FIRE STOP PENETRATION TESTS ON FIRE PROTECTION SYSTEM

SLAB NO. 2

PROJECT NO. 03-5980-003

by

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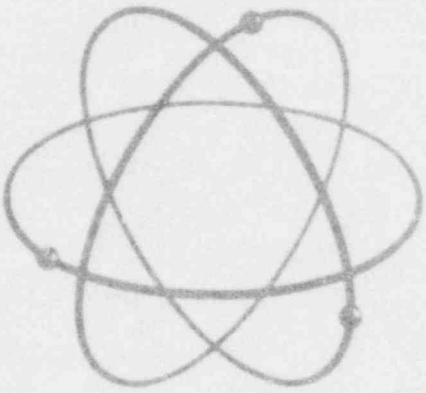

FINAL REPORT

Prepared for:
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SUMMARY

On 30 July 1980, six cable tray penetrations designed by Baltimore Gas and Electric Company and installed by Insulation Consultants and Managements Services (ICMS), Incorporated and Southwest Research Institute were exposed to a three hour fire endurance qualification test following the ASTM E119-76 time/temperature curve. The penetrations were also subjected to a hose stream test as described in Section 5.3.12 of IEEE 634-1978.

The purpose of the test was to obtain a three-hour fire rating for existing and modified fire stop designs in accordance with ASTM E119-76 time/temperature requirements, the hose stream test of IEEE 634-1978, and Baltimore Gas and Electric Company Fire Test Procedure for Calvert Cliffs, Units 1 and 2, dated 12 June 1980. The fire exposure test was conducted without a differential pressure only, as the differential pressure test (Test 2b of the referenced procedure) was deleted by BG&E in their letter of 2 July 1980 which is reproduced on page I-19, Appendix I.

Penetration seal construction consisted of various loaded cable trays filled with Kaowool, silicone foam and coatings.

TEST ATTENDEES

Conducting the test project:

Mr. Michael D. Pish, Project Manager
Mr. Jesse J. Beitel, Test Engineer
Mr. A. L. Schraeder, Test Coordinator
Mr. L. J. Poirier, Test Documentation

Witnessing the test for Baltimore Gas and Electric Company:

Mr. Premnath Bhatia, Senior Engineer
Mr. Gregory W. Powell, Fire Prevention Engineer

Also witnessing the test was:

Mr. Mike Stine, ICMS

DESCRIPTION

A test slab that had been previously used for a similar test of Baltimore Gas and Electric Company cable penetrations was used to mount six cable trays in a 36" x 72" blockout opening cast into the test slab, details of which are shown in Figures 1 and 2. The cable trays were grouted in place, and the remaining openings were sealed by welding or bolting 3/8" steel plates on the bottom of each opening and filling them with sand. Penetration identification and cable loading is shown in Figure 3.

Based on the information given to Southwest Research Institute by BG&E the following descriptions are included:

1) Cable trays 1, 4, and 5 represent the fire stop design as originally proposed by BG&E.
2) Cable tray 2 represents the most conservative configuration which could exist in the plant with 50% fill.
3) Cable tray 3 represents the design which was previously tested successfully for three hours but during the application of a straight stream hose pattern some water was observed on the unexposed side. This tray is being retested.
4) Tray 6 represents the fire stop design as originally proposed with additional modifications.

The test slab was placed on a horizontal furnace and exposed to the standard ASTM E119 time/temperature curve. After three hours of exposure, the test slab was lifted in a horizontal position for the hose stream test and then moved to an area adjacent to the furnace, where it was put on blocks to cool and view.

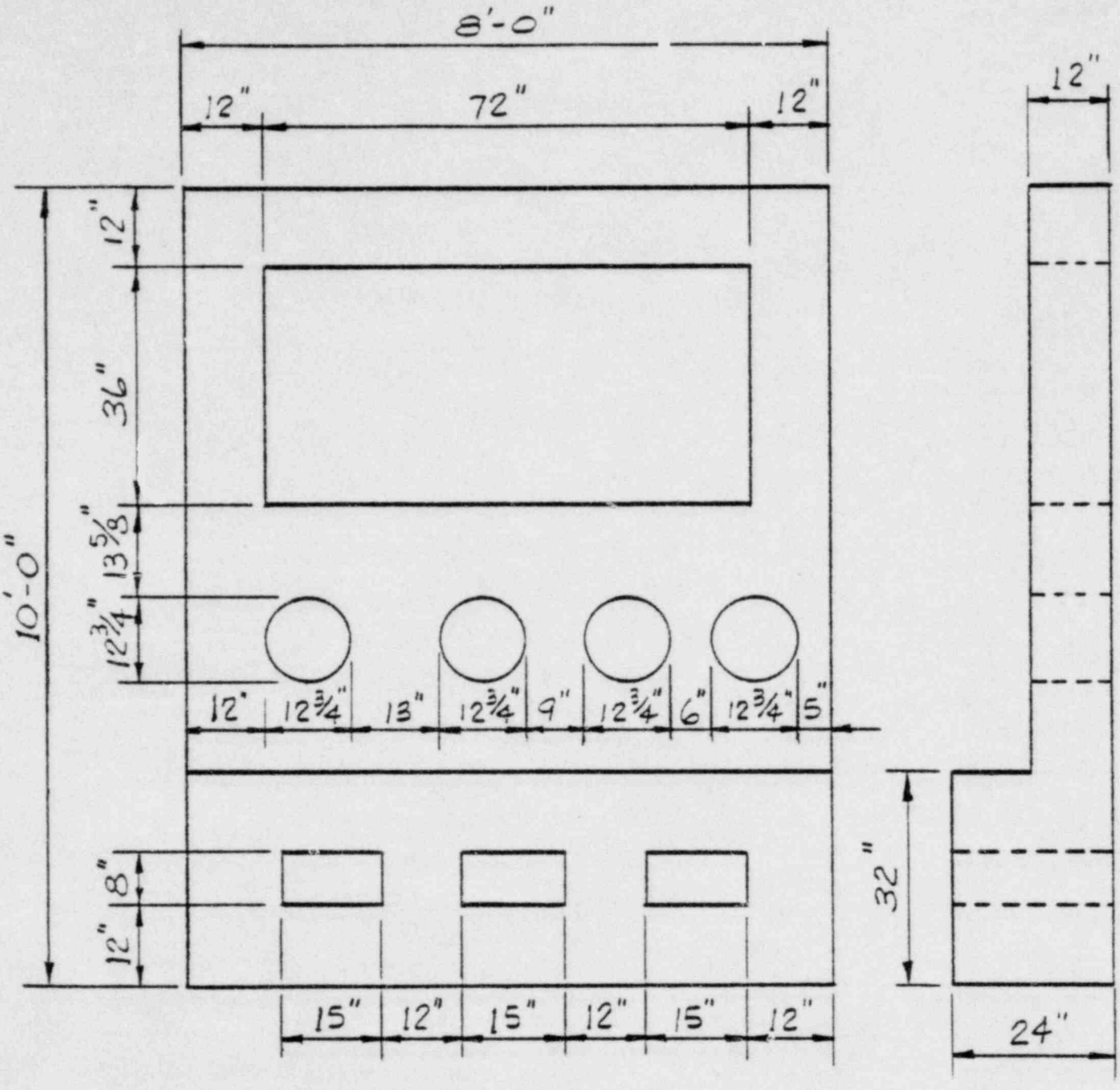


Figure 1. Test Slab Layout

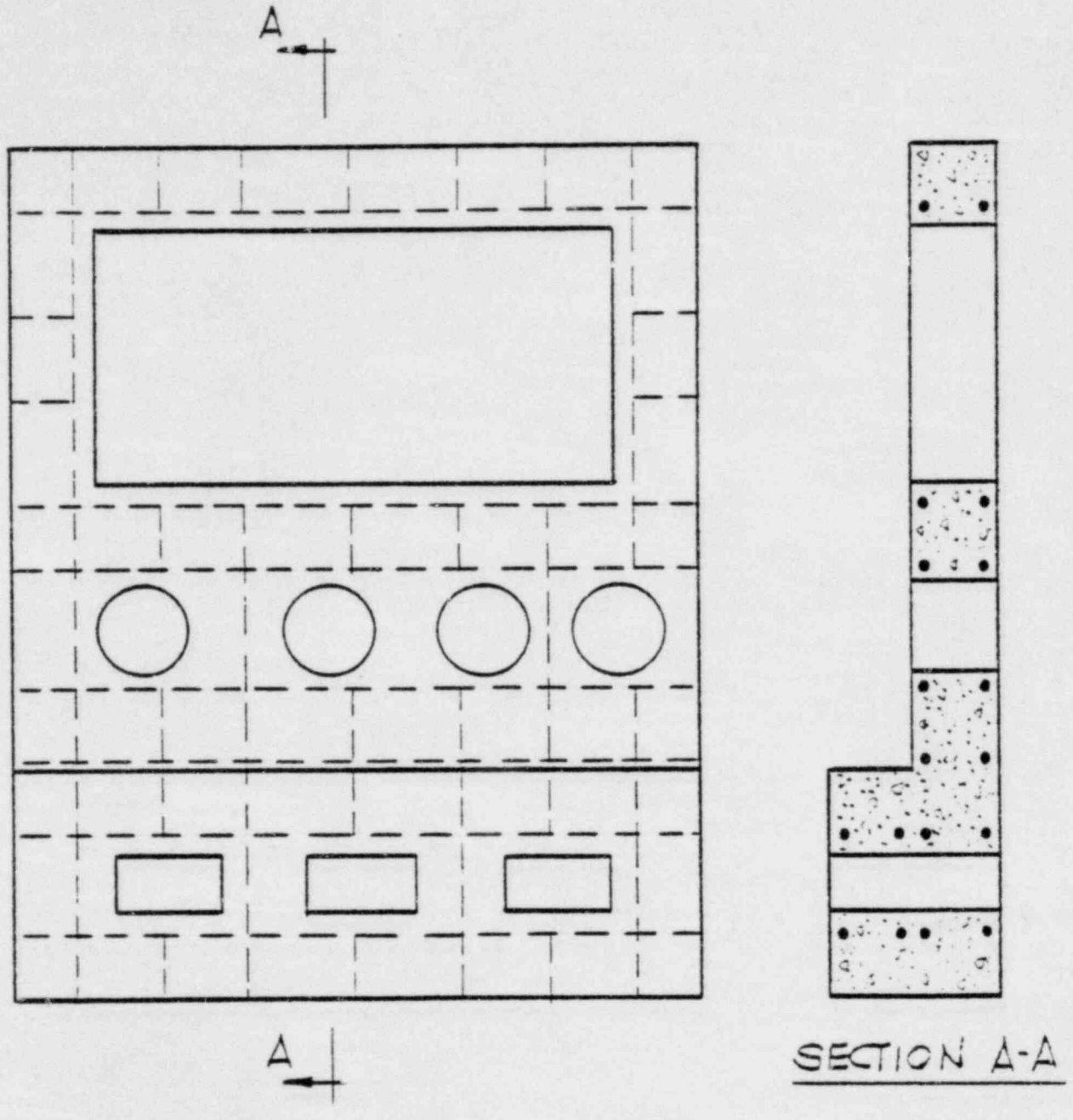


Figure 2. Reinforcement Detail

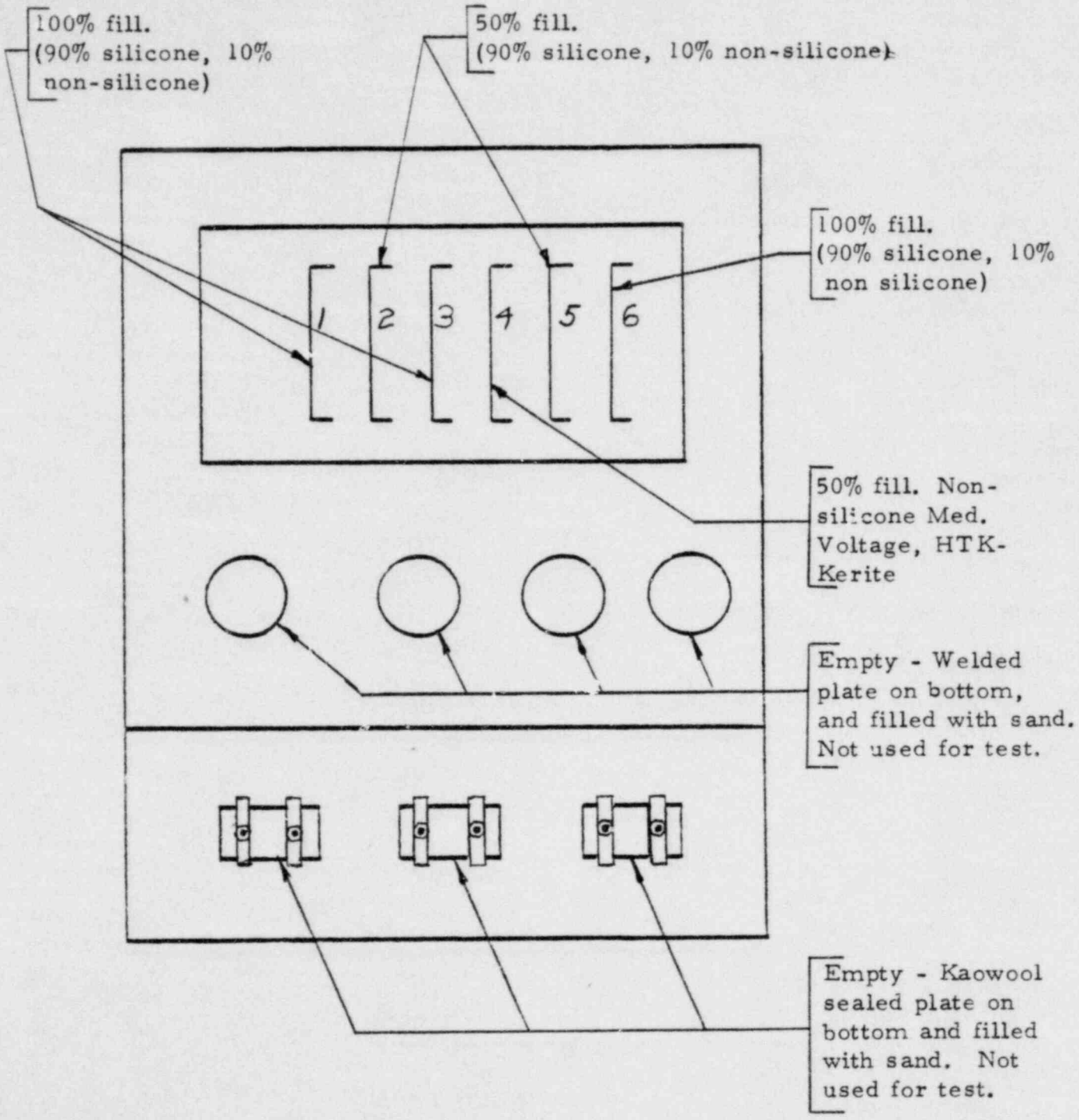


Figure 3. Penetration Identification and Cable Loading

TEST SLAB

A. CONSTRUCTION

A floor section form, 8 ft. x 10 ft. x 12" stepped to 24" thick had been previously constructed of 12" steel channel with a double mat of No. 8 rebar on 10" centers as shown in Figures 1, 2 and 4. A series of eight openings were cast into the test slab. One of these was a 36" x 72" blockout for six cable tray openings, four were pipe penetrations, and three were blockout/wireway openings. The cable tray blockout was the only opening used for this test. The pipe sleeve openings were sealed by welding a 3/8" steel plate on the bottom of each sleeve and the wireway openings were sealed by bolting a 3/8" steel plate, sealed with Kaowool, with threaded rods through each opening. The unused openings were then filled with sand. The test slab and cable tray grouted openings were then reconditioned by patching a few spalled areas with Embeco 636 grout, and cable tray supports were then welded to the basic framework.

B. PENETRATION LOADING

The cable trays were loaded as defined by the Baltimore Gas and Electric Company Fire Test Procedure for Calvert Cliffs, Units 1 and 2, dated 12 June 1980, which is reproduced in Appendix I. The type and exact number of cables used is shown in Tables 1 and 2.

C. SEALING OF PENETRATIONS

The cable trays were installed and sealed by ICMS and SwRI personnel using the materials specified in the referenced Procedure. A detailed listing of the installation procedures used during the seal preparation and Quality Control documentation appears in Appendix III. Drawings of the cable tray assemblies appear in Figures 5 through 11.

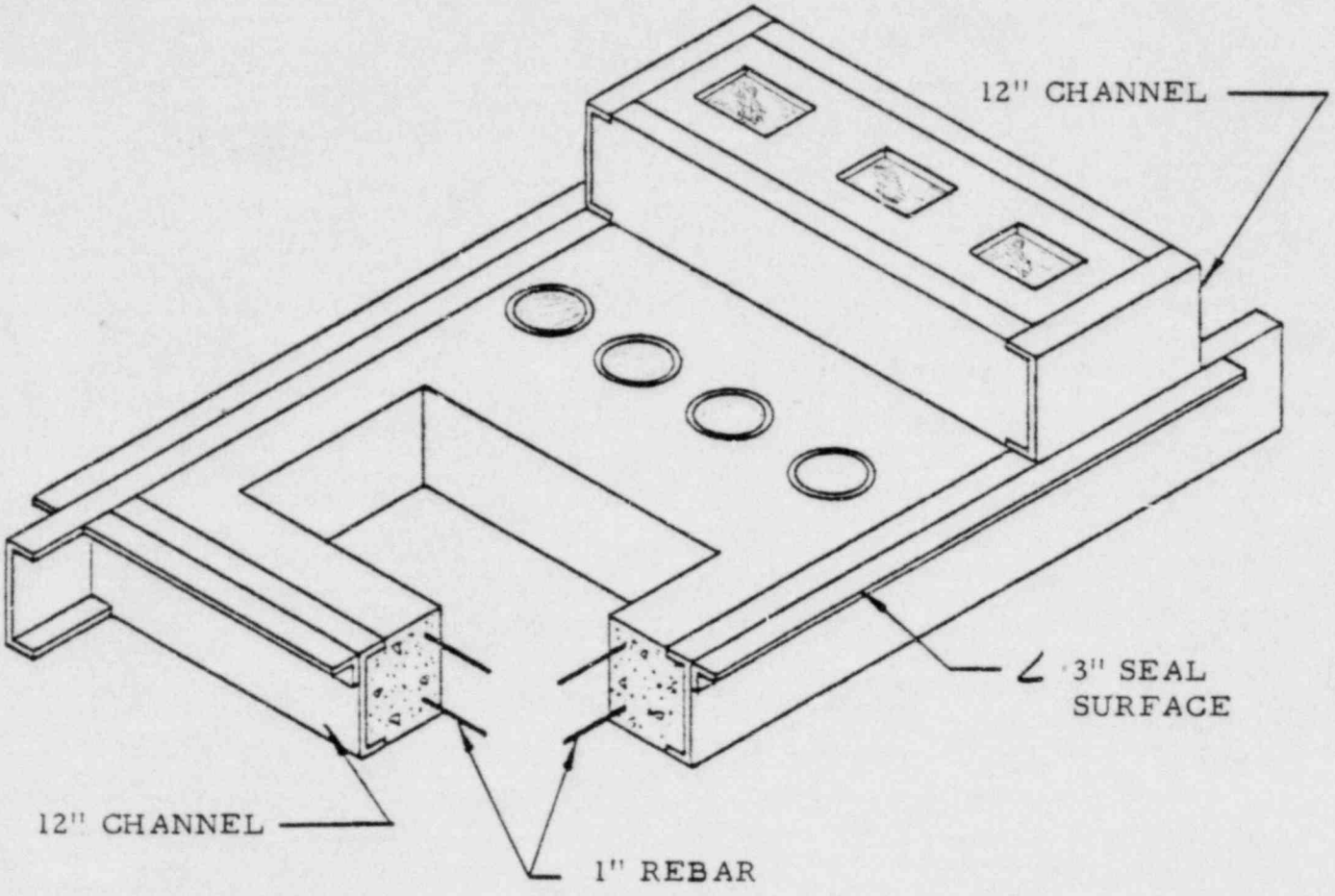


Figure 4. Schematic of Slab Layout

TABLE 1

CABLE TYPES USED

Number of Conductors	Conductor Size	Insulation	Function	BG&E Cable Code
2	14AWG	Silicone	Control	B12/B62
5	14AWG	Silicone	Control	B14/B64
7	12AWG	Silicone	Control	B19
3	10AWG	Silicone	Power	B01/B51
2	14AWG	Silicone	Instrument	C01/C51
2	14AWG	XLP	Control	B25
5	14AWG	XLP	Control	B27
3	350MCM (Triplexed)	HTK	Med. Volt. Power (5KV)	A02

