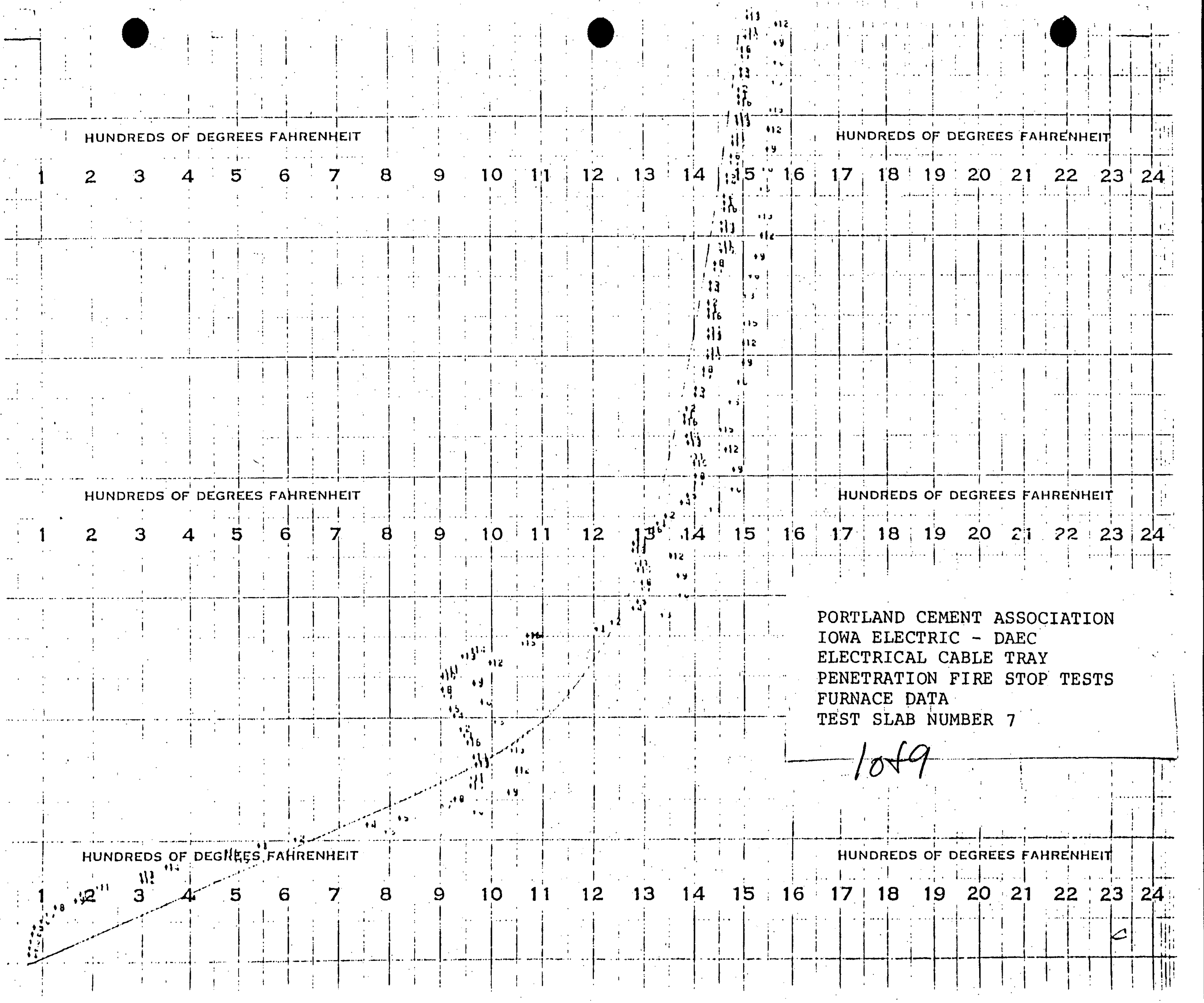
Thermocouple Location - See Table



PORTLAND CEMENT ASSOCIATION
IOWA ELECTRIC - DAEC
ELECTRICAL CABLE TRAY
PENETRATION FIRE STOP TESTS
FURNACE DATA