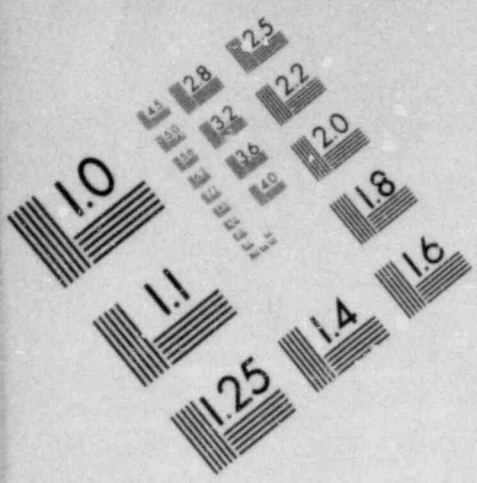
TABLE 2

CABLE LOADING

Type and number of cables per tray

Cable Code	Tray 1 (100%)	Tray 2 (50%)	Tray 3 (100%)	Tray 4 (50%)	Tray 5 (50%)	Tray 6 (100%)
B12	22	16	25	- -	16	19
B14	24	16	19	- -	16	25
B19	32	22	37	- -	22	35
B01	28	22	20	- -	22	22
C01	24	22	24	- -	22	17
B25	10	6	12	- -	6	10
B27	10	6	10	- -	6	10
A02	- -	- -	- -	4*	- -	- -
TOTAL	150	110	145	4*	110	138

* Four sets of three 350MCM cables, triplexed



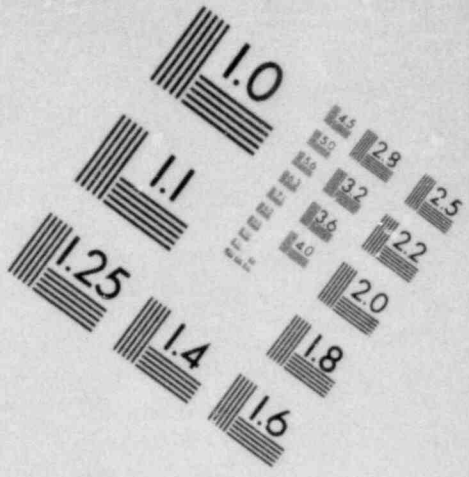
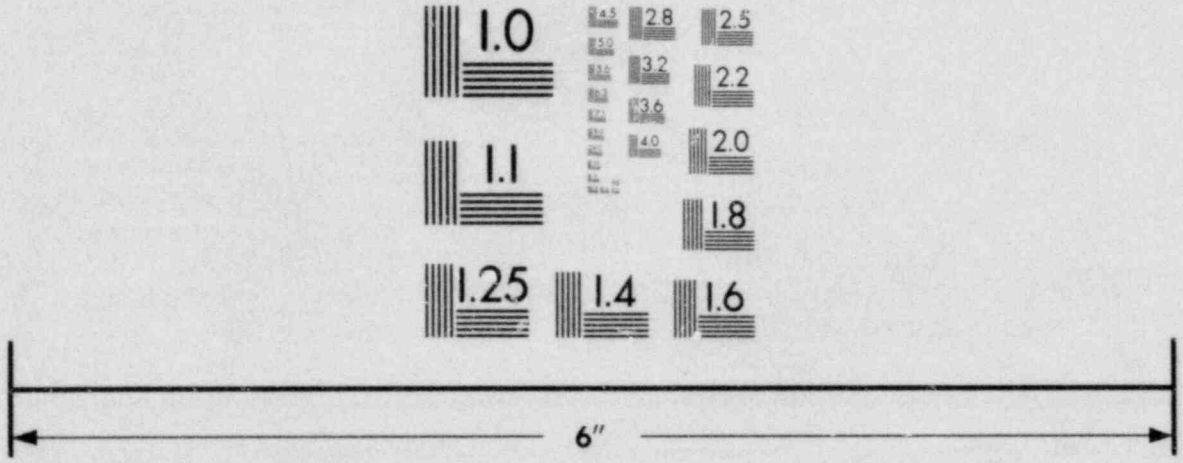
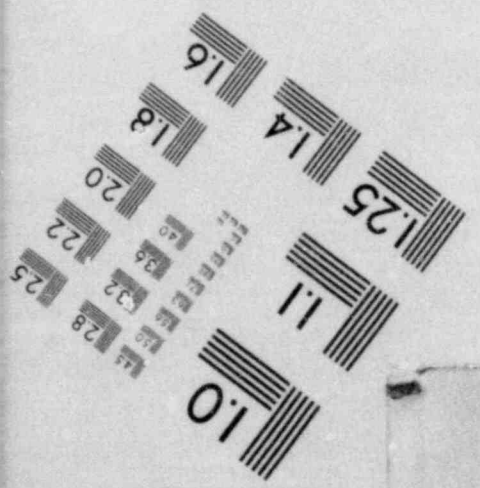
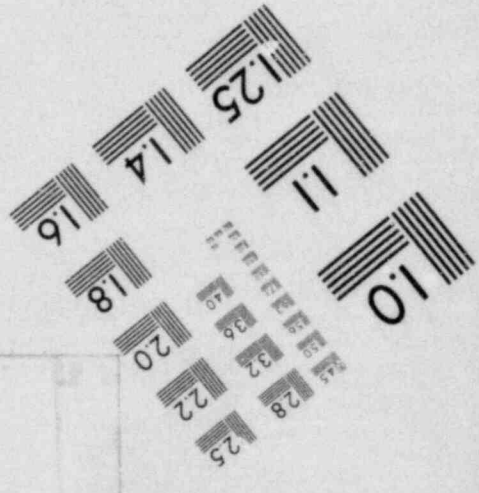


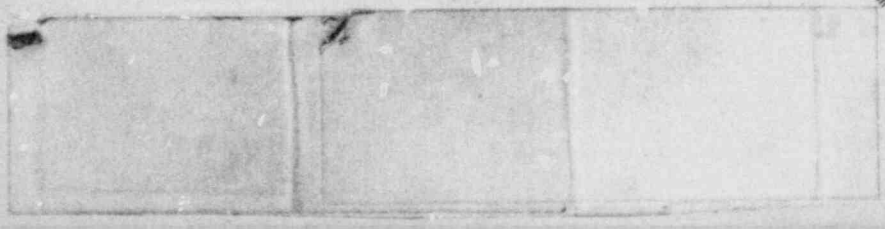
IMAGE EVALUATION
TEST TARGET (MT-3)

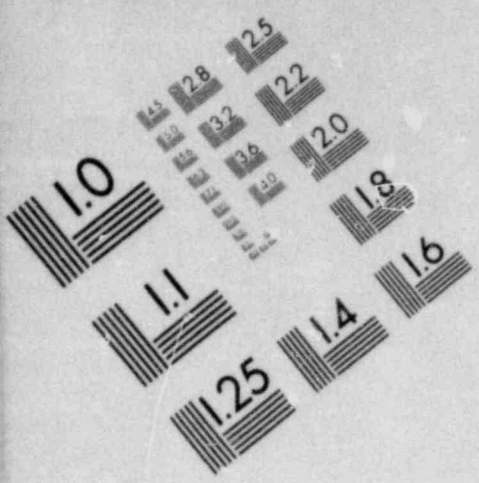


MICROCOPY RESOLUTION TEST CHART









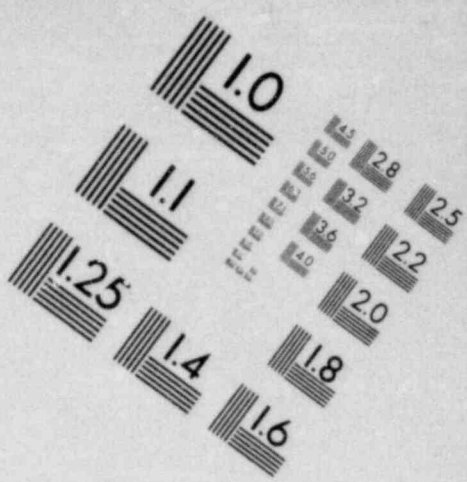
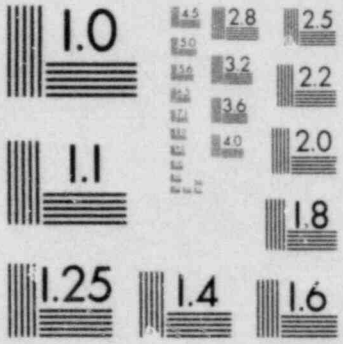
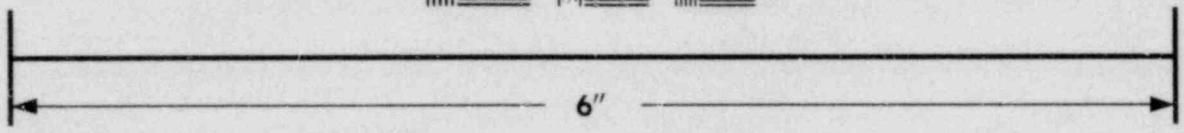
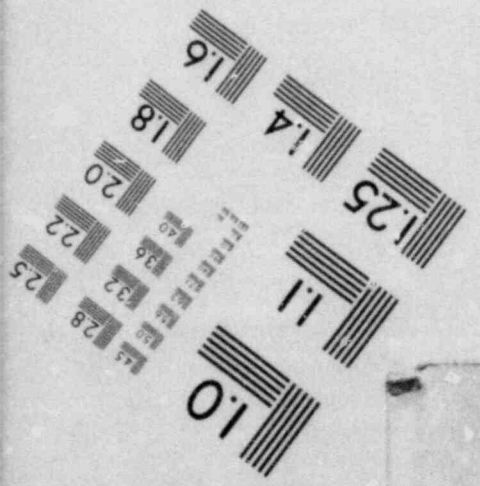


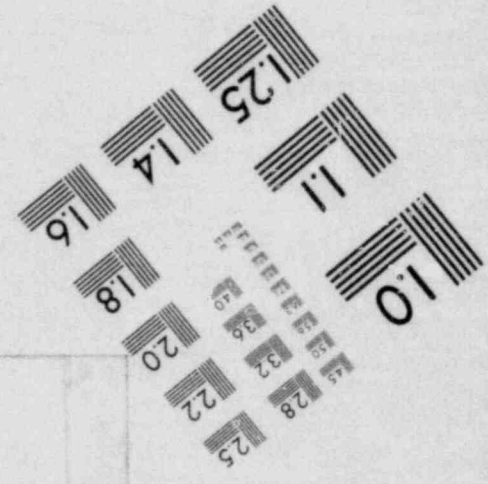
IMAGE EVALUATION
TEST TARGET (MT-3)





MICROCOPY RESOLUTION TEST CHART





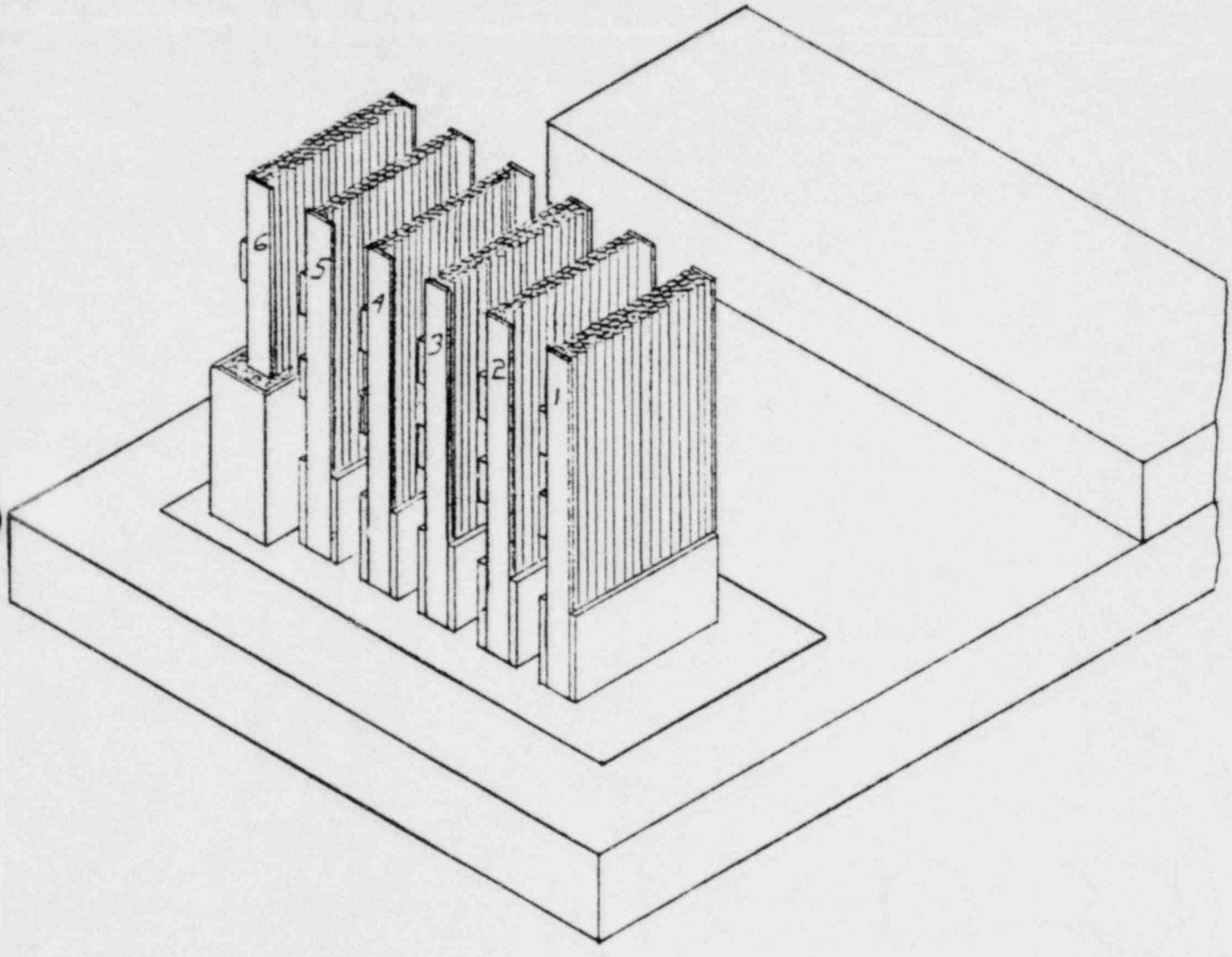


Figure 5. Cable Tray Layout

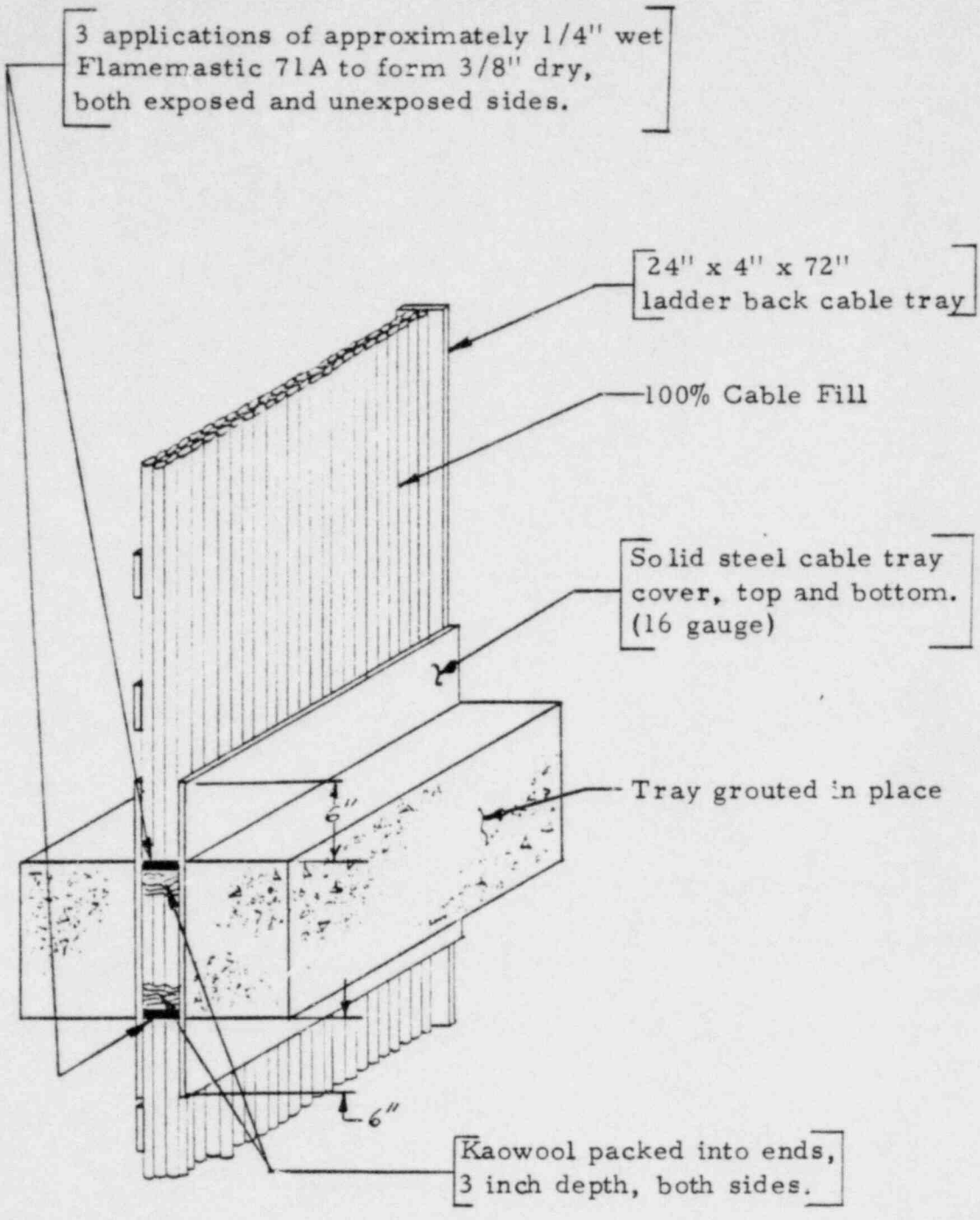


Figure 6. Cable Tray Penetration No. 1

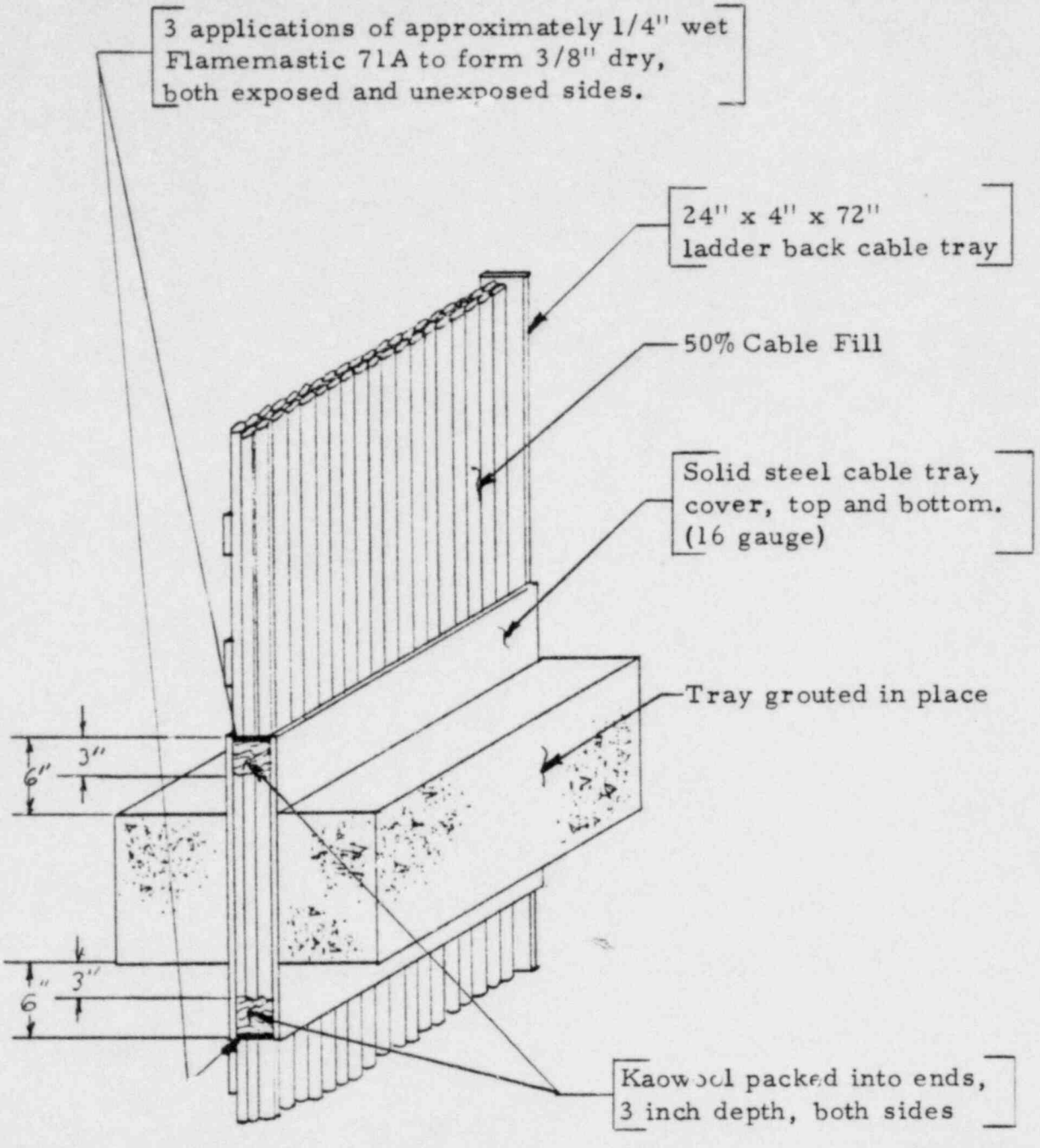


Figure 7. Cable Tray Penetration No. 2

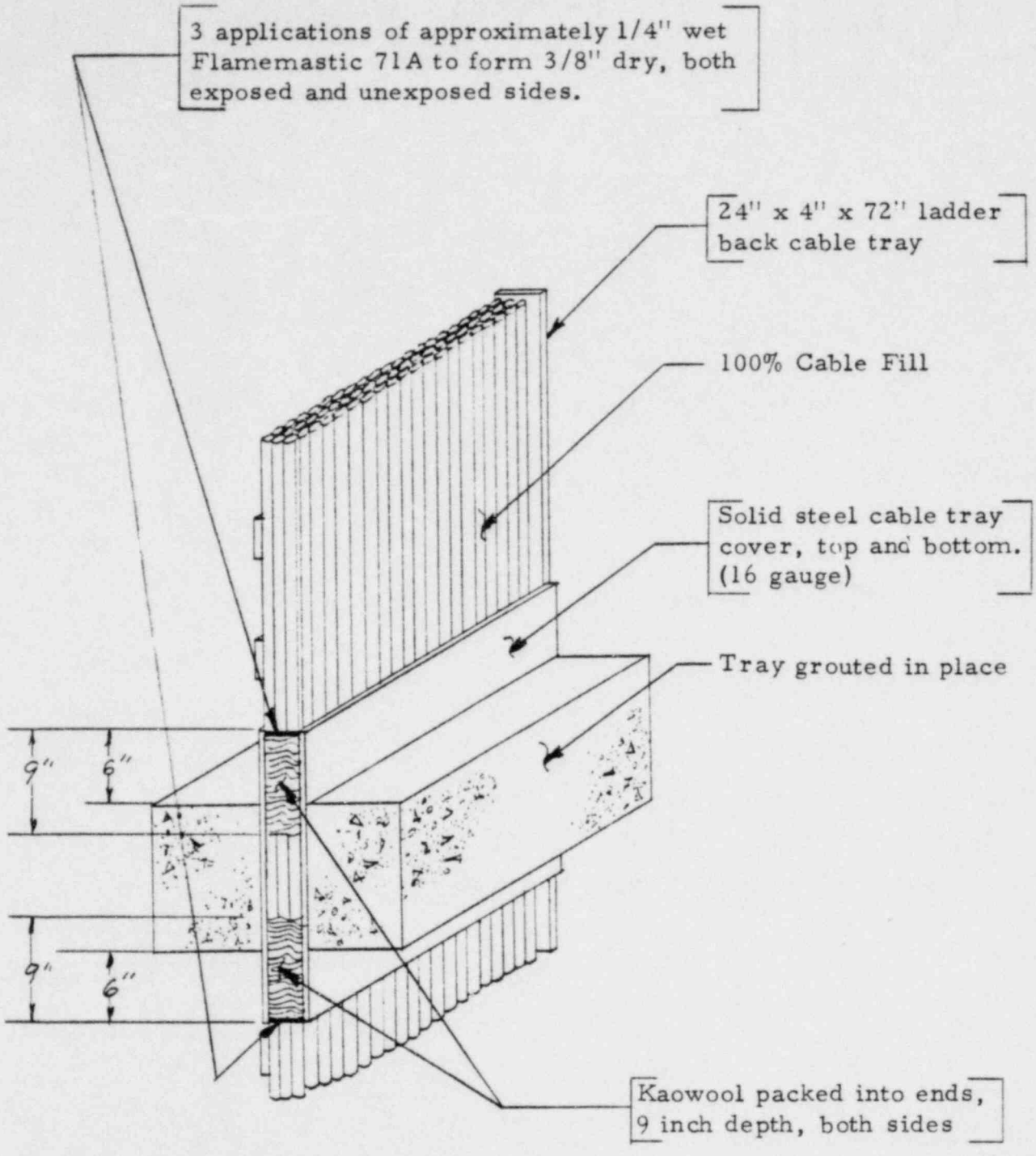


Figure 8. Cable Tray Penetration No. 3

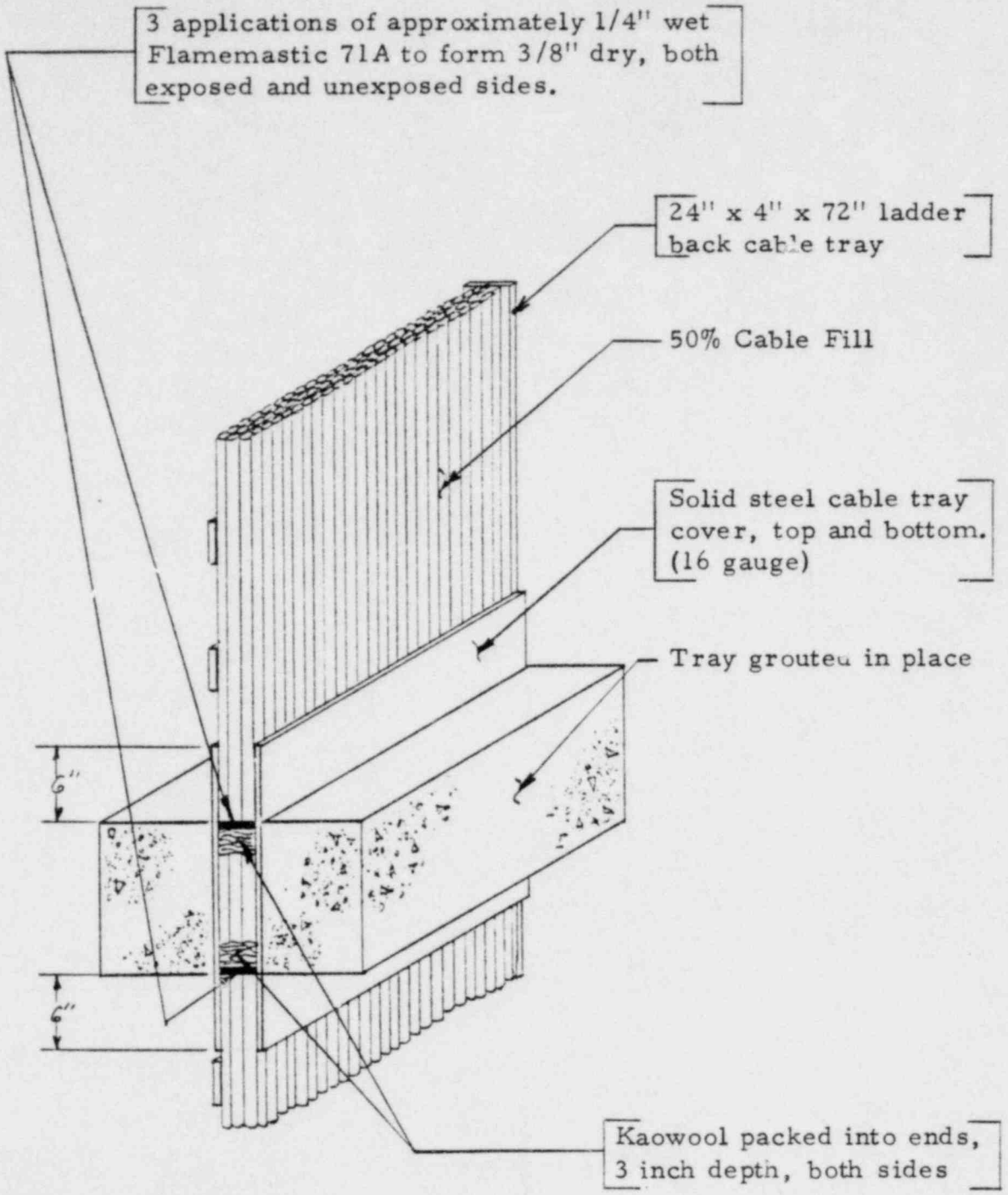


Figure 9. Cable Tray Penetration No. 4

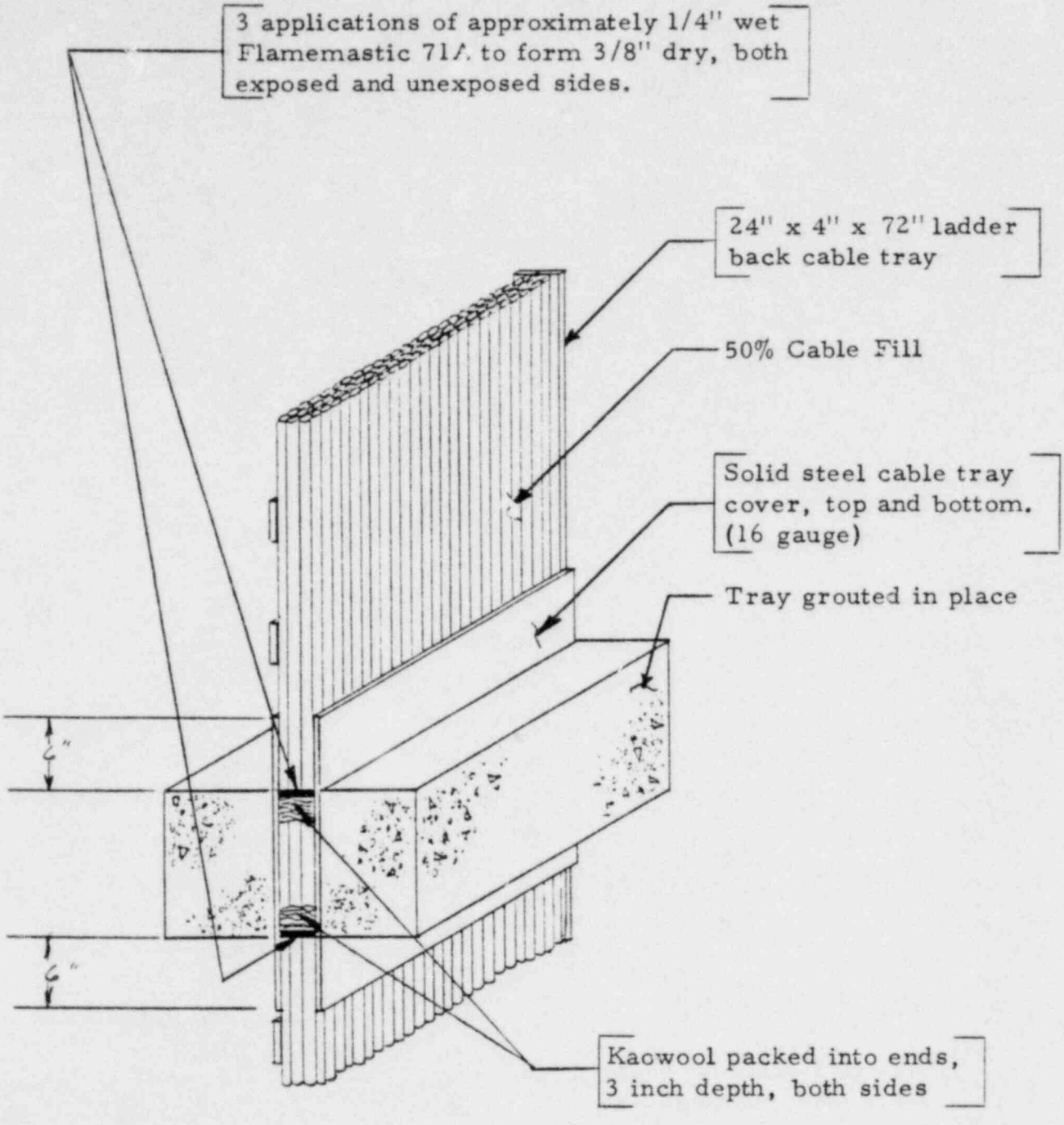


Figure 10. Cable Tray Penetration No. 5

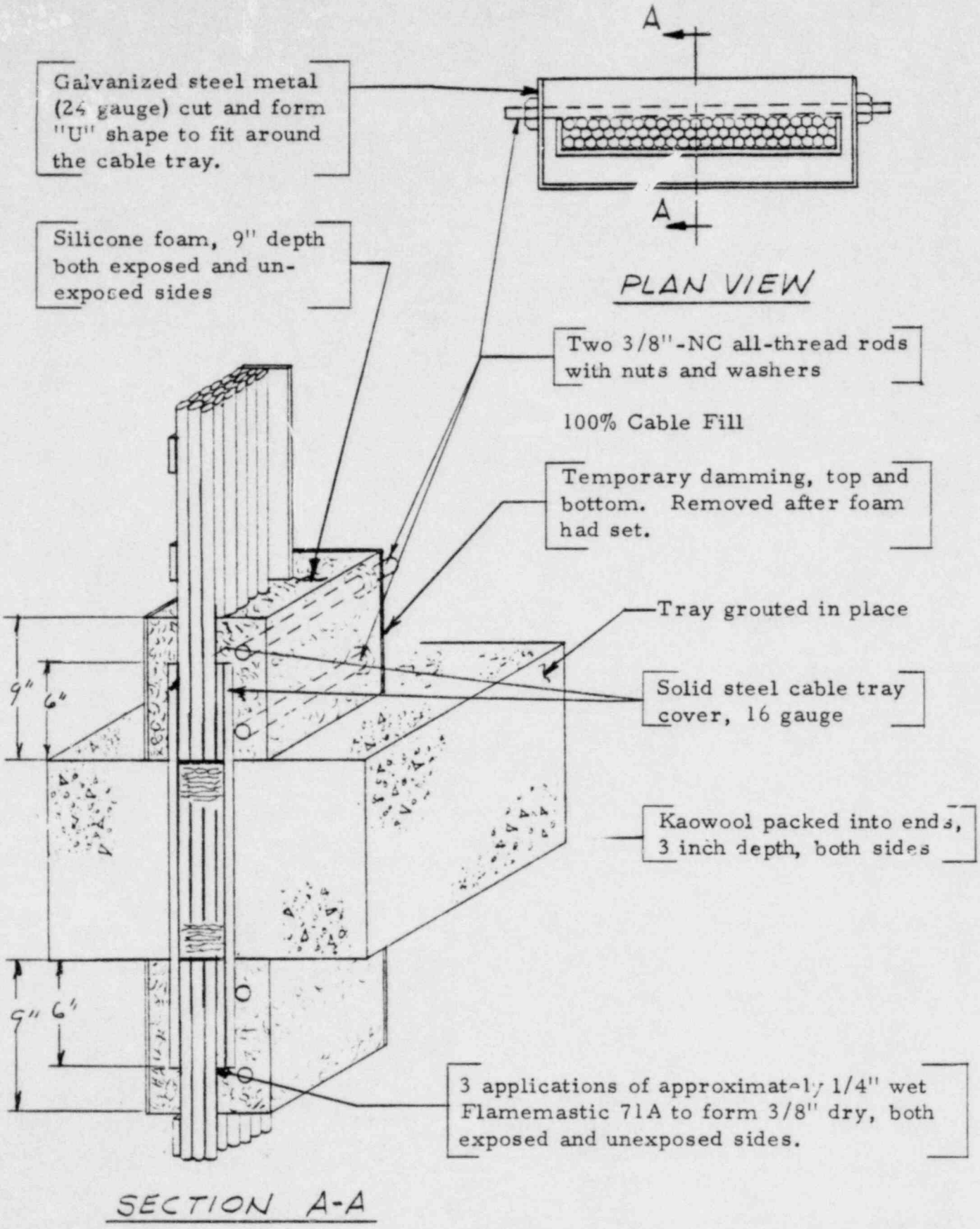


Figure 11. Cable Tray Penetration No. 6

TEST FACILITY

The floor penetration assembly fire resistance test was conducted using a horizontal furnace with an open area of 8ft. x 10 ft. (See Figure 12). A flue gas opening was provided on one end. Eight Maxon self-aspirating burners were mounted in the sides and ends of the furnace. Eight furnace temperature thermocouples were located 2-1/2 ft. inside each side wall at 2 foot centers with the first pair of thermocouples 1-1/2 ft. from the flue end of the furnace at the 24" elevation. Twenty four thermocouples on the unexposed side of the six cable trays were connected to multi-point temperature recorders having a range of 0 to 2,000°F and a digital printout of 60 points per minute. The instrumentation is described in Appendix V and the data obtained is contained in Appendix IV.

All gas flow to the burners was controlled manually and continuously indicated by the average of six furnace temperature thermocouple readings taken at 12" from the exposed specimen surface. These average temperatures are shown in Figure 13 and Table 3.

Since the test was conducted outdoors, a building was erected around the furnace to meet ASTM E119 standards. This structure was adequate to prevent excessive air currents over the unexposed surface of the test slab. The outside temperature was 80 degrees F at the start of the test.