TEST SLAB NUMBER 7

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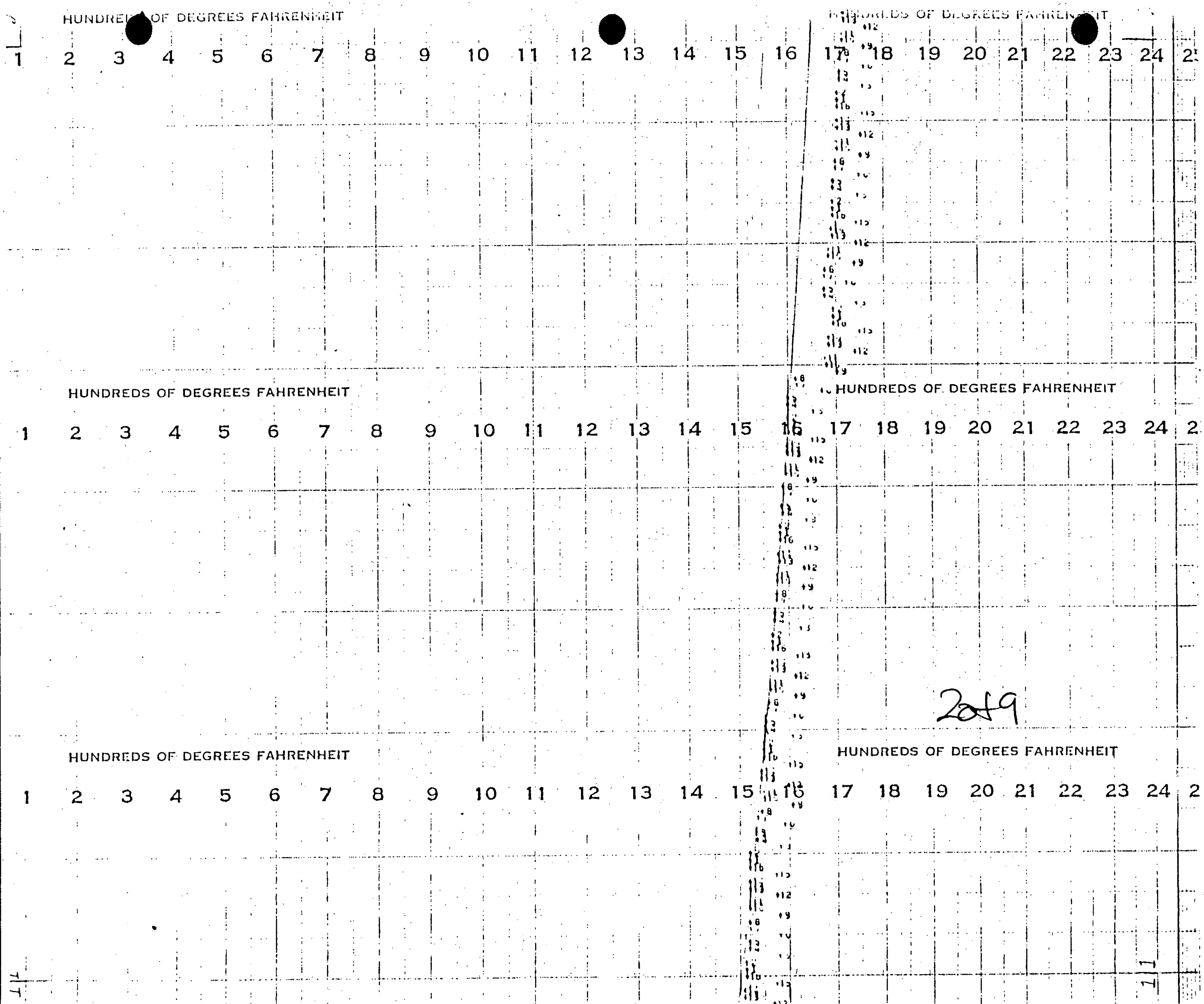
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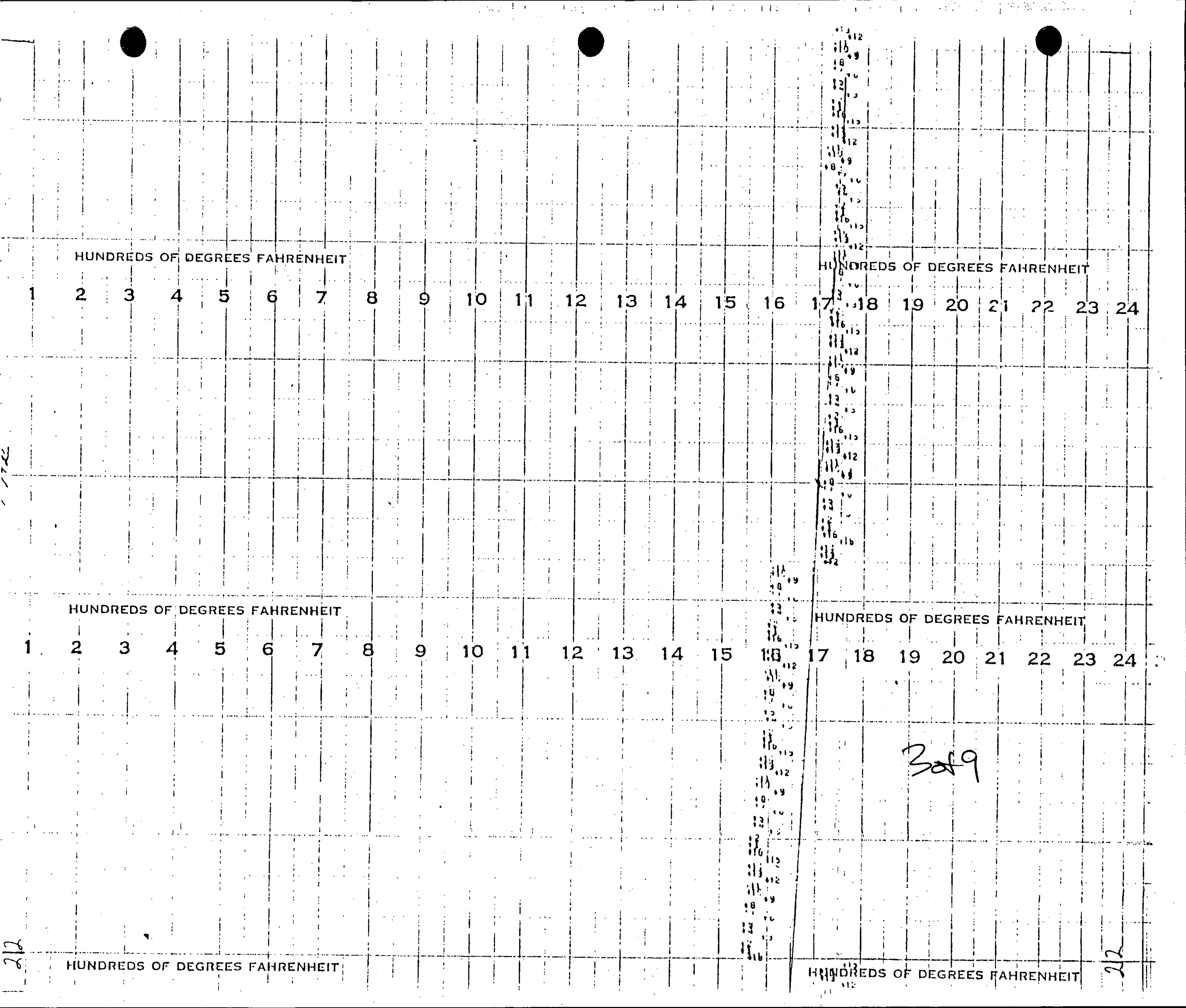