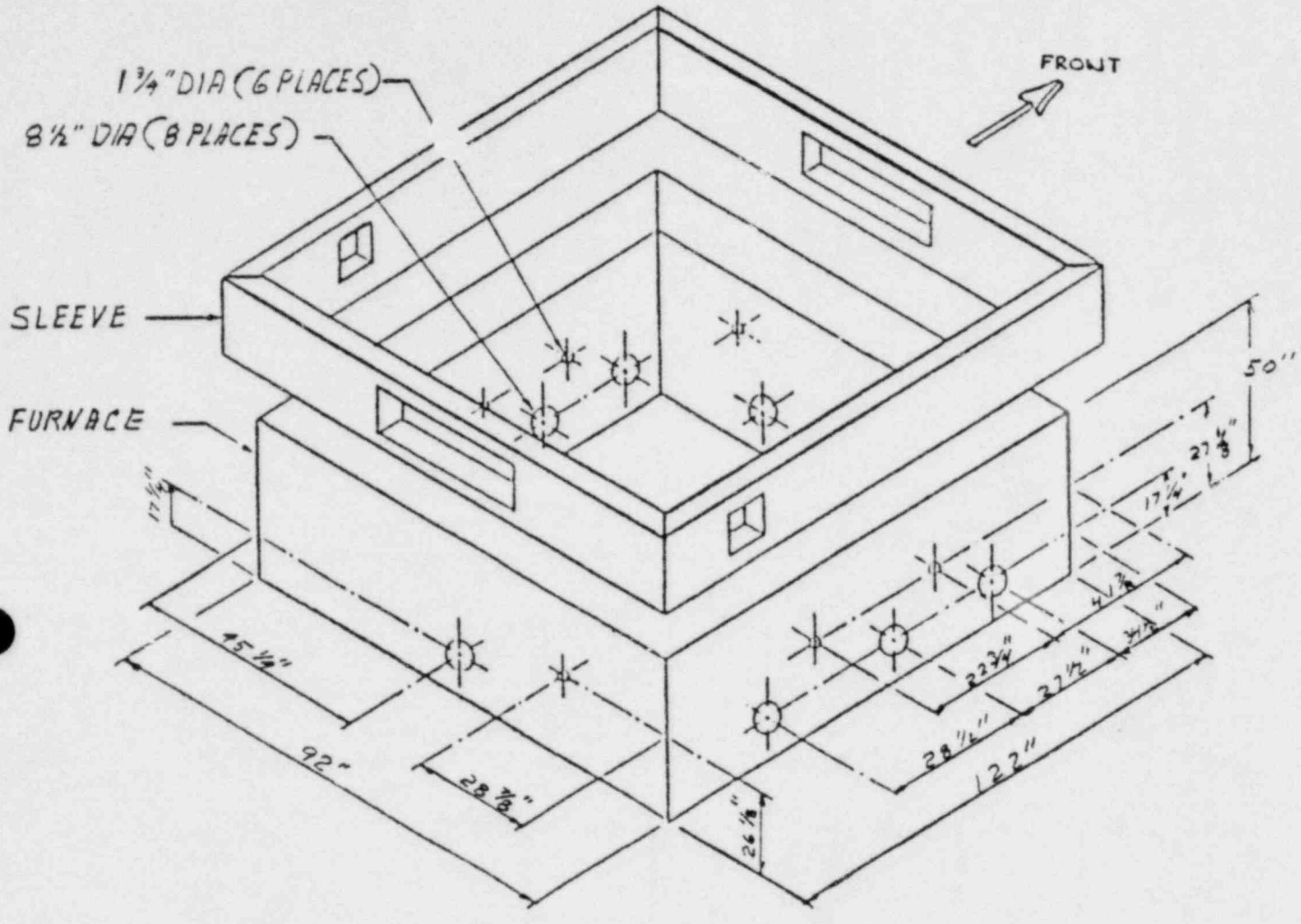


Figure 12. Test Furnace

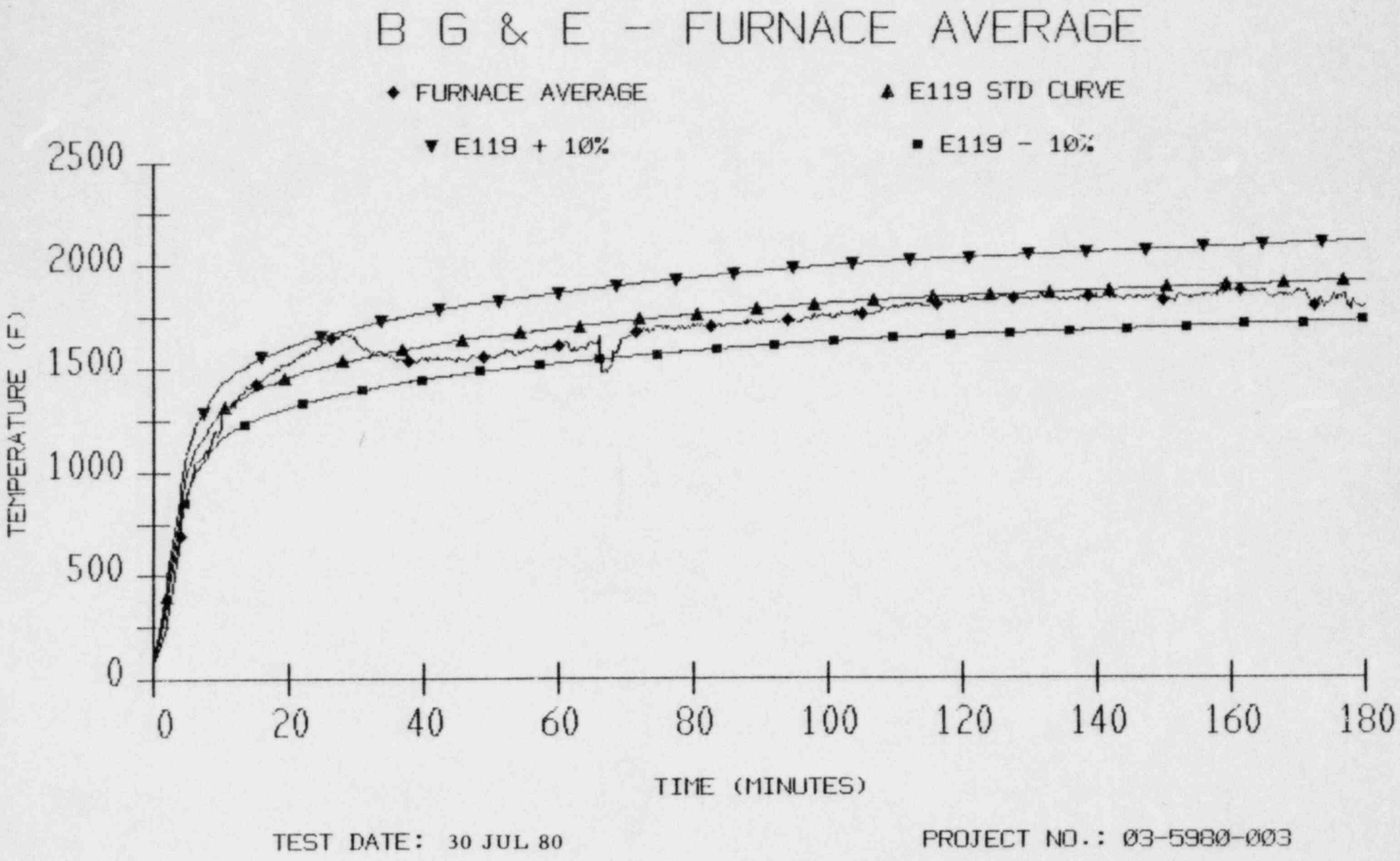


Figure 13. Furnace Temperature

TABLE 3

ASTM E119 Time/Temperature Curve

Time	Standard Curve	-10%	Actual	+10%	Time
0	70	63	80	77	0
1	200	180		220	1
2	400	360		440	2
3	600	540		660	3
4	800	720		880	4
5	1000	900	883	1100	5
6	1100	990		1212	6
7	1150	1035		1265	7
8	1200	1080		1320	8
9	1250	1125		1375	9
10	1300	1170	1228	1430	10
11	1320	1188		1452	11
12	1350	1206		1474	12
13	1360	1224		1496	13
14	1380	1242		1518	14
15	1399	1259	1430	1539	15
16	1414	1274		1555	16
17	1429	1286		1572	17
18	1435	1291		1579	18
19	1450	1305		1595	19
20	1462	1316	1523	1608	20
21	1474	1327		1621	21
22	1486	1337		1635	22
23	1498	1348		1648	23
24	1500	1350		1650	24
25	1510	1359	1622	1661	25
26	1520	1368		1672	26
27	1528	1375		1681	27
28	1537	1363		1691	28
29	1541	1387		1695	29
30	1550	1395	1636	1705	30
35	1584	1425	1560	1742	35
40	1613	1452	1554	1774	40
45	1630	1467	1546	1793	45
50	1661	1495	1561	1827	50
55	1681	1513	1591	1849	55
60	1700	1530	1611	1870	60
65	1718	1546	1632	1890	65
70	1735	1561	1657	1909	70
75	1750	1575	1704	1925	75
80	1765	1589	1717	1941	80
85	1779	1601	1714	1957	85
90	1792	1613	1726	1971	90
95	1804	1624	1731	1984	95
100	1815	1633	1753	1994	100
105	1826	1643	1784	2009	105
110	1835	1651	1794	2019	110
115	1843	1659	1804	2027	115
120	1850	1665	1834	2035	120
130	1862	1676	1835	2048	130
140	1875	1687	1853	2063	140
150	1888	1699	1826	2077	150
160	1900	1710	1870	2090	160
170	1912	1721	1869	2103	170
180	1925	1733	1797	2117	180

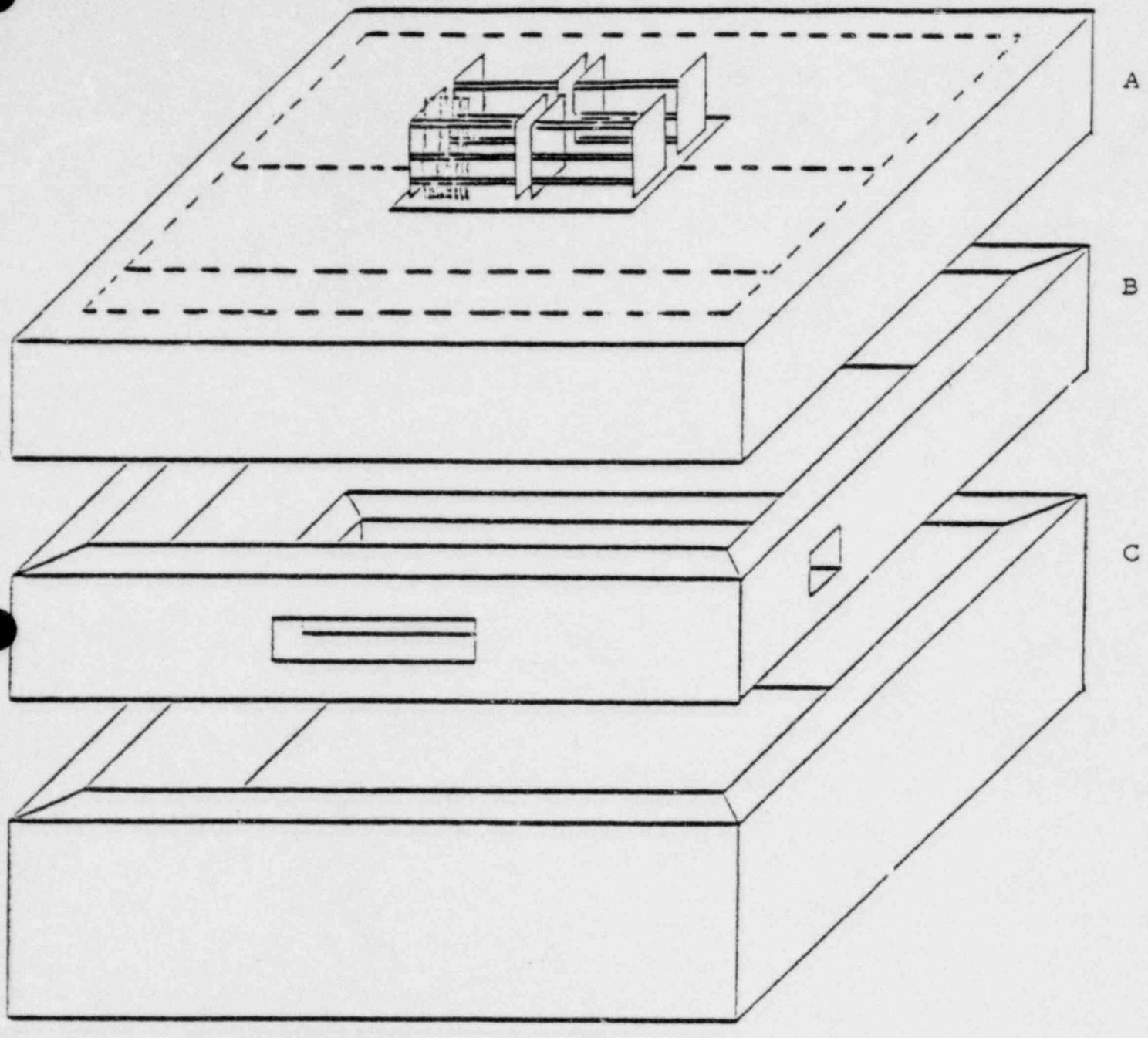
TEST PROCEDURE

The prepared floor penetration slab with the fire stop materials in place was placed in position on top of the furnace. The temperature recorders were turned on, natural gas was fed to the burners, ignited, and the test clock was started. The unexposed surface was continually observed for penetration by flame or hot gases and its temperature monitored, by using the multipoint recorders. The internal pressure of the furnace was also monitored throughout the test, and was maintained at +0.01 to +0.02 inches of water. At one hour of elapsed time into the test, there was an apparent increase of the furnace internal pressure to +0.22 inches of water, but examination of the pressure sensing tube showed that it had become obstructed, possibly by droppings from the cables, and the pressure increase observed on the manometer was caused by heating of the obstructed tube. The sensing tube was cleared and the furnace pressure indicator immediately returned to normal, i.e., +0.015 inches of water.

At the end of the three hour fire exposure period, the fuel gas was shut off and, as quickly as possible, the protective enclosure over the test slab was removed. The test slab was removed from the furnace, remaining in a horizontal position.

A spray stream supplied from a 1-1/2 inch fire hose with a spray stream setting at 30° included angle and 75 psi nozzle pressure was then directed at the floor penetration fire stops from a distance of 10 feet to conduct the hose stream test. The nozzle was a Goodall Utility FHN-172-U supplied by Baltimore Gas and Electric from its Calvert

Cliffs plant. This hose stream test is identified on page 13, Section 5.3.12 of IEEE 634-1978 (Page VI-12, Appendix VI), and is commonly referred to as the "NEL-PIA Hose Stream Test". The required hose stream application time for penetrations installed in a 3 ft. x 6 ft. blockout was 27 seconds. The time/temperature record of the test is shown in Figure 13 and Table 3. Figure 14 shows an exploded view of the test setup.



A) Test Slab (Typical)
B) Furnace Extension Sleeve
C) Furnace

Figure 14. Furnace Assembly

TEST RESULTS

A. TEST OBSERVATIONS

The following are observations made during the fire exposure period, the hose stream test and the post-test inspection.

TABLE 4. TEST OBSERVATIONS

Test Time	Event	
-0.05	Furnace loaded, very light winds, 81°F, 88% RH	
0:00	Burners on, timer on, recorders on, start test	
0:05	Temp. 880°F	Light smoke, furnace/spacer interface
0:10	Temp. 1228°F	Very light smoke, trays 1, 2, 3, 6 from between cables
0:20	Temp. 1523°F	Smoke increasing slightly, tray 2
0:30	Temp. 1636°F	Slightly above norm, reduce gas flow a little. Only tray 2 smoking now, smoke is white, cool to touch
0:40	Temp. 1554°F	Increase gas flow, bit below norm.
0:50	Temp. 1561°F	Smoke from tray 2 easing off
1:00	Temp. 1611°F	Furnace pressure +0.22" H_2O Cleaned obstruction in sensing tube pressure now normal, +0.015"
1:10	Temp. 1657°F	Light smoke, Trays 1, 2, 3, 5, & 6
1:20	Temp. 1717°F	Stable, on curve
1:30	Temp. 1726°F	Trace of cool, white smoke from Tray 4.
1:40	Temp. 1753°F	Only trays smoking now are 2 and 3, very light smoke from between cables
1:50	Temp. 1794°F	
2:00	Temp. 1834°F	Still light, white smoke from Tray 2
2:10	Temp. 1835°F	
2:20	Temp. 1853°F	Tray 2 smoke slacking off
2:30	Temp. 1826°F	Very small amount of light smoke from Tray 3, very little smoke from 2
2:40	Temp. 1870°F	All stable, looking good
2:50	Temp. 1869°F	Smoke from tray 2 light gray
3:00	Temp. 1797°F	Very light smoke again, tray 1, gray smoke from tray 2. Center of tray 5 metal cover, south side, slightly distorted, pulling away from grout. Same on tray 2, both sides

TABLE 4. TEST OBSERVATIONS - Continued

Test Time	Event
3:02	Protective housing removed
3:03	Slab hooked and moved for hose stream test
3:04	Start hose stream test
3:05	Hose stream test complete, no water penetration
3:10	Photodocumentation complete
3:12	Slab settled for viewing

Post-Test Observations

1. All seals (6) did not allow the passage of flames during the fire exposure period

2. Light smoke did pass through all of the trays during the course of the fire exposure period, but remained cool to the touch.

3. None of the seals allowed water to pass during the hose stream test.

B. SUMMARY OF TEST ACCEPTANCE CRITERIA

A fire stop shall be considered as meeting the requirements for acceptable performance as prescribed in the BG&E test procedure, Section E, "Acceptance Criteria". (See Appendix I). It is restated below:

1. Each of the individual cable fire stops shall be considered acceptable for use in rated fire barrier provided:

   a. Each fire stop withstands the fire endurance tests as described without passage of flame or gases hot enough to ignite the cable or other fire stop materials on the unexposed side for a period equal to the required fire rating.

b. Each fire stop withstands the hose stream test as described without causing an opening through the fire stop.

2. The successful completion of the above tests by such penetration assembly in the horizontal configuration shall qualify each such assembly for field installation consistent with the rating achieved in both horizontal and vertical penetrations.

3. Results of one or several cable tray penetrations shall not prejudice the results of any other individual penetration design.

C. TEST CONCLUSIONS

As prescribed by the fire test procedure and the guidelines in ASTM E119-76 for the fire test, IEEE 634-78 Section 5.3.12 for the hose stream test, and the ANI-MAERP Test Method for the temperature rise on the unexposed side, the following is a list of conclusions made:

1. ORIGINALLY PROPOSED DESIGN

Trays 1, 4, and 5 successfully passed the referenced E119 fire test, the IEEE hose stream test and the ANI temperature requirement.

2. CONSERVATIVE CONFIGURATION, 50% FILL

Cable tray 2 successfully passed the referenced E119 fire test, the IEEE hose stream test and the ANI temperature requirement.

3. PREVIOUSLY TESTED DESIGN

Cable tray 3 successfully passed the referenced E119 fire test, the IEEE hose stream test and the ANI temperature requirement.

4. ORIGINALLY PROPOSED DESIGN WITH ADDITIONAL MODIFICATIONS

Cable tray 6 successfully passed the referenced E119 fire test, the IEEE hose stream test and the ANI temperature requirement.

5. The highest temperature reached on any penetration field, (F Thermocouples) was 311°F on Cable Tray no. 5. All other penetration field temperatures were below 300°F.
6. The highest temperature reached on any grout field, (E thermocouples) was 320°F on Cable Tray no. 2. All other grout field temperatures were below 260°F.

TABLE 5

SUMMARY OF TEST RESULTS

BG&E ACCEPTANCE CRITERIA (APPENDIX I)

Penetration Identification	No passage of flames	No passage of gases hot enough to ignite cable of seal	No opening due to Hose Stream Test
Tray 1	Pass	Pass	Pass
Tray 2	Pass	Pass	Pass
Tray 3	Pass	Pass	Pass
Tray 4	Pass	Pass	Pass
Tray 5	Pass	Pass	Pass
Tray 6	Pass	Pass	Pass
Grout	Pass	Pass	Pass

APPENDIX I

PROCEDURE FOR FIRE TEST OF CABLE PENETRATIONS

FIRE TEST PROCEDURE FOR CABLE PENETRATIONS

ADDITIONAL TESTS

CALVERT CLIFFS NUCLEAR POWER PLANT

UNITS 1 AND 2

BALTIMORE GAS AND ELECTRIC COMPANY

BALTIMORE, MARYLAND

Prepared By Premnath Bhatta Date June 12, 1980

Reviewed By [signature] Date 6/12/80

Reviewed By [signature] Date 6/12/80

Approved By [signature] Date [illegible]

FIRE TEST PROCEDURE FOR CABLE AND PENETRATIONS

CONTENTS

CALVERT CLIFFS NUCLEAR POWER PLANT

Sponsor: Baltimore Gas and Electric Company

Laboratory:

A. Purpose:

1. The purpose of this test is to evaluate the existing cable penetration fire stop design and construction in order to qualify them by test at an independent test laboratory per ASTM E-119-1976 Standard Time-Temperature Curve for the required three hour separation. In addition, proposed modifications to fire stop designs and construction will be tested simultaneously.
2. Two tests should be conducted:
   a. one with no differential pressure
   b. one with a differential pressure of 2" of H_2O

B. Scope:

1. Test shall be conducted on a custom concrete slab having a 1'-0" thick segment with a blockout as shown in Figure 1. It shall be fire endurance tested for a minimum of three hours in accordance with ASTM E-119-1976 Standard Time-Temperature Curve and hose stream test shall be performed per IEEE Std. 634-1978, Section 5.3.12, except for the use of a nozzle from the Sponsor's inventory.
2. A single test, having various fire stop penetration configurations as shown on Figure 2, shall be conducted within fifteen (15) days of issuance of a written Purchase Order to proceed.
3. Each arrangement, i.e., each of six trays, shall be tested and reported independently from every other arrangement, thus constituting six concurrent fire endurance tests and hose stream tests in each of two tests.
4. The fire stop assembly shall be tested in the horizontal configuration (floor configuration) to qualify for both floor and wall fire stop design.

C. Description of Test Materials:

1. Two test slabs shall be furnished to fit the test furnace with required blockouts as shown in Figure 1. The Laboratory shall supply the Sponsor with the necessary drawings of the final slab design at the time of, or prior to, written acceptance of the contract.
2. The test slab, masonry grout, all test instrumentation, unistrut material, miscellaneous hardware and tools shall be supplied by the Laboratory. Materials other than cables and nozzles, shall be provided by the Laboratory.
3. All cables shall be supplied by the Sponsor in order that the test reproduces the installed field conditions.
4. The installation of electrical cable and cable trays, grouting and filling with fire resistive materials shall be by the Laboratory. The Sponsor shall furnish no test site labor, but shall provide a representative to witness the installation.
5. Cable trays, shall be approximately six (6) ft. long and installed with approximately one (1) foot extension below the slab (into the furnace) leaving four (4) feet extending above the slab top surface.
6. Cable trays and covers shall be galvanized steel or reconditioned with galvanized paint by the laboratory and installed as shown on Figures 1 through 6.
7. Cable supplied in trays, shall be medium voltage (kerite), low voltage power, control and instrumentation with silicone rubber insulation, glass braid and an overall asbestos braid jacket, as provided by the Sponsor. Sponsor shall also furnish non-silicone rubber (EETK, XLP or EPR) insulated cable for use as outlined in C.8.
8. Cable tray fill shall be as follows, based on physical capacity, i.e., level cross section as opposed to a percentage of mass vs. void area as is common in the electrical trade:

Tray	Fill	Cable Type*
1	100%	90% Silicone, 10% Non-silicone
2	50%	90% Silicone, 10% Non-silicone

Tray	Fill	Cable Type*
3	100%	90% Silicone, 10% Non-silicone
4	50%	100% Non-silicone (Med. volt, HTK-Kerite)
5	50%	90% Silicone, 10% Non-silicone
6	100%	90% Silicone, 10% Non-silicone

*Percentage by number of cables.

The recommended cable tray fills are shown in Appendix C.

D. Description of Test

1. The fire stop configuration shall be fire endurance tested to the ASTM E-119-1976 Standard Time-Temperature Curve for a minimum of three hours.
2. Immediately following the fire endurance test, the assembly shall be hose stream tested to IEEE Std. 634-1978, Section 5.3.12, consisting of a spray stream set at 30° included angle, from a 1 1/2 inch nozzle from the Sponsor's stock at a pressure of 75 psi, at a distance of 10 ft., with a minimum flow of 75 gal./min. The hose-stream shall be directed at the exposed side of the slab for a period of time determined by the net exposed slab surface area, on the basis of 2 1/2 min. per 100 sq. ft.
3. Thermocouples shall be available and instrumented for use in monitoring temperatures of various elements during the fire endurance test. Minimum requirements of IEEE Std. 634-1978, Section 5.3.7 through 11, should be used.

E. Acceptance Criteria

1. Each of the individual cable fire stops shall be considered acceptable for use in rated fire barrier provided:
   a. Each fire stop withstands the fire endurance tests as described without passage of flame or gases hot enough to ignite the cable or other fire stop materials on the unexposed side for a period equal to the required fire rating.
   b. Each fire stop withstands the hose stream test as described without causing an opening through the fire stop.

2. The successful completion of the above tests by such penetration assembly in the horizontal configuration shall qualify each such assembly for field installation consistent with the rating achieved in both horizontal and vertical penetrations.

3. Results of one or several cable tray penetrations shall not prejudice the results of any other individual penetration designs.

F. Documentation

1. Following the procedures as outlined in this Specification and also the standards as listed in B.1, all data shall be provided to document satisfactory compliance.

2. Engineering data and references to the other publications which were used to make the test and select the equipment shall be included in the documentation.

3. The results, pass or fail for each penetration, shall be documented and supplemented with photographs and a statement of the conclusions drawn by Laboratory. A final certified test report shall be transmitted to the Sponsor within 15 days of the completion of the test.

4. Installation methods shall be described including any Quality Assurance data applicable to the specific materials and installation methods used.

G. General

Personnel from Baltimore Gas and Electric Company, Bechtel Corporation (consultant) and NRC shall be allowed to witness the tests. The Sponsor shall be notified 5 working days in advance of the performance of the test.

APPENDIX A

Installation Details

Figure 1

A general arrangement plan view of the stepped, two thickness test slab is shown which was sized by the SWR Lab for previous tests conducted for the spouser. The same slab shall be used for additional testing. Only 1 foot thick section of the slab with a blockout for cable trays shall be used. All other blockouts shall be closed for the duration of the test. The test slab shall be "patched-up" by application of concrete patching materials containing epoxies to restore the test slab and protect exposed reinforcant as may be required.

A similiar test slab, not having the two thickness feature, shall be reconditioned for use in the second test.

Figure 2

Figure 2 represents cable trays with different configuration of fire stops.

Cable trays 1, 4 and 5 represent the fire stop design as shown in Fire Study Figure D-2.

Cable tray 2 represents the most conservative configuration which could exist in the plant with 50% fill.

Cable tray 3 represents the design which was tested successfully for three hours but during the application of a straight stream hose pattern some water was observed on the unexposed side of the test slab. This is to be tested again.

Cable tray 6 represents the design as shown in Fire Study Figure D-2 with additional modifications, which may be used if required.

All cable trays in the existing slab shall be cleaned. Apply a coating of galvanized paint if required. (It is the responsibility of the lab to assure that cable trays and slab will not deteriorate since this was used previously.)

Each tray shall have Kaowool handpacked as shown in Fig. 2 (and also in Figs. 3, 4, 5 and 6) at both top and bottom surfaces of the blockout. The depth of the Kaowool

shall be as shown in respective figures. Kaowool shall be handpacked after cables have been laced in cable travs. Both exposed surfaces (ie. opposite sides of this wall) of the Kaowool packing shall be covered with a succession of three (3) applications of approximately 1/4" wet flamemastic 71A spray to form a final, cured coating of 3/8" depth. See individual tray details for precise location of Kaowool packing and flamemastic coating.

Tray No. 6 (Refer to Fig. 6) shall be the same as tra No. 1 except a "U" shaped (9" x 9" x width of the trav) galvanized metal sheet shall be bolted around tray with 1/4" all threaded rod. This shall be filled with Silicone RTV Foam (20 lbs/cu ft density). Necessary damming material shall be provided wherever required and then removed before the test.

Figures 3, 4, 5 and 6

The above figures represent individual trays.

Note: All cables in the cable tray shall be supported on both sides of the slab.

APPENDIX B

Material List

Cables and spray nozzle will be supplied by the sponsor. All other material shall be supplied by the Laboratory.

APPENDIX C

A. The following cable types and quantities will be supplied by the sponsor.

Type	Function	BG&E Cable Code	Req'd Quantity Feet
2/C #14AWG Silicone	Control	B12/B62	680
5/C #14AWG Silicone	Control	B14/B64	680
7/C #12AWG Silicone	Control	B19	870
3/C #10AWG Silicone	Power	B01/B51	870
2/C #14AWG Silicone	Instrument	C01/C51	870
3/C - 350MCM HTK Triplexed	Medium Voltage Power (5KV)	A02	24

A-1. The following cable types and quantities will be supplied by the Laboratory:

(To be purchased from Rockbestos Company.)

2/C #14AWG XLP	Control	B25	152
5/C #14AWG XLP	Control	B27	152

B. Recommended Fills

The eight cable types are to be cut into 6 foot lengths and installed into various raceways with the following distribution and quantities:

Tray Numbers 1, 3 and 6 (100% Fill)

B12/B62	27 Cables
B14/B64	27 Cables
B19	37 Cables
B01/B51	37 Cables
C01/C51	37 Cables
B25/B75	10 Cables
B27/B77	10 Cables
Total	- 185

Tray Numbers 2 and 5 (500% Fill)

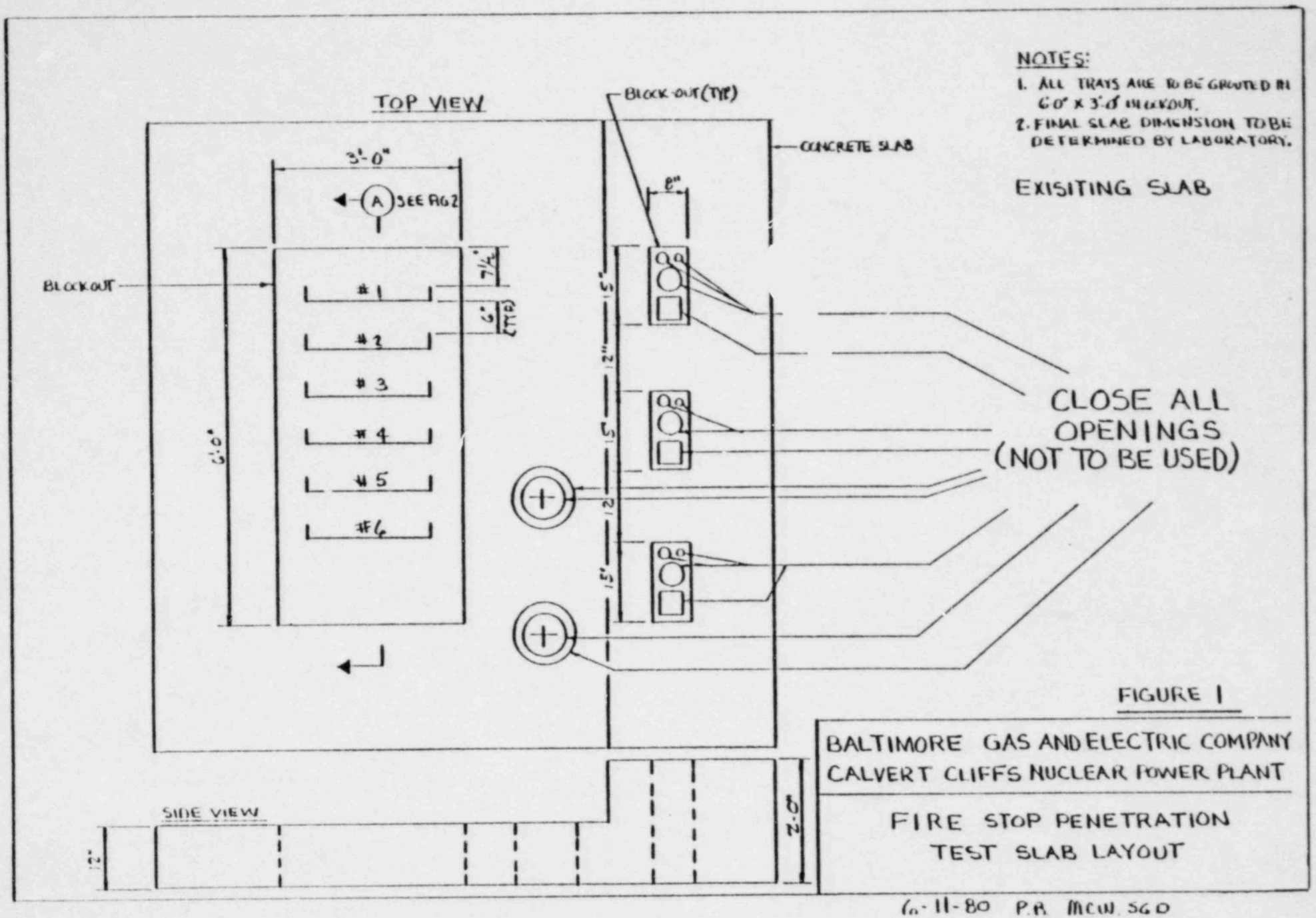
B12/B62	16 Cables
B14/B64	16 Cables
B19	22 Cables
B01/B51	22 Cables
C01/C51	22 Cables
B25/B75	6 Cables
B27/B77	6 Cables

Total - 110

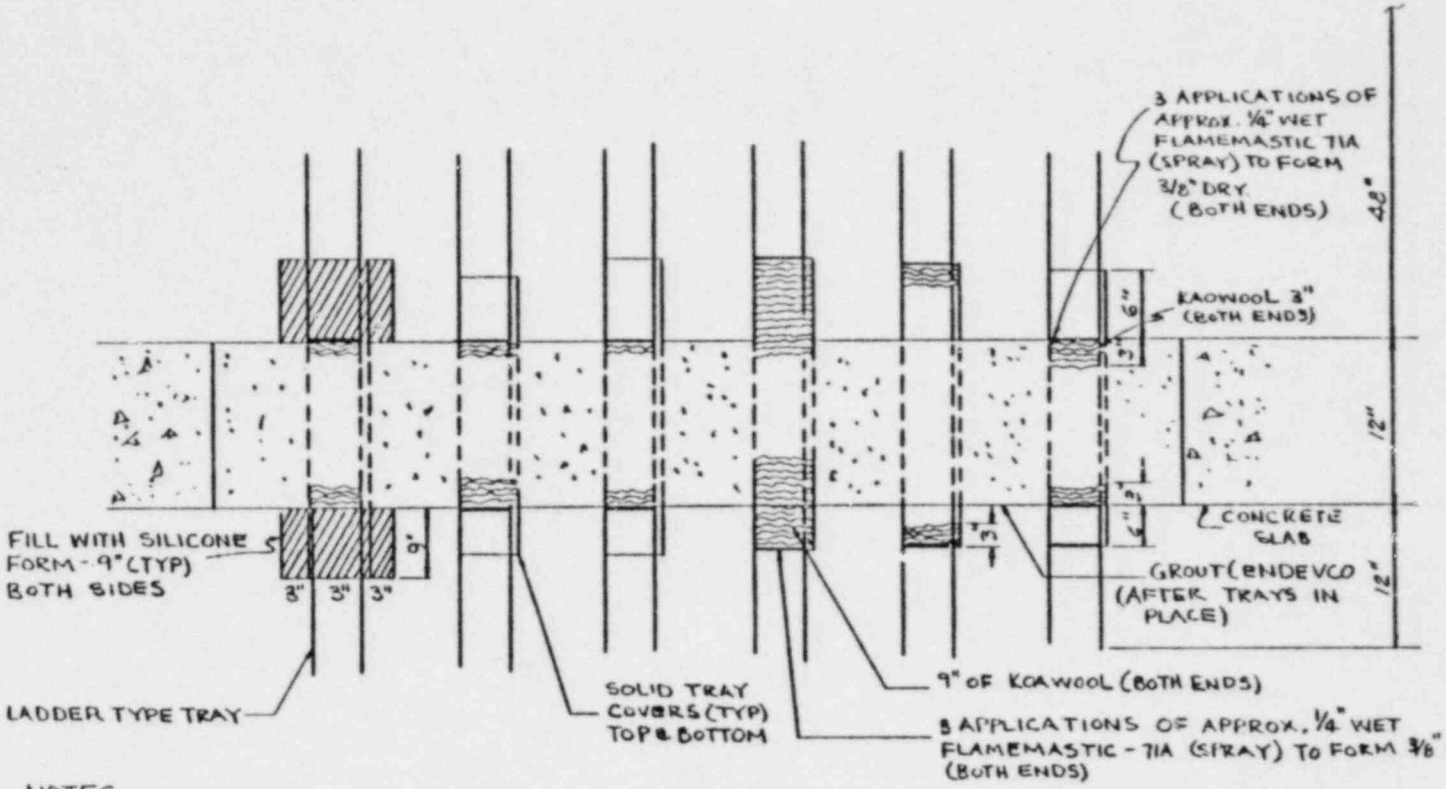
Tray Number 4

A02	4 Cables

For tray No. 4, use 1/4" diameter spacing between the cables.


NOTES:
1. ALL TRAYS ARE TO BE GROUTED IN 6'0" X 3'-0" BLOCKOUT.
2. FINAL SLAB DIMENSION TO BE DETERMINED BY LABORATORY.
EXISITING SLAB
TOP VIEW
BLOCK-OUT (TYP)
CONCRETE SLAB
3'-0"
A SEE AG 2
8"
BLOCKOUT
#1
#2
#3
#4
#5
#6
7½"
6" (TYP)
6'-0"
5'-2"
5'-2"
5'-2"
CLOSE ALL OPENINGS (NOT TO BE USED)
SIDE VIEW
1'-
2'-0"
FIGURE 1
BALTIMORE GAS AND ELECTRIC COMPANY
CALVERT CLIFFS NUCLEAR POWER PLANT
FIRE STOP PENETRATION TEST SLAB LAYOUT
6-11-80 P.R. MCW. 560

	TRAY #6	TRAY #5	TRAY #4	TRAY #3	TRAY #2	TRAY #1
SIL. RUBBER	90%	90%	—	90%	90%	90%
NON-SIL. RUBBER	10%	10%	100% MED VOLT (KERITE)	10%	10%	10%