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
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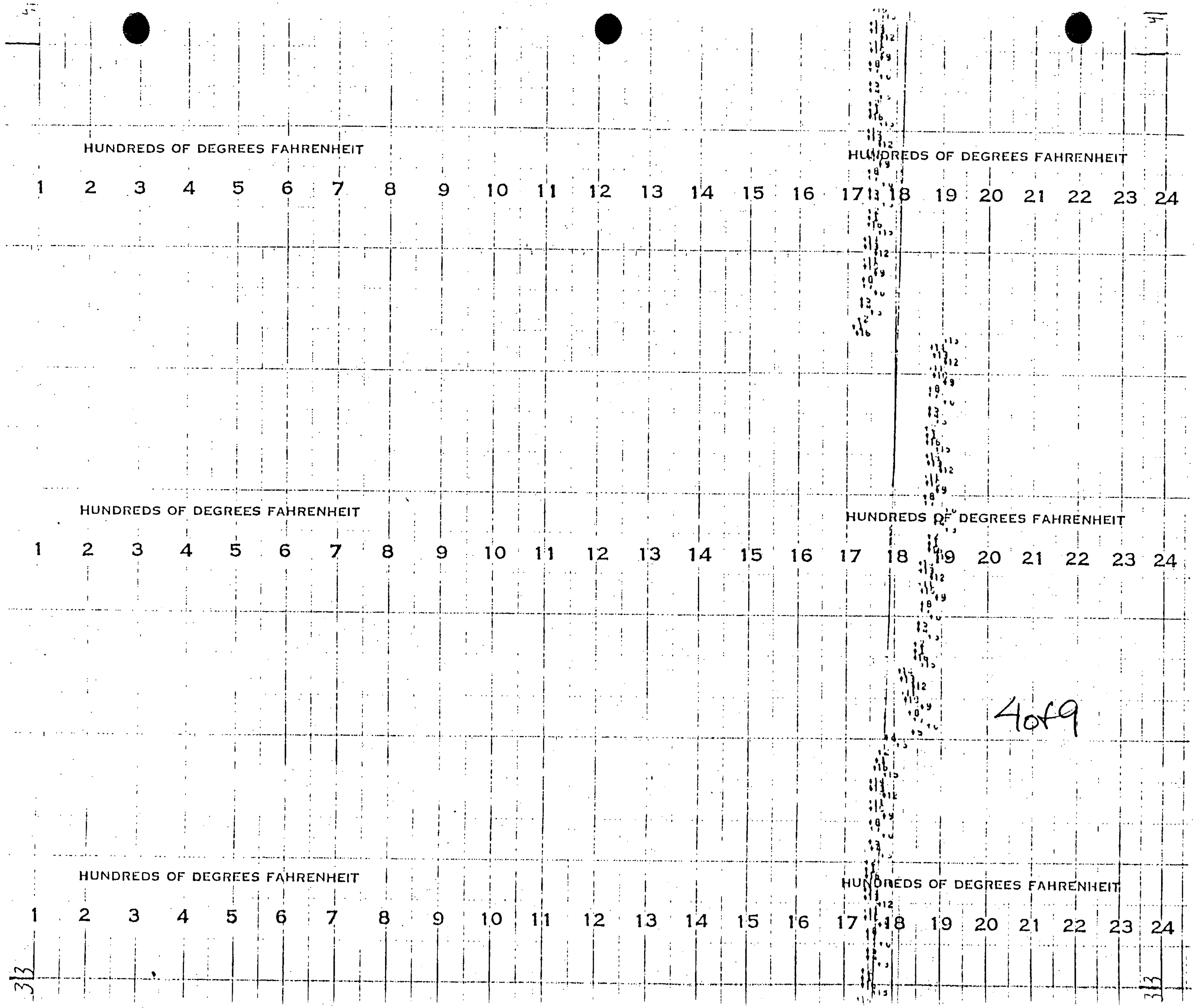
3 of 9
212