NOTES

1. FOR TRAYS # 1, 4 & 5 - SEE FIG 3
2. " " #3 SEE FIG 4
3. " " #2 SEE FIG 5
4. " " #6 SEE FIG 6

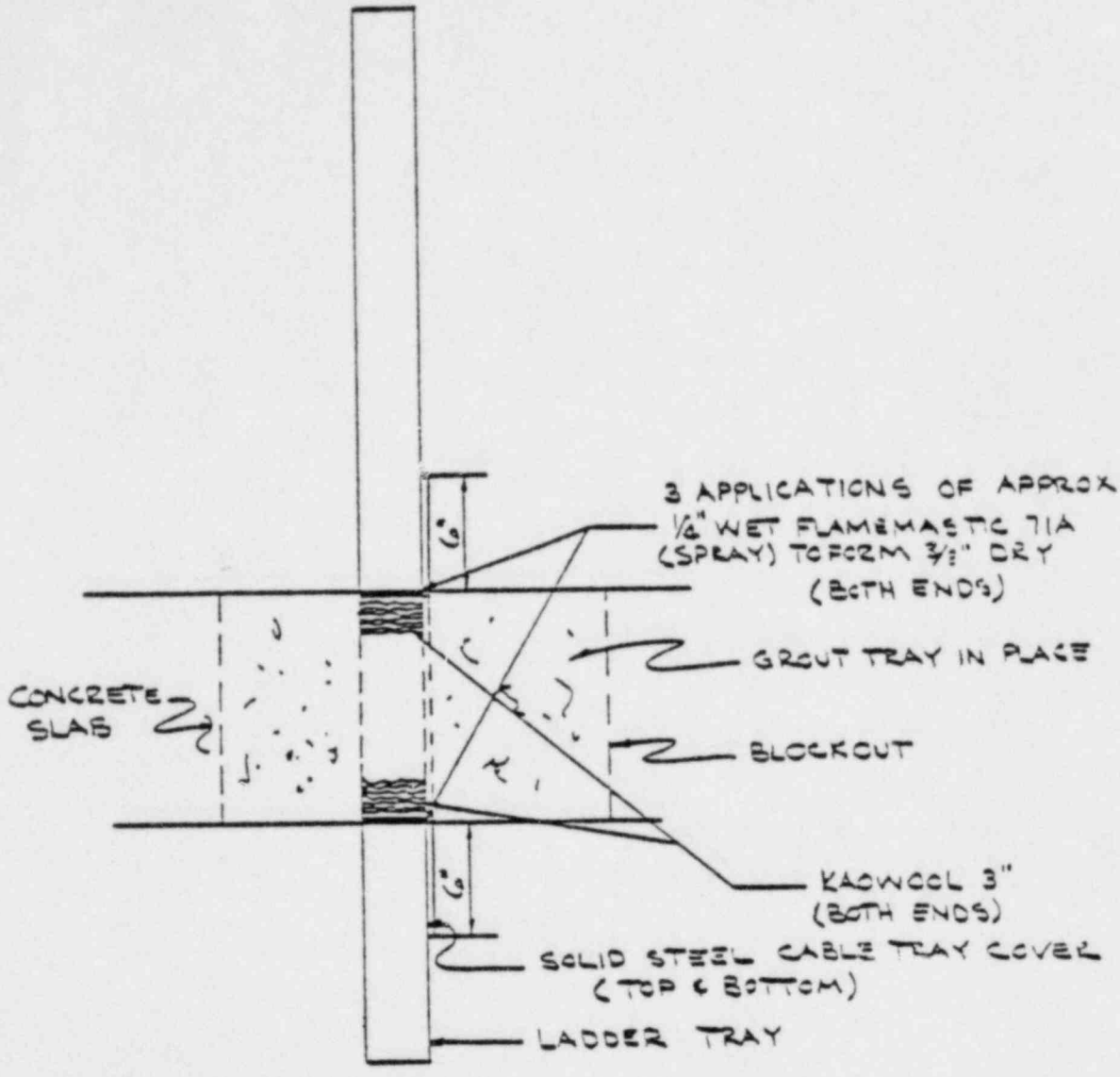
FIG 2

BALTIMORE GAS AND ELECTRIC COMPANY
CALVERT CLIFFS NUCLEAR POWER PLANT

FIRE STOP PENETRATIONS
TRAY BLOCKOUT DETAILS

6-11-80 P.R. MCNULTY

FIRE STOP DESIGN TRAY NO'S 1, 4 & 5



NOTE: THE DESIGN REPRESENTS ORIGINAL DESIGN AS SHOWN IN FIRE STUDY FIG 0-2

FIG. 3

BALTIMORE GAS AND ELECTRIC COMPANY CALVERT CLIFFS NUCLEAR POWER PLANT
FIRE STOP PENETRATION TRAY BLOCKOUT DETAIL

6-11-80 P.C., INCL. 560

FIRE STOP DESIGN - TRAY NO. 2

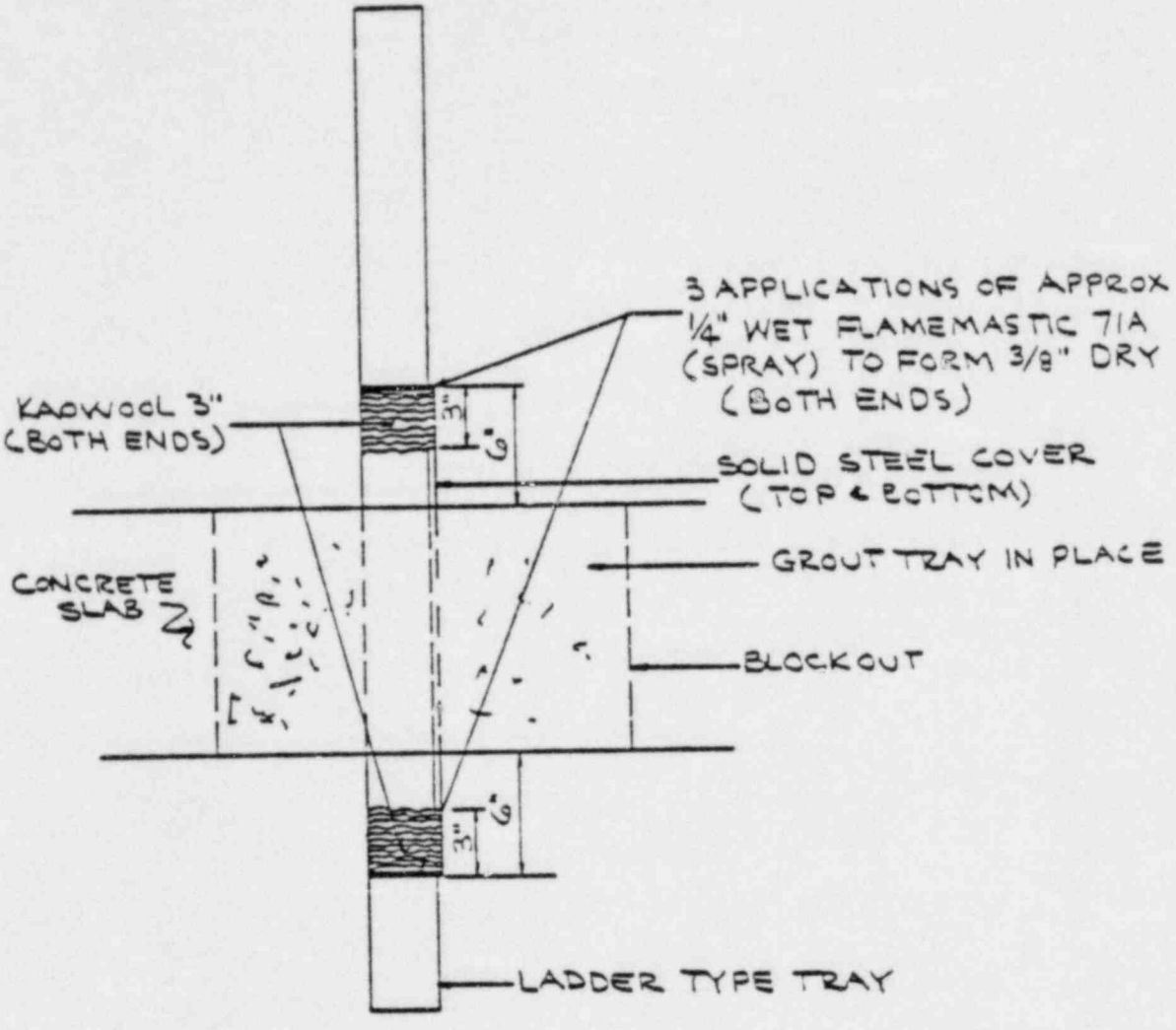
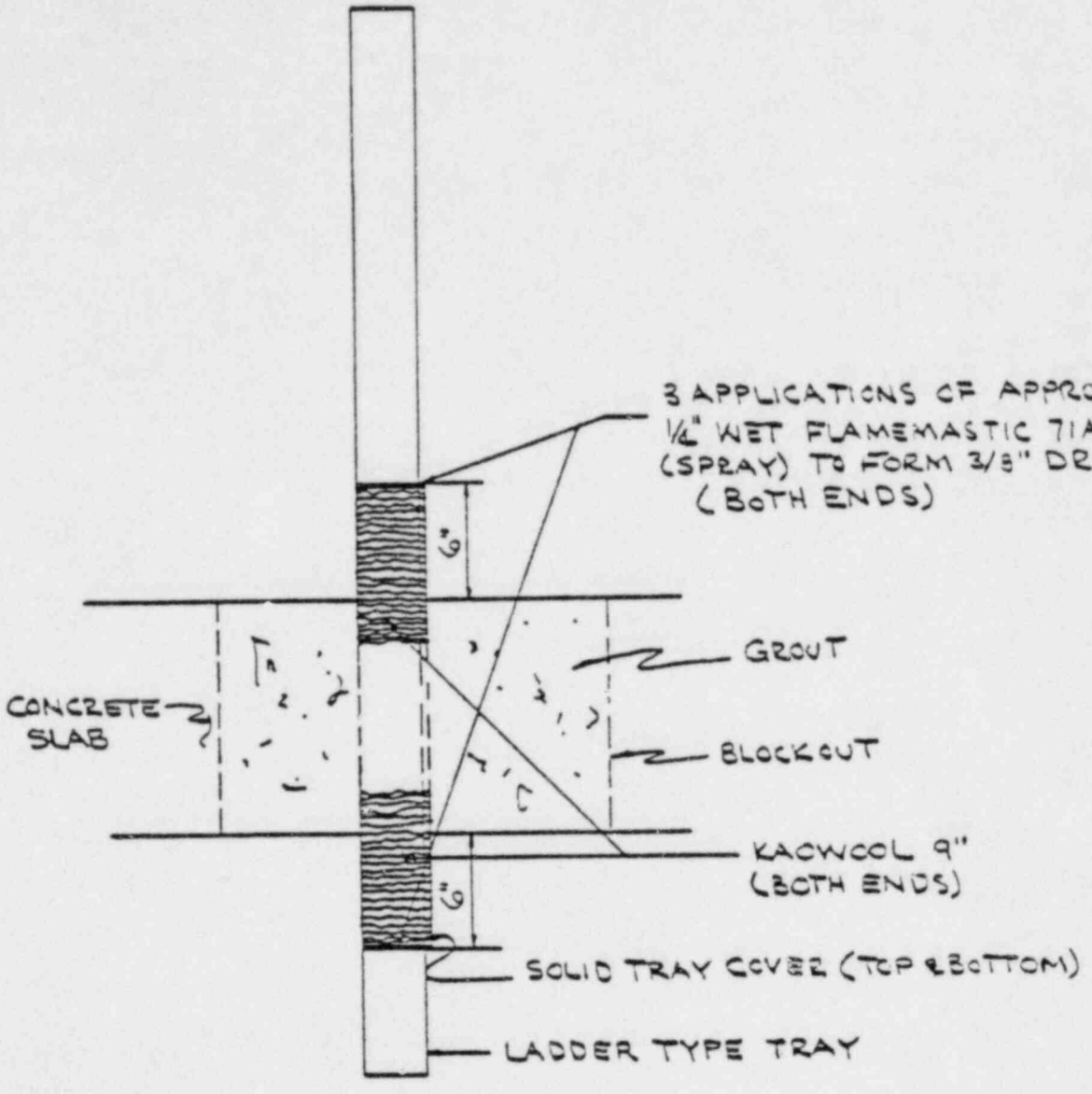


FIG. 5

BALTIMORE GAS AND ELECTRIC COMPANY CALVERT CLIFFS NUCLEAR POWER PLANT
FIRE STOP PENETRATION TRAY BLOCKOUT DETAIL

6-11-80 P.S., MCW, SGO

FIRE STOP DESIGN - TRAY NO. 3



NOTE: THE DESIGN REPRESENTS SAME DESIGN AS TESTED PREVIOUSLY

FIG. 4

BALTIMORE GAS AND ELECTIC COMPANY CALVERT CLIFFS NUCLEAR POWER PLANT
FIRE STOP PENETRATION TRAY BLOCKOUT DETAIL

6-11-80 P.E., MCW, SGO

FIRE STOP DESIGN - TRAY NO. 6

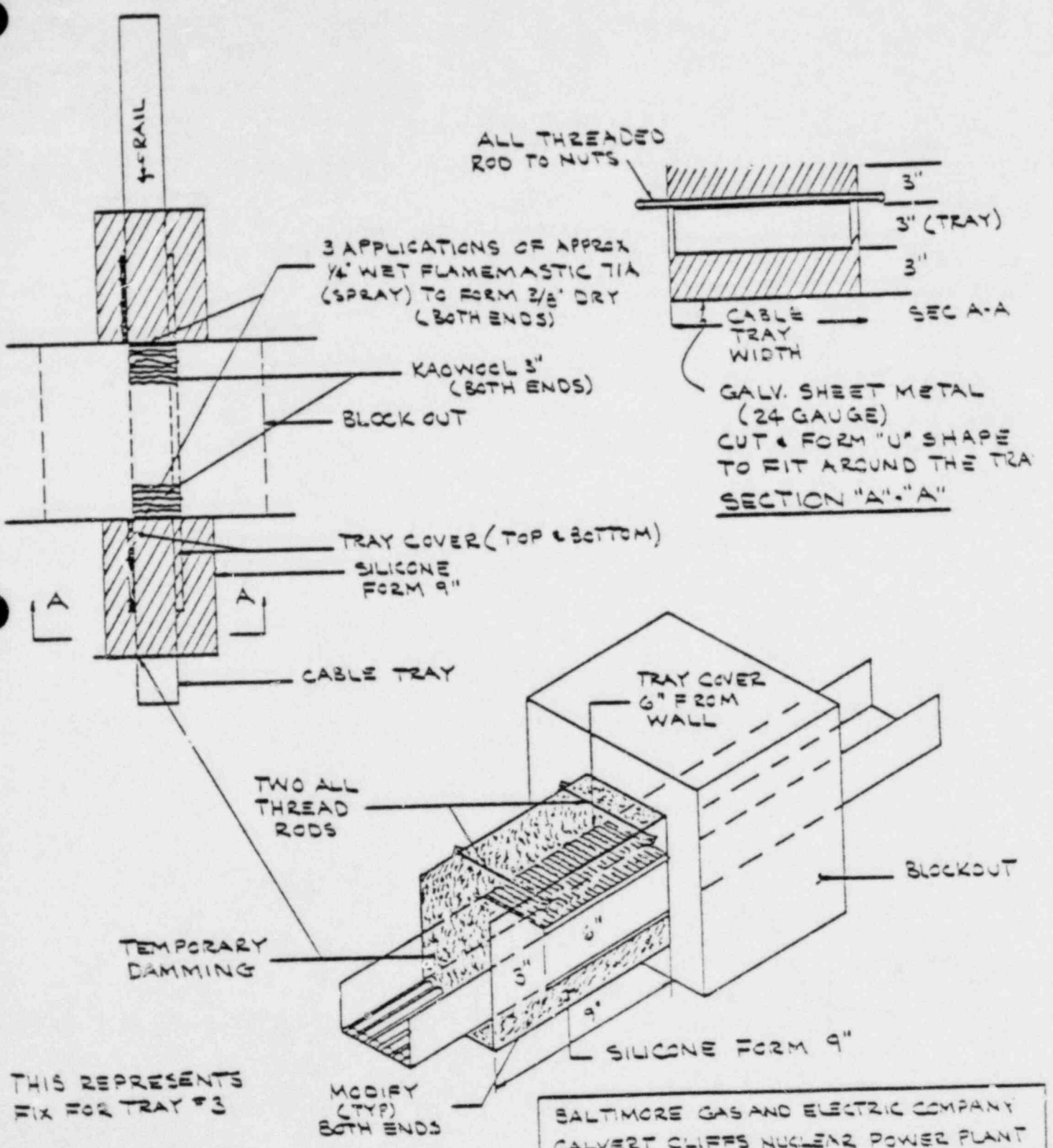


FIG. 6

BALTIMORE GAS AND ELECTRIC COMPANY
CALVERT CLIFFS NUCLEAR POWER PLANT

FIRE STOP PENETRATIONS
TRAY BLOCKOUT DETAIL

6-11-80 R.B. MCW, SGD

BALTIMORE GAS AND ELECTRIC

CHARLES CENTER • P.O. BOX 1475 • BALTIMORE, MARYLAND 21203

ELECTRIC ENGINEERING DEPARTMENT

July 2, 1980

Mr. Michael D. Pish
Senior Research Engineer
Southwest Research Institute
6220 Culebra Road
P. O. Drawer 28510
San Antonio, Texas 78284

Subject: Performance of Additional Fire Stop Tests
Fire Protection System (FCR 79-1053)
Calvert Cliffs Nuclear Power Plant
Units No. 1 and 2
Regn. No. 42759-EE

Dear Mr. Pish:

This is to confirm our telephone conversation of June 23, 1980 in reference to additional fire stop tests at your facility. Please refer to our specification "Fire Test Procedure for Cable Penetrations, Additional Tests" dated June 12, 1980 and delete test A.2.b at this time. We are presently reviewing NRC requirements and we will advise you later if we wish to perform this test.

As I understand, the installation of fire-stop seals for test A.2.a will start the week of July 7, 1980 and the actual test can be performed during the week of July 14, 1980. Please let me know if there will be any changes to the above schedule.

Should you have any questions, please call.

Very truly yours,

Premnath Bhatia

Premnath Bhatia
Senior Engineer
Electric Engineering Dept.

PB:jdw

cc: Messrs. R. F. Ash
D. T. Ward/C. H. Linthicum
D. R. Holland/K. H. Sebra
J. L. Larduskey
R. P. Hunt
T. P. Schaffer
L. B. Russell/J. T. Carroll
G. W. Powell
L. A. Sundquist
M. J. Gahan
R. C. Smith

APPENDIX II

PHOTOGRAPHS OF INSTALLATIONS; FIRE EXPOSURE PERIOD; HOSE STREAM TEST; AND POST TEST EXAMINATION

INSTALLATIONS

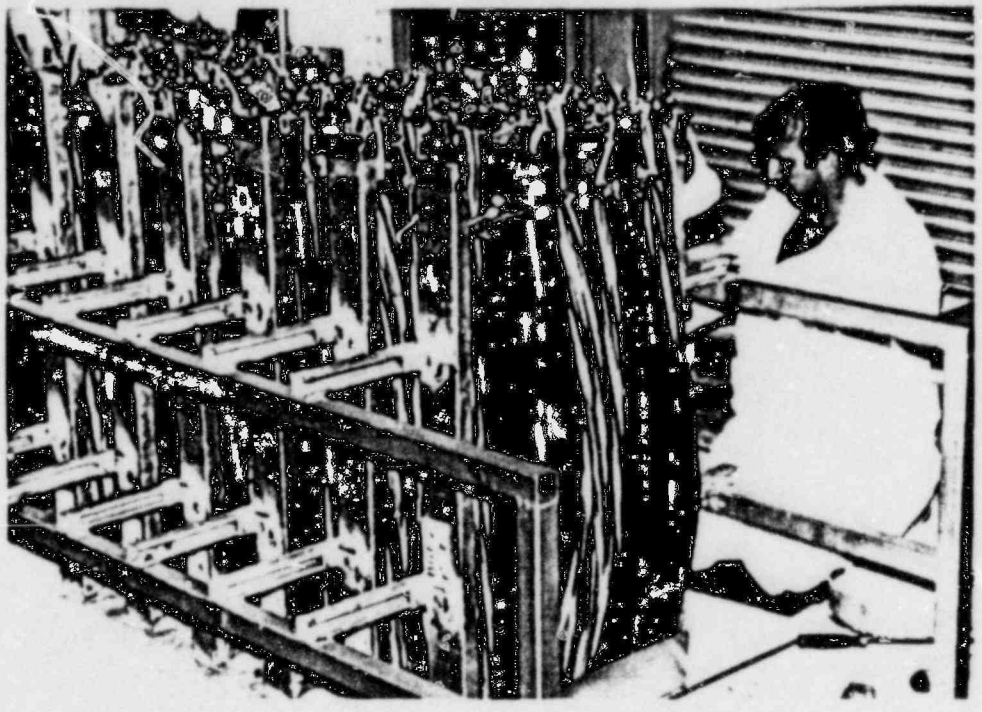


Figure II-1. Cable trays and supports in place

Figure II-2. Kaowool Installation, Unexposed side, Tray 1

Figure II-3. Typical Kaowool Installation, Exposed Side

Figure II-4. Close-up of Cable Trays and Grout

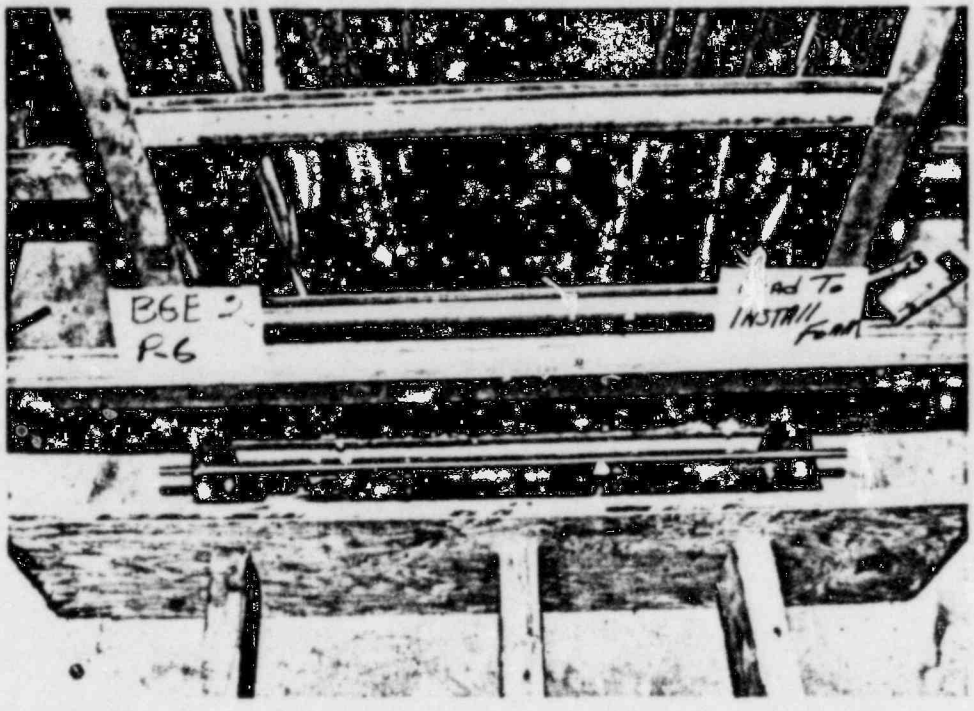


Figure II-5. Temporary Dam Installation, Tray 6

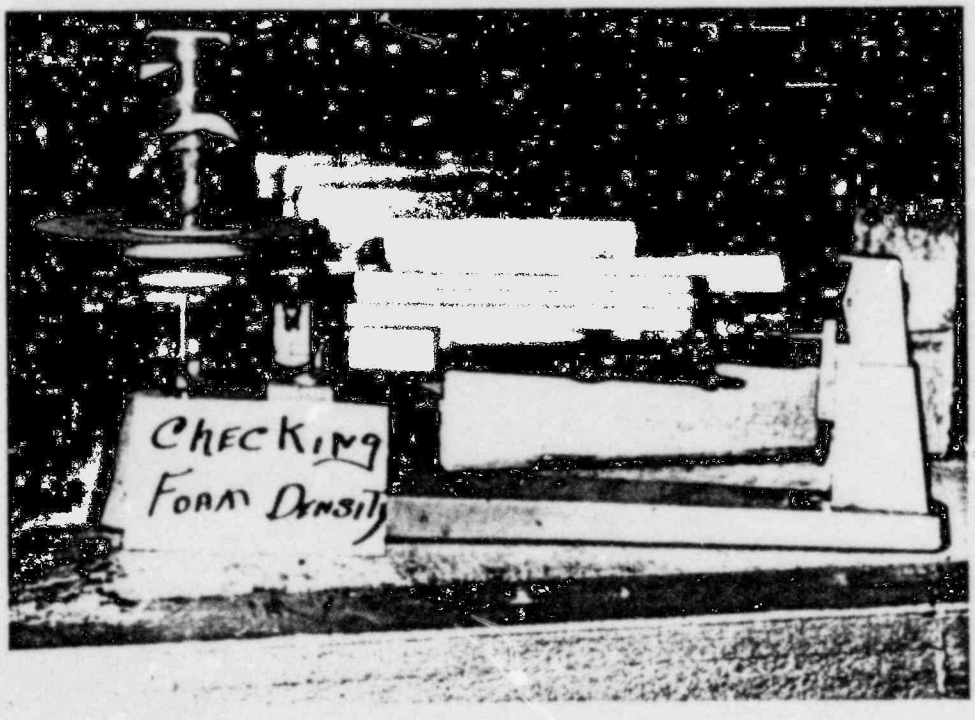


Figure II-6. Weighing Silicone foam to check for proper density

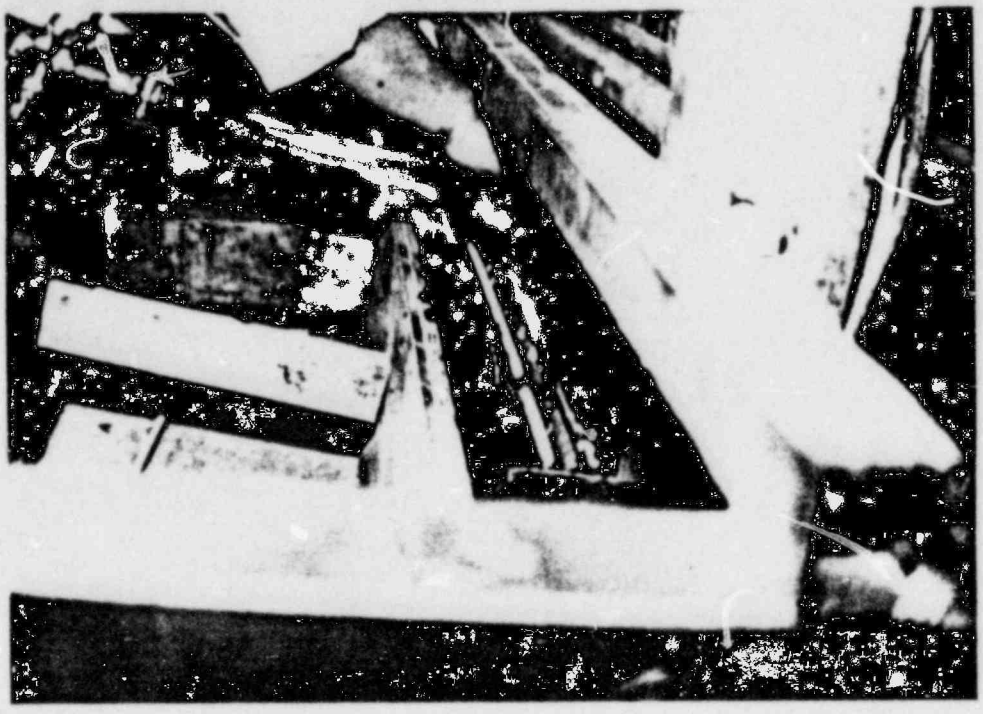


Figure II-7. Installing Foam, Tray 6, Unexposed side

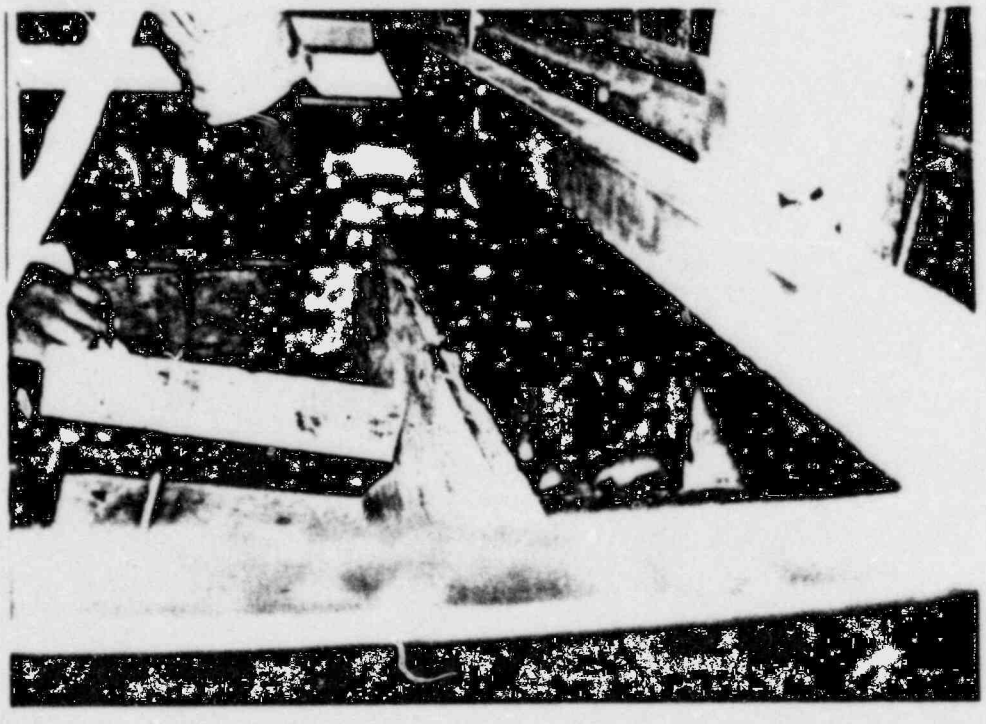


Figure II-8. Silicone Foam in place, Tray 6, Unexposed side

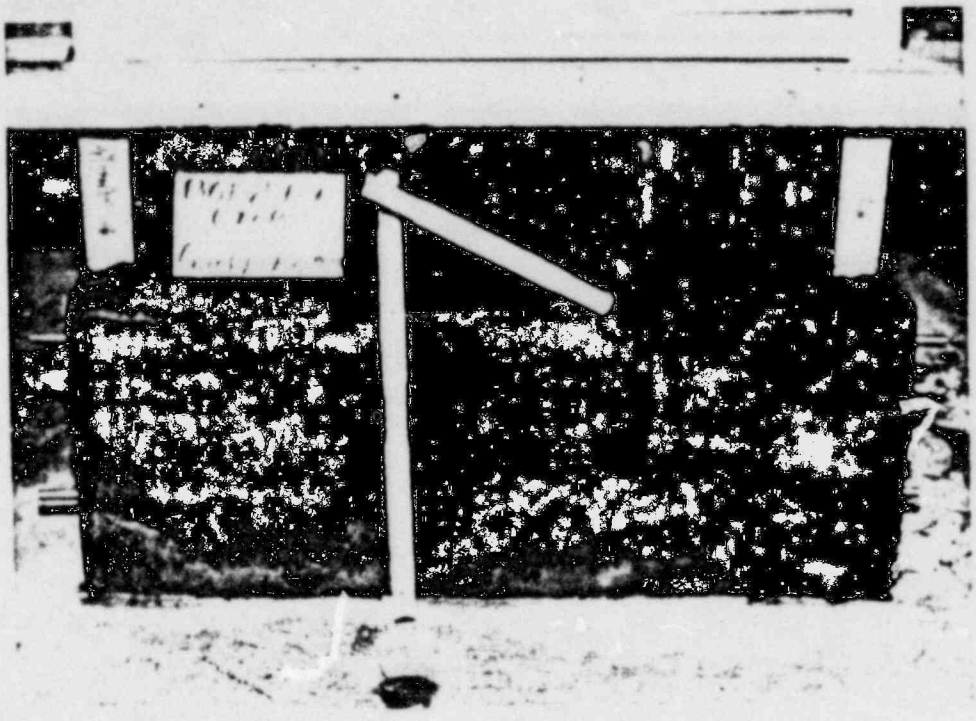


Figure II-9. Completed Silicone Foam Installation Tray 6, Unexposed side

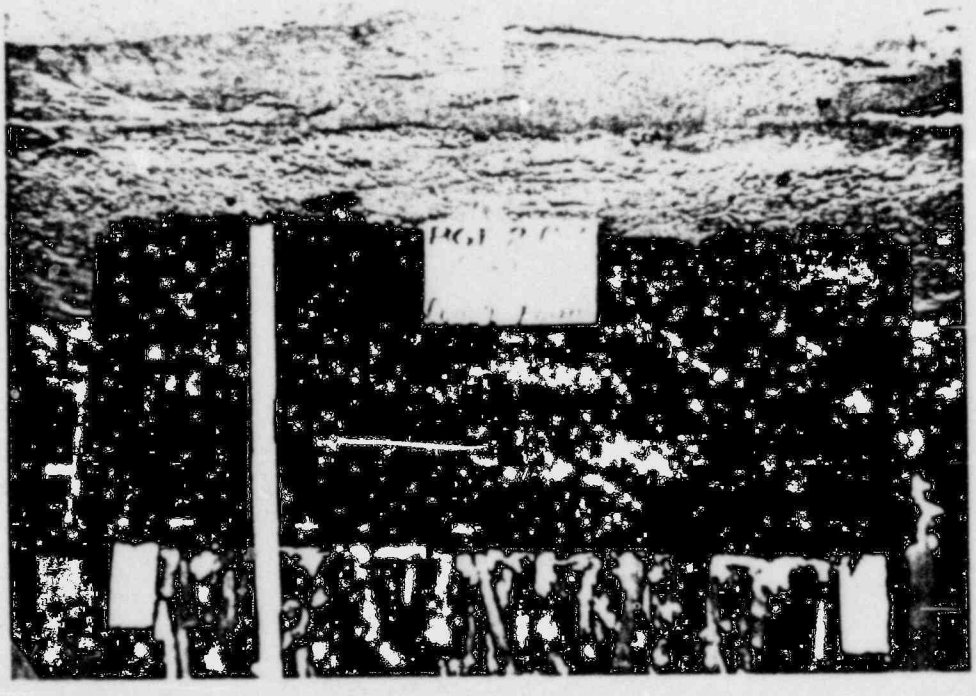


Figure II-10. Completed Foam Installation, Tray 6, Exposed side

Figure II-11. Typical Flamemastic Installation, Unexposed side

Figure II-12. Typical Flamemastic Installation, Exposed side

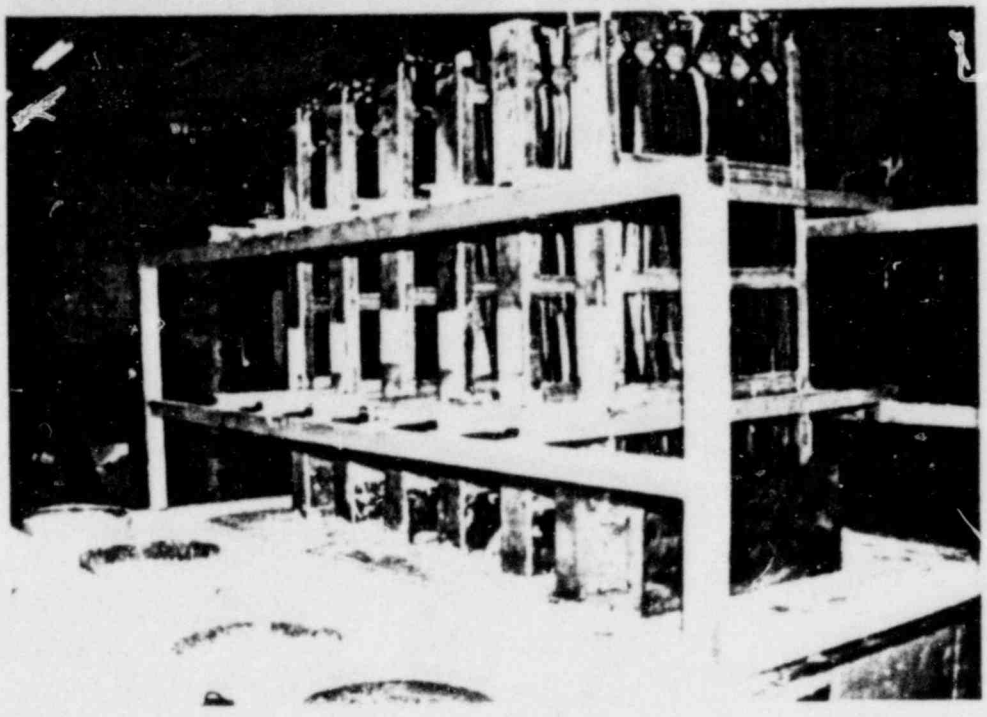


Figure II-13. Completed Cable Tray Installation, Unexposed side

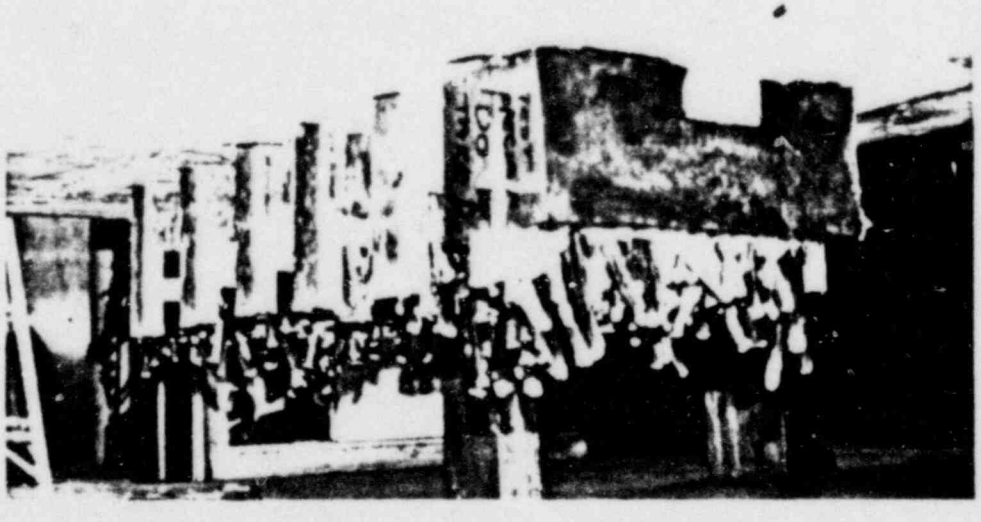


Figure II-14. Completed Cable Tray Installation, Exposed side

FIRE EXPOSURE PERIOD

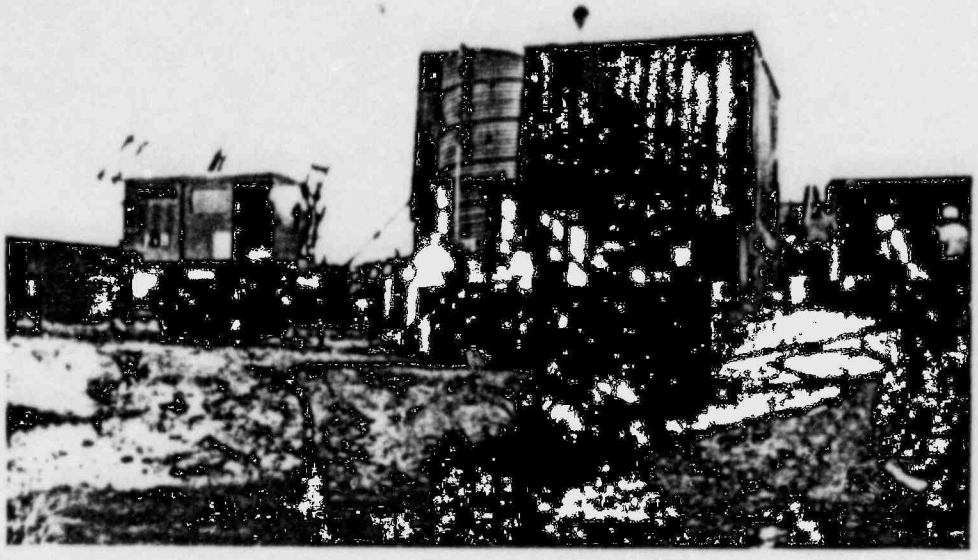


Figure II-15. Overall view, start of test

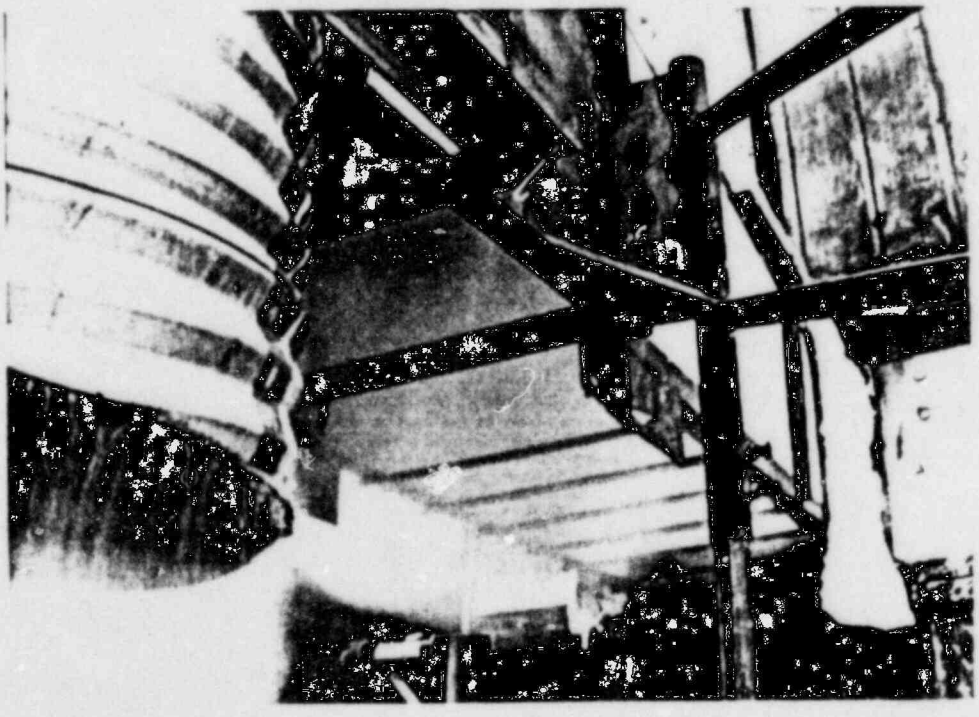


Figure II-16. Furnace flue, approximately 30 minutes into test period

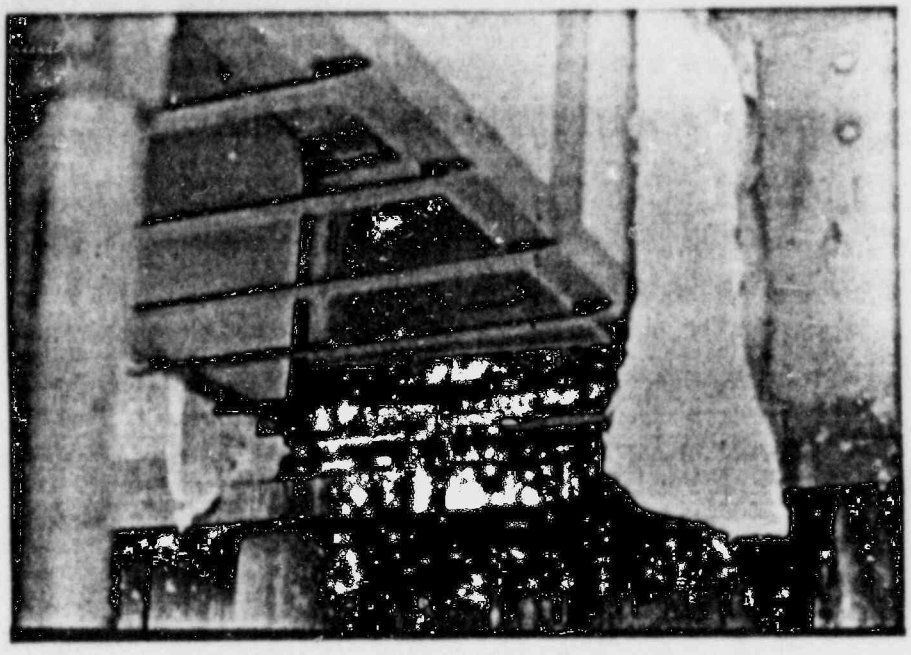


Figure II-17. Furnace flue, approximately 2 hours into test period

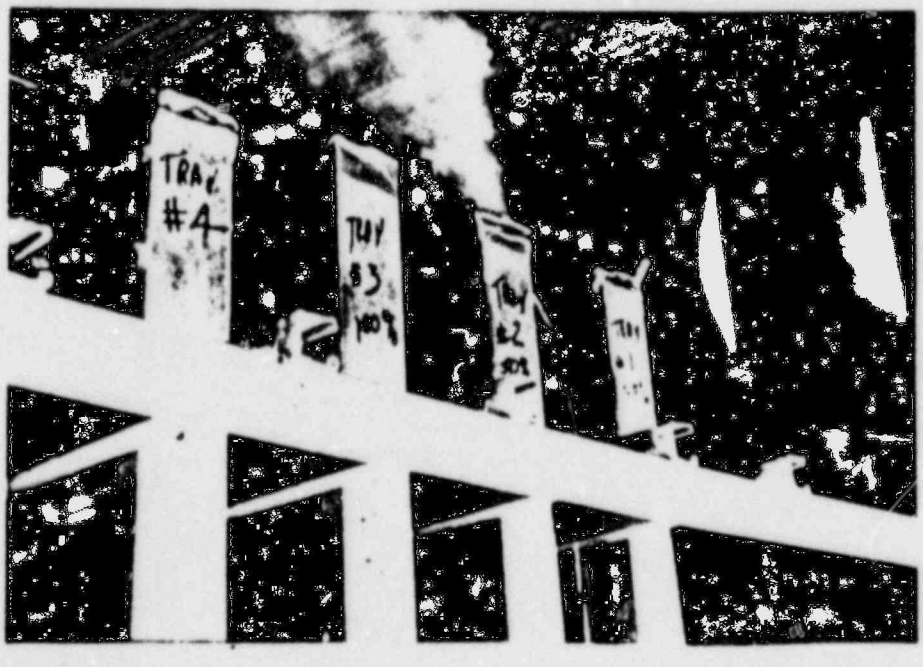


Figure II-18. Cable trays, approximately two hours into test period, showing white smoke from Tray 2