HUNDREDS OF DEGREES FAHRENHEIT
HUNDREDS OF DEGREES FAHRENHEIT
212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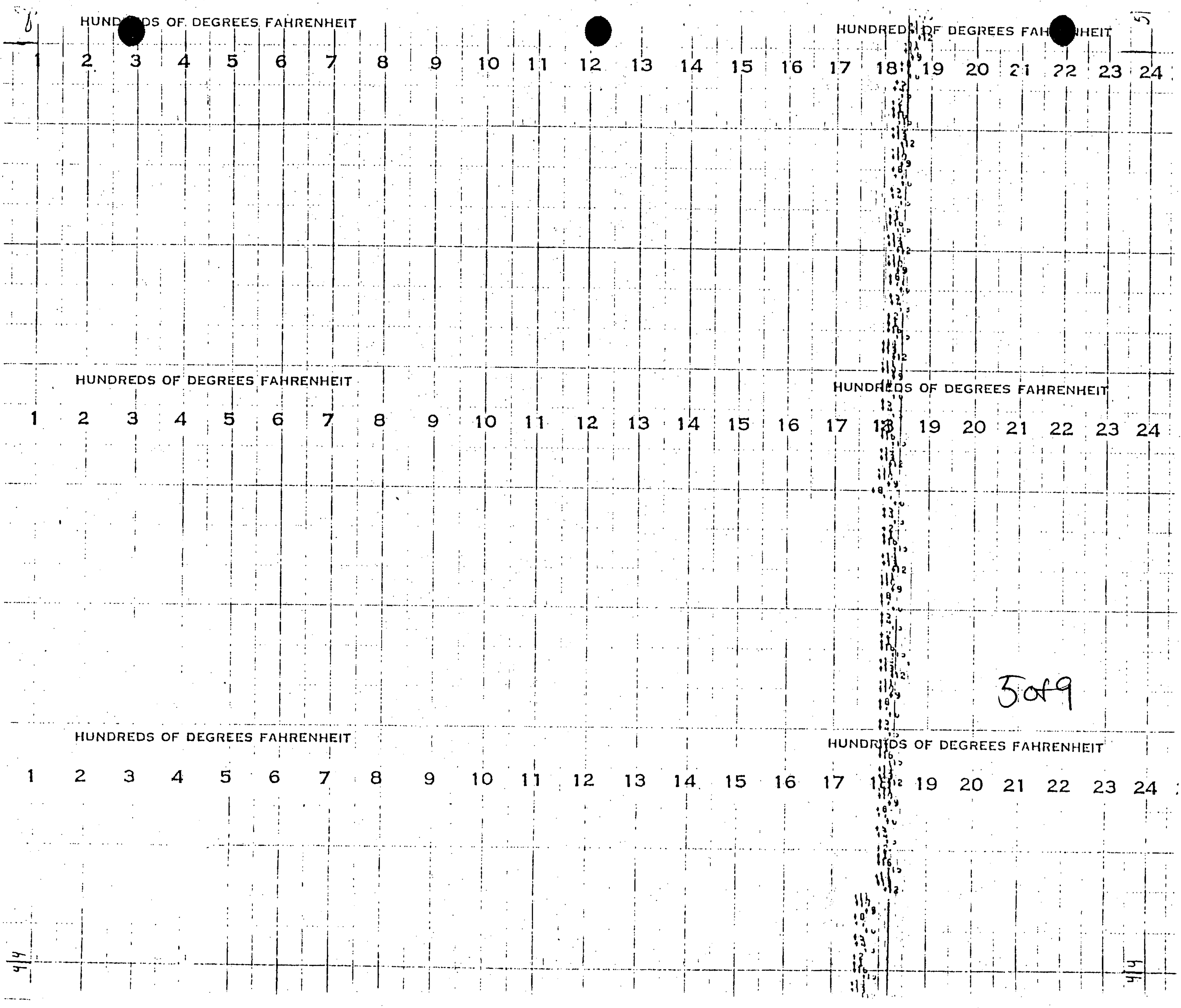
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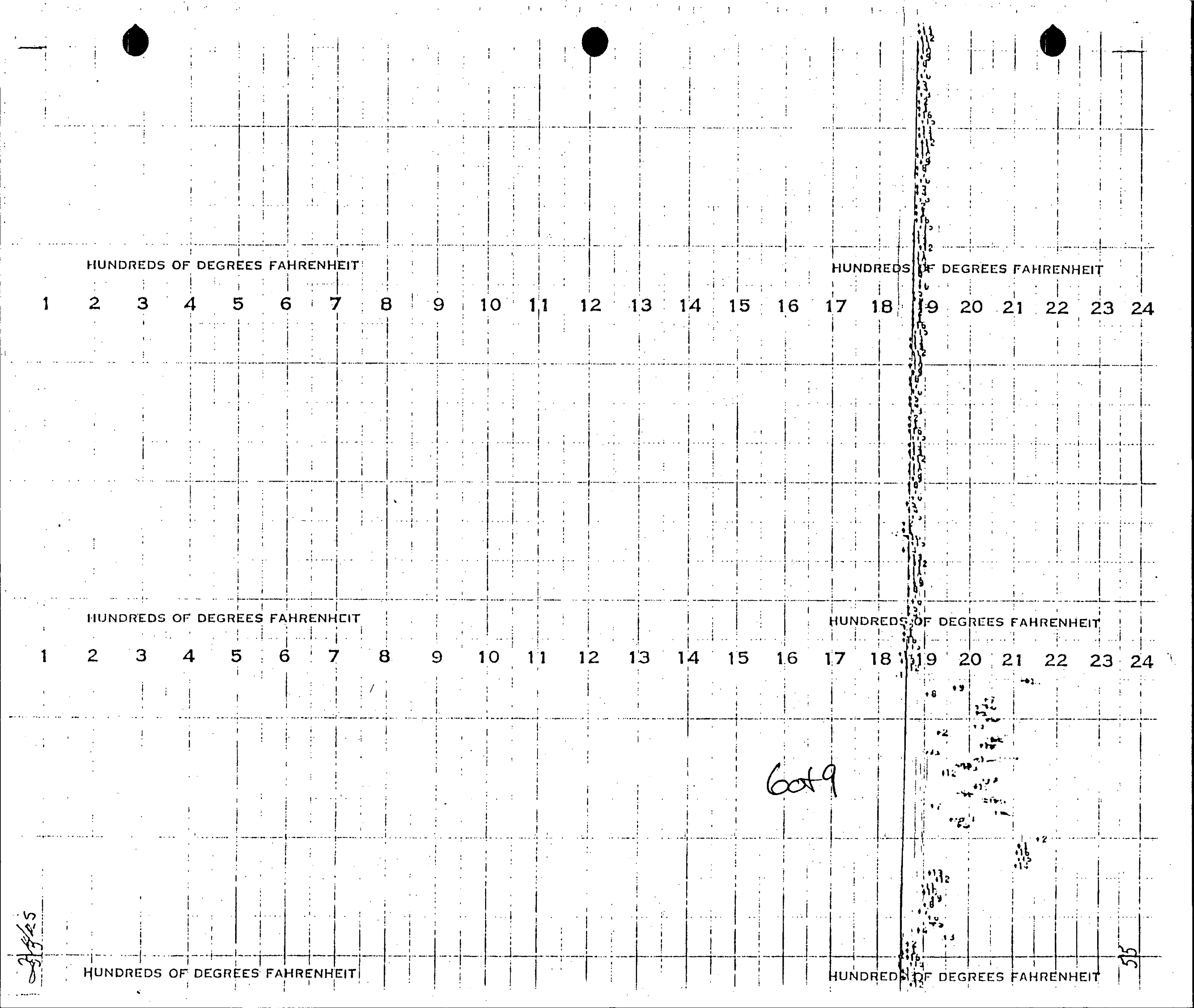

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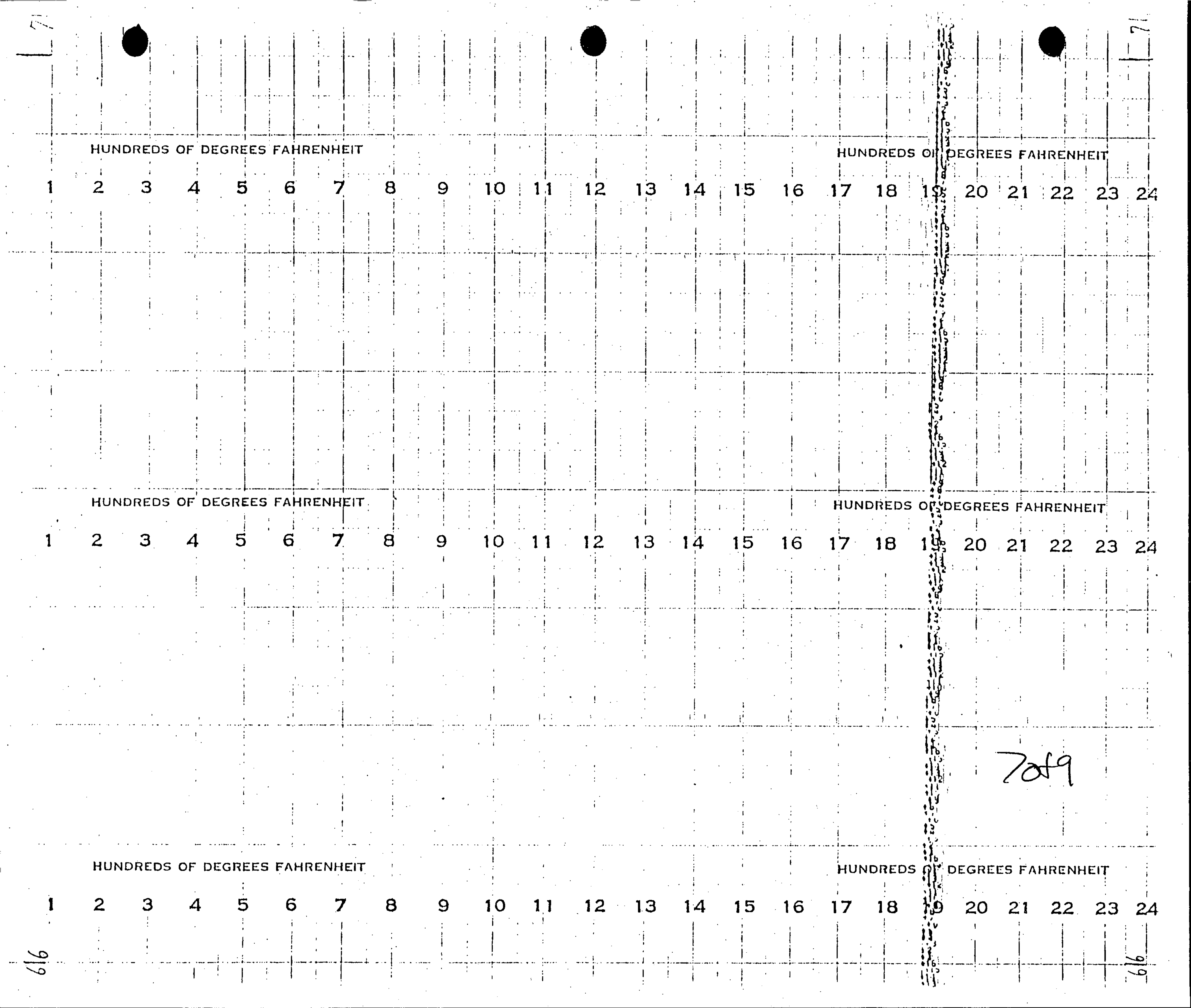
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
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HUNDREDS OF DEGREES FAHRENHEIT
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616
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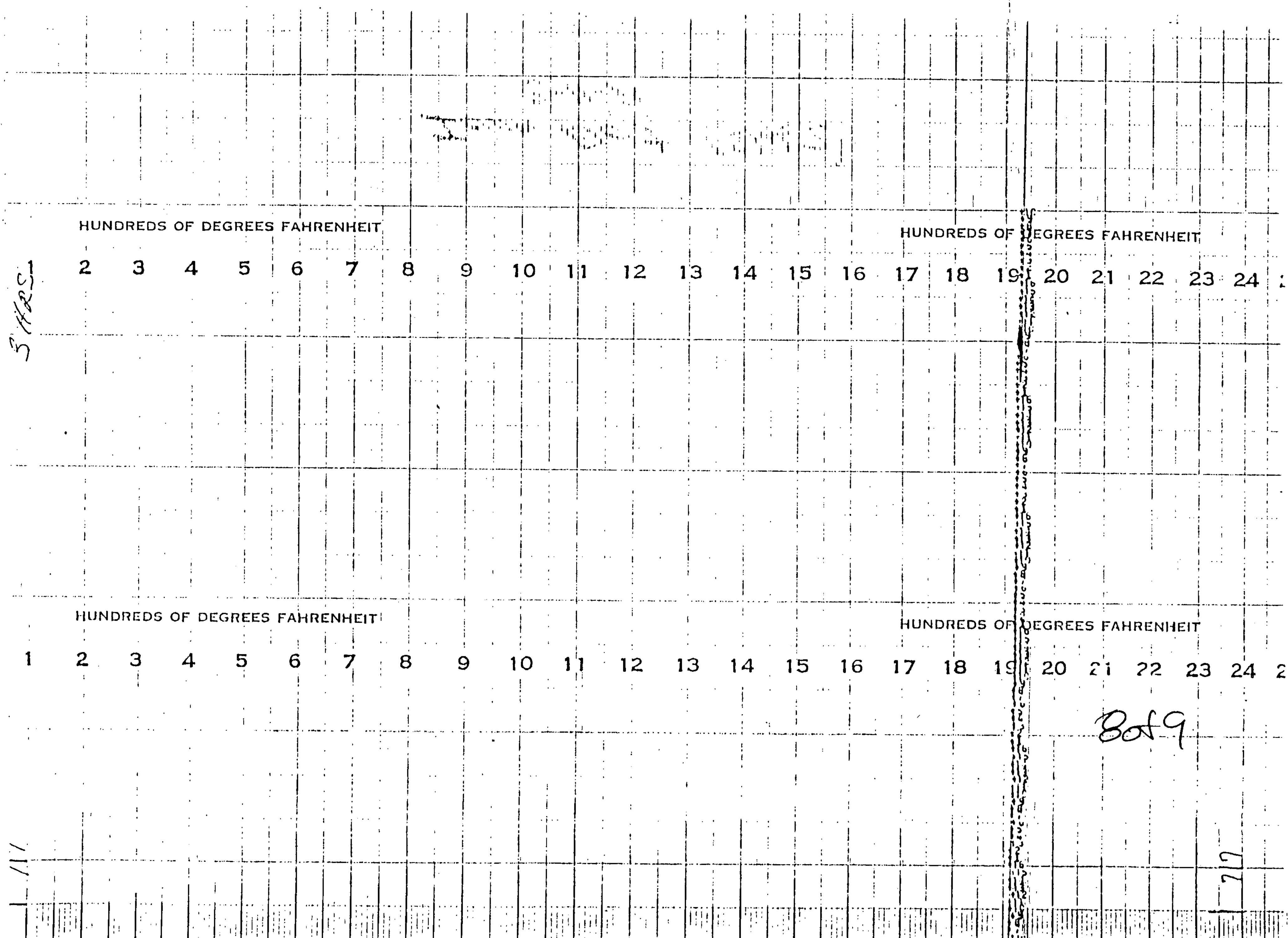
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3 HRS
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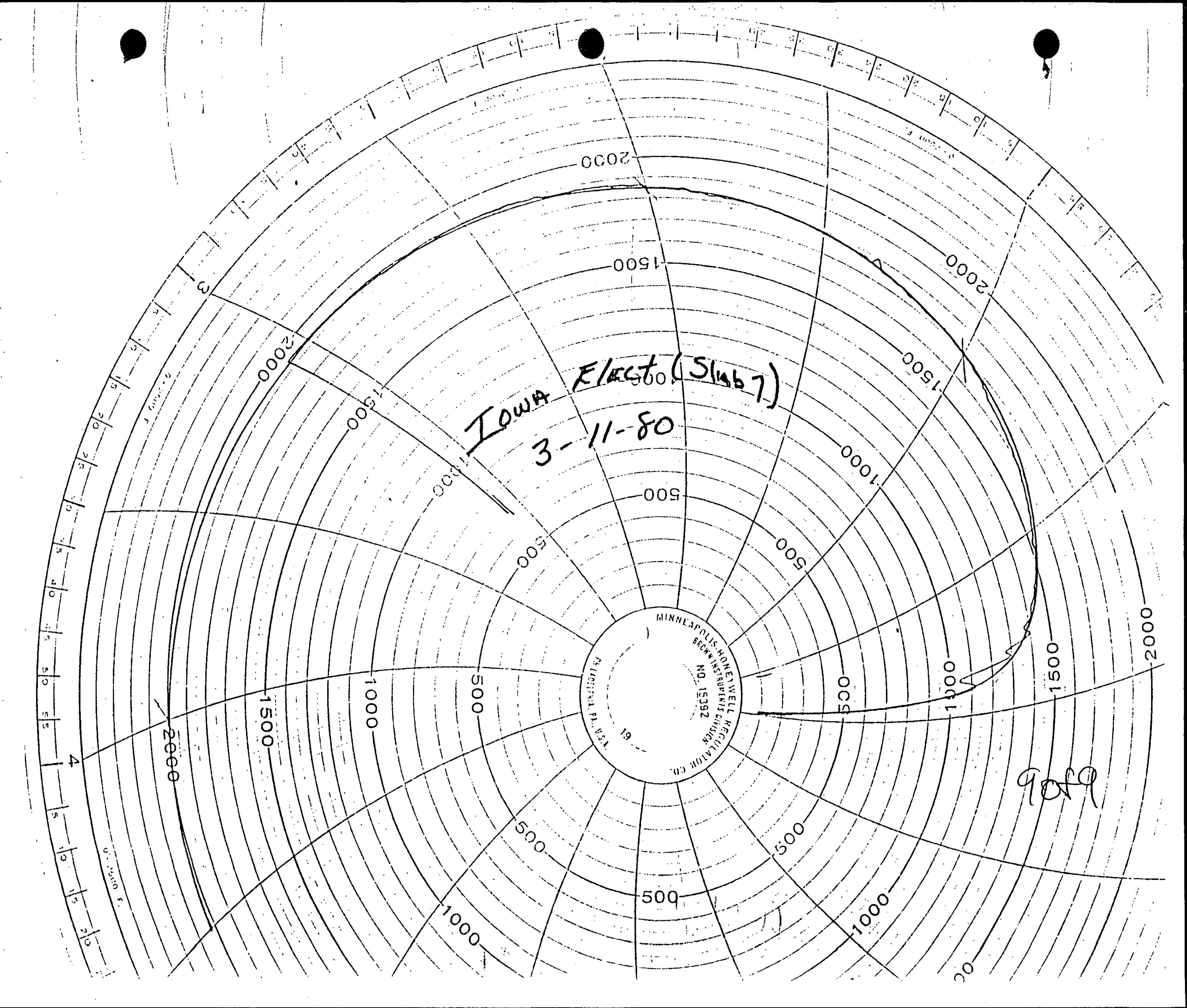
IOWA Elect (Slab 7)
3-11-80
MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
NO. 15392
PHILADELPHIA, PA. U.S.A.
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