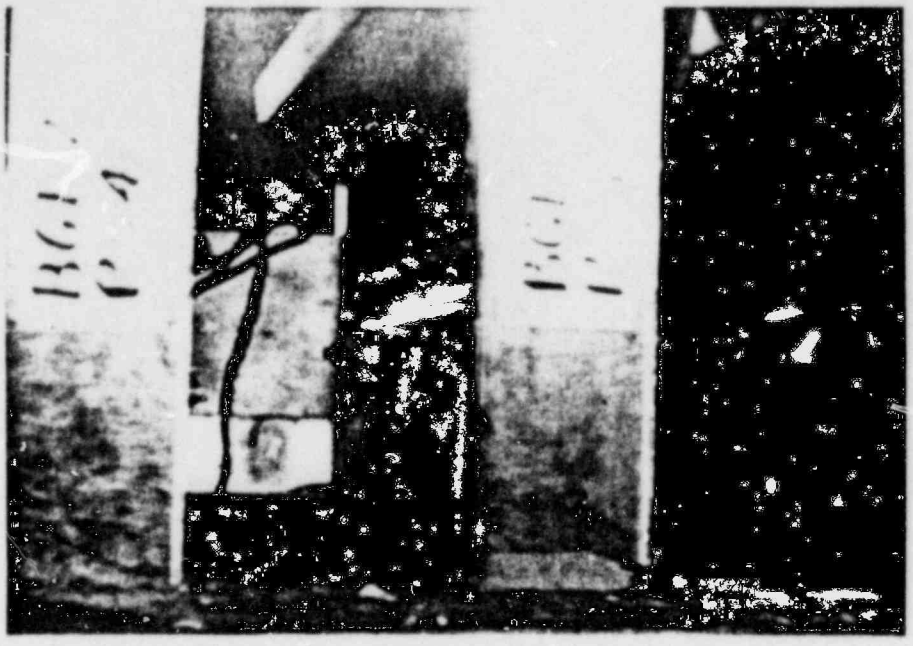


Figure II-19. Close-up of Tray/Grout interface during test

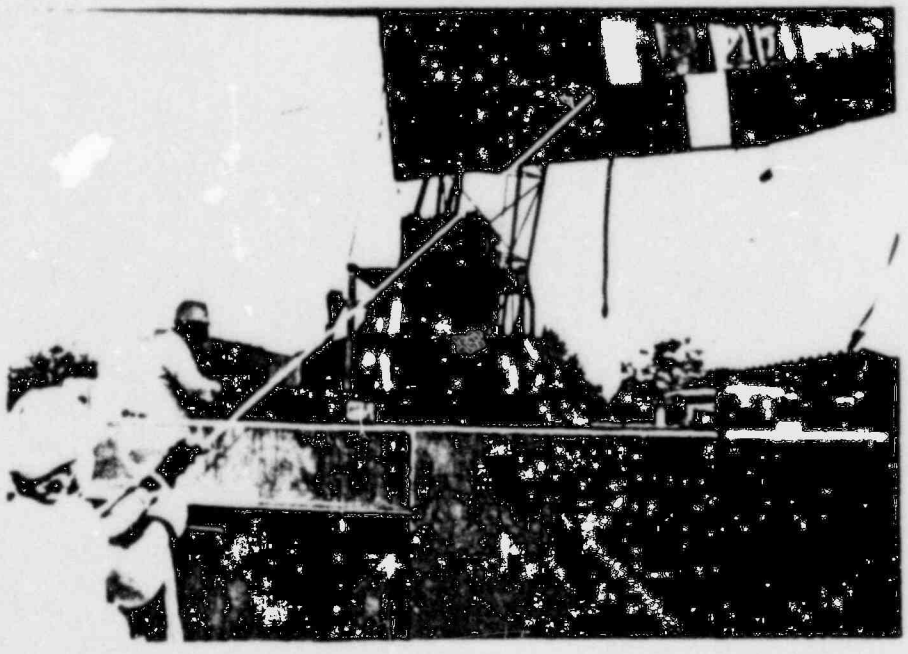


Figure II-20. Removing Protective Enclosure from Furnace at end of test

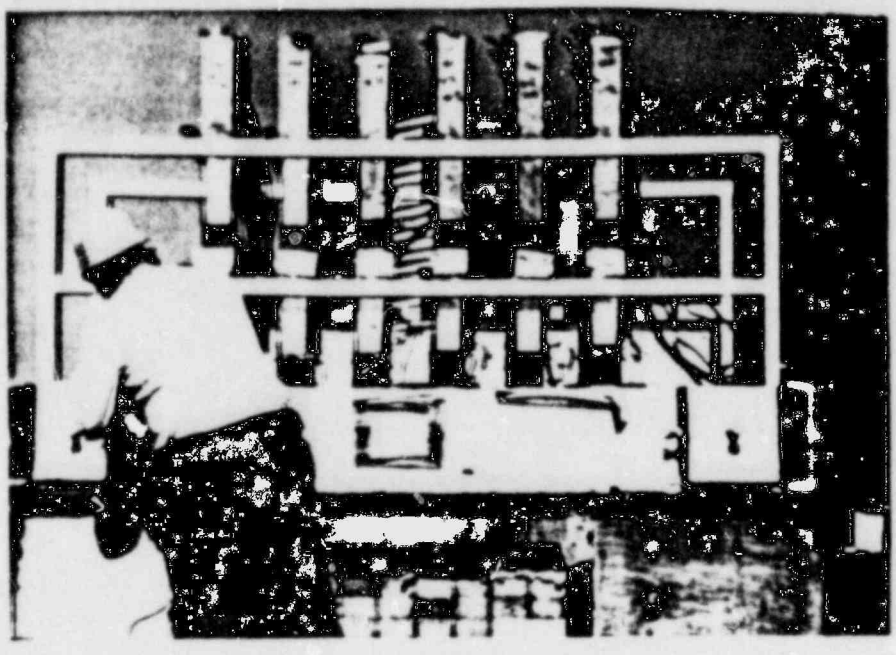


Figure II-21. Test Slab at end of Fire Exposure Period

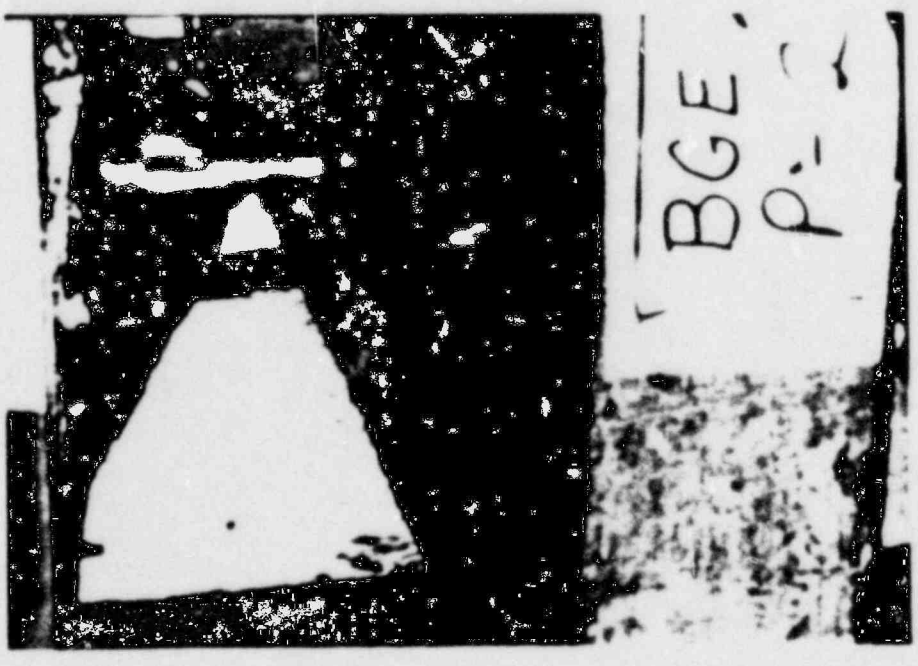


Figure II-22. Close-up of Tray 2 at end of test period

HOSE STREAM TEST

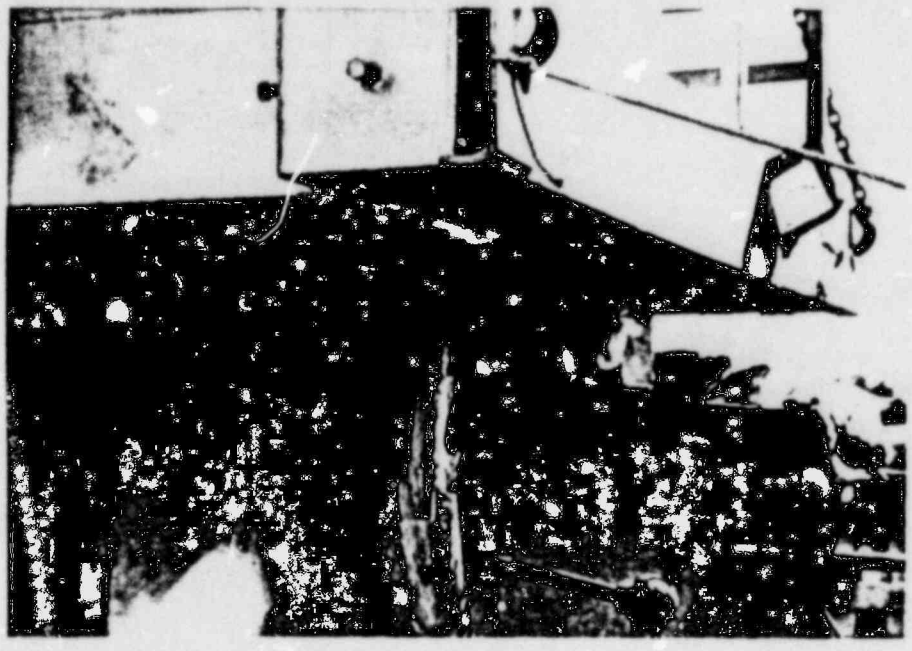


Figure II-23. Lifting Test Slab from Furnace

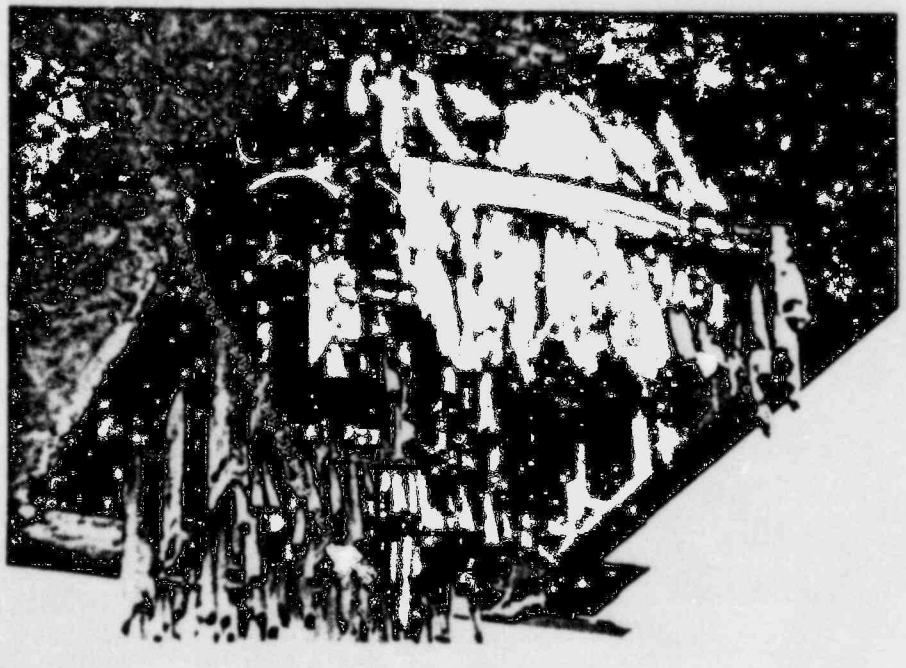


Figure II-24. Test Slab being positioned for Hose Stream Test

Figure II-25. Start of Hose Stream Test

Figure II-26. Hose Stream Test

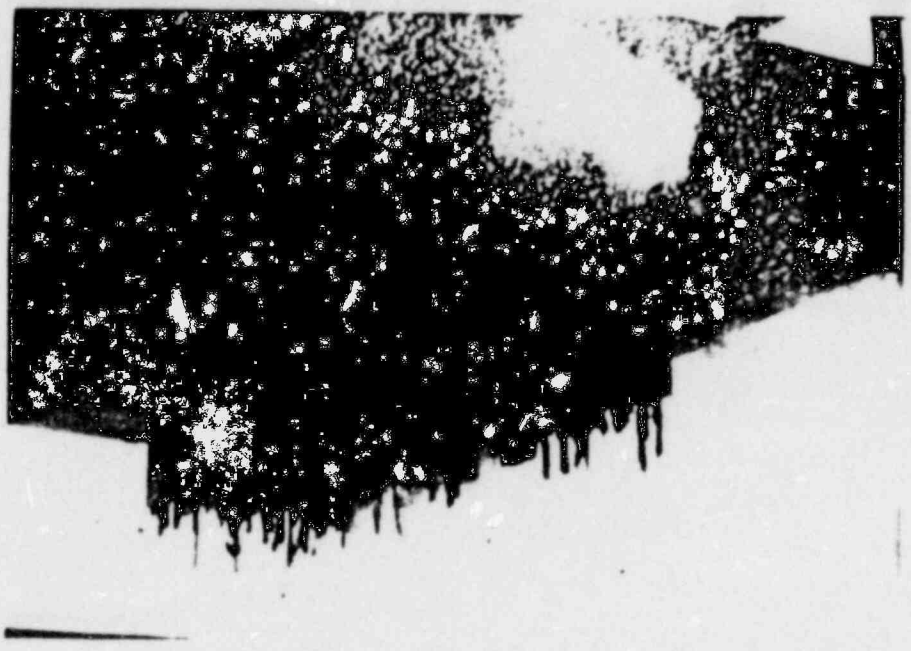


Figure II-27. Hose Stream Test

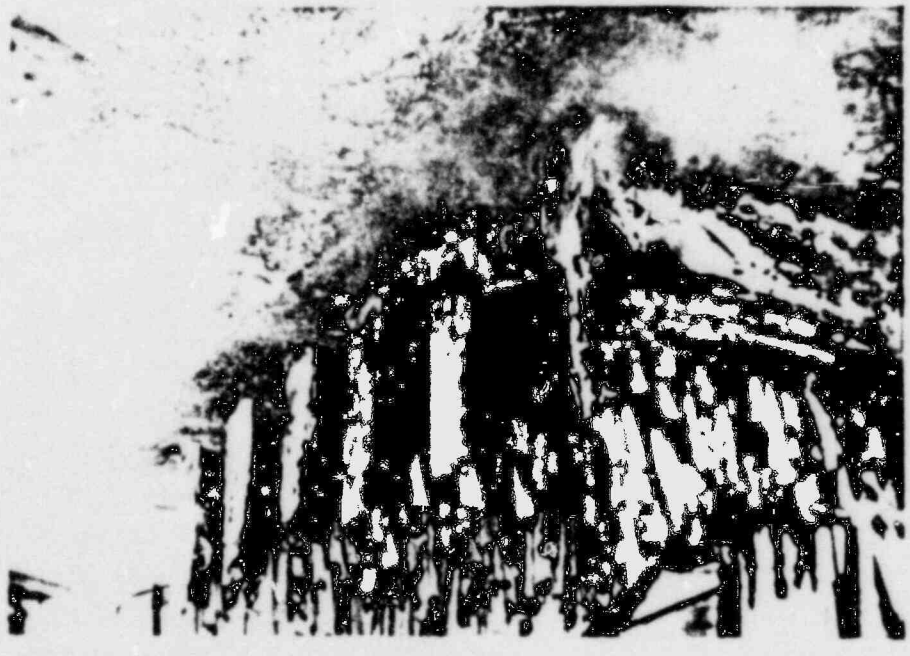


Figure II-28. End of Hose Stream Test

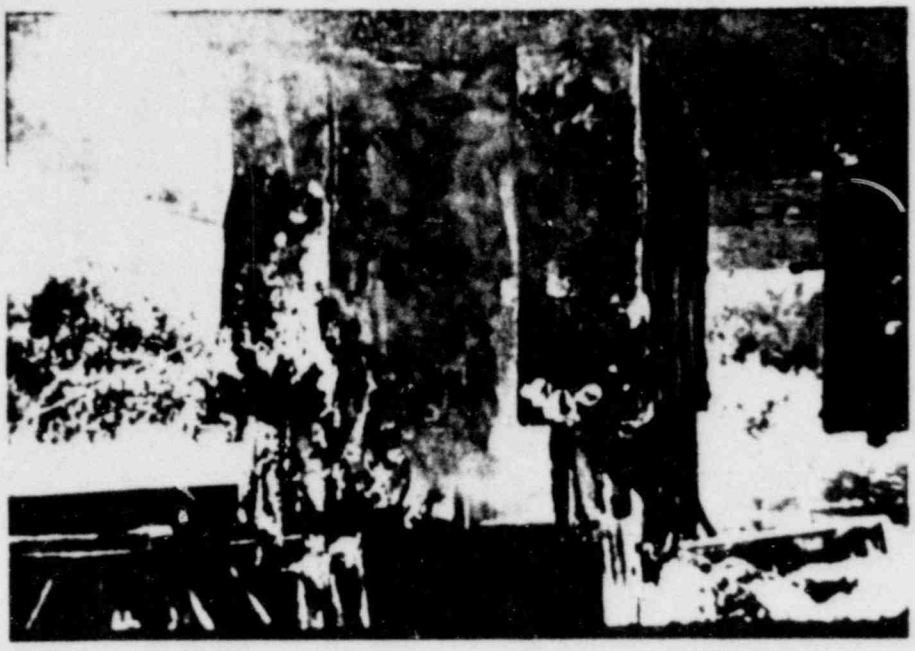


Figure II-29. Cable Trays at end of Hose Stream Test

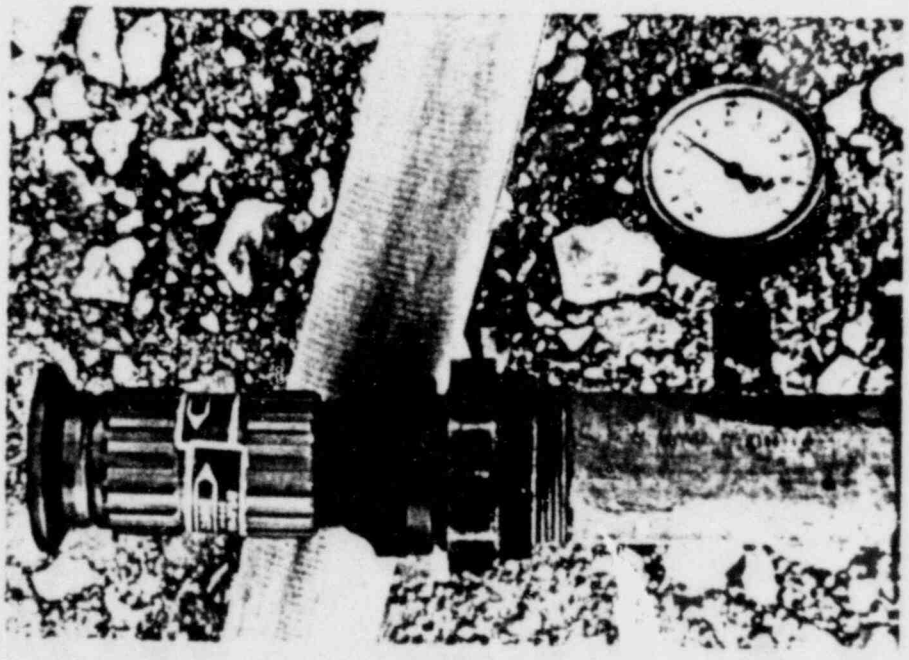


Figure II-30. BG&E Furnished Nozzle used for Hose Stream Test

POST TEST EXAMINATION

Figure II-31. Cable Trays 1, 2, 3, top view, after test

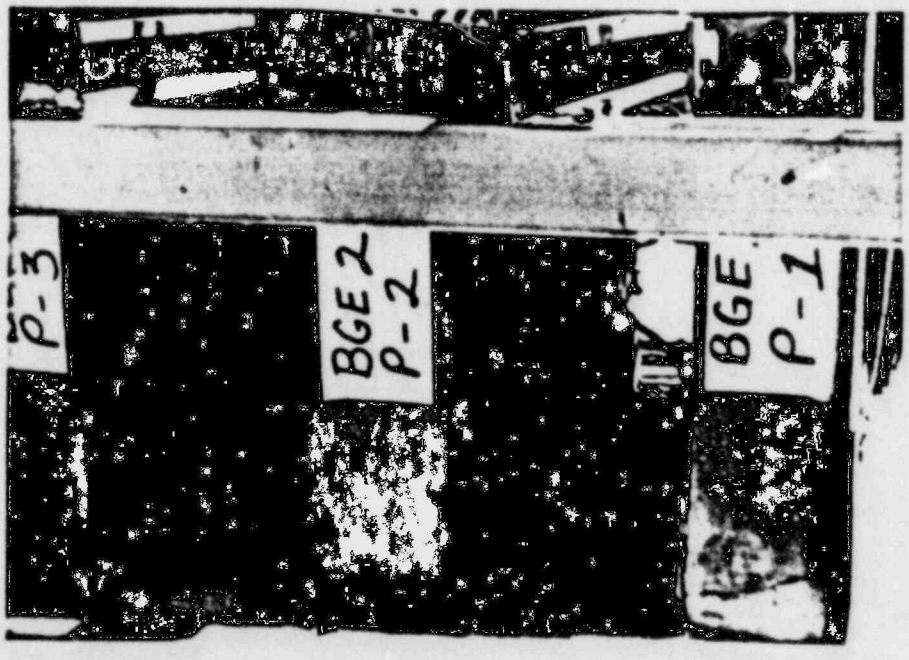


Figure II-32. Cable Trays 1, 2, 3, top view, after test

Figure II-33. Cable Trays, 4, 5, 6, top view, after test

Figure II-34. Front view of Cable Tray 6, after test

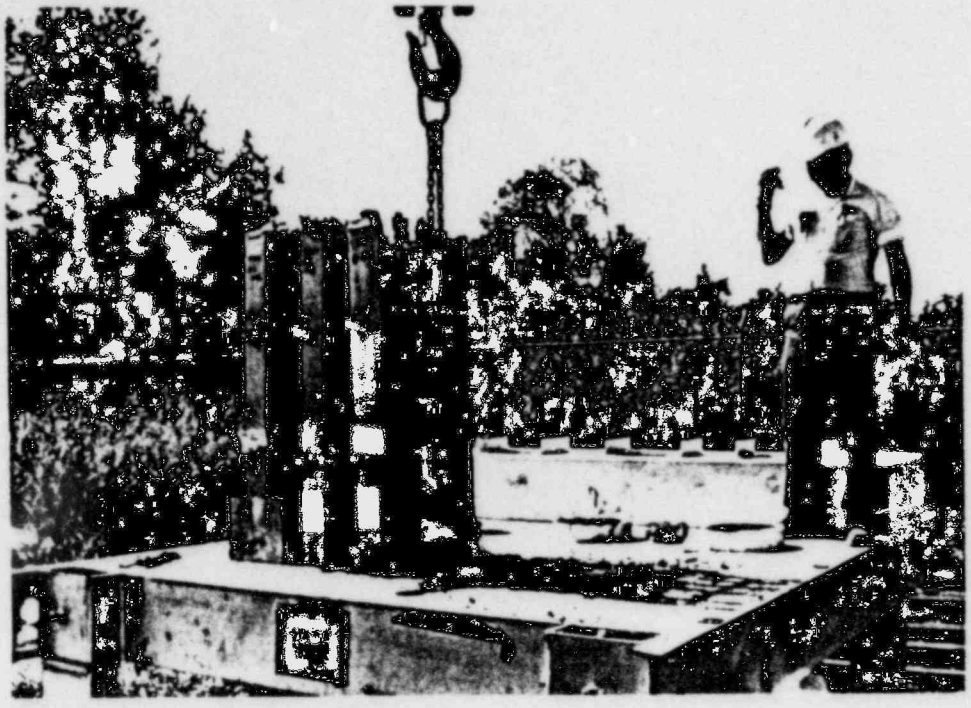


Figure II-35. Removing Cable Trays from test slab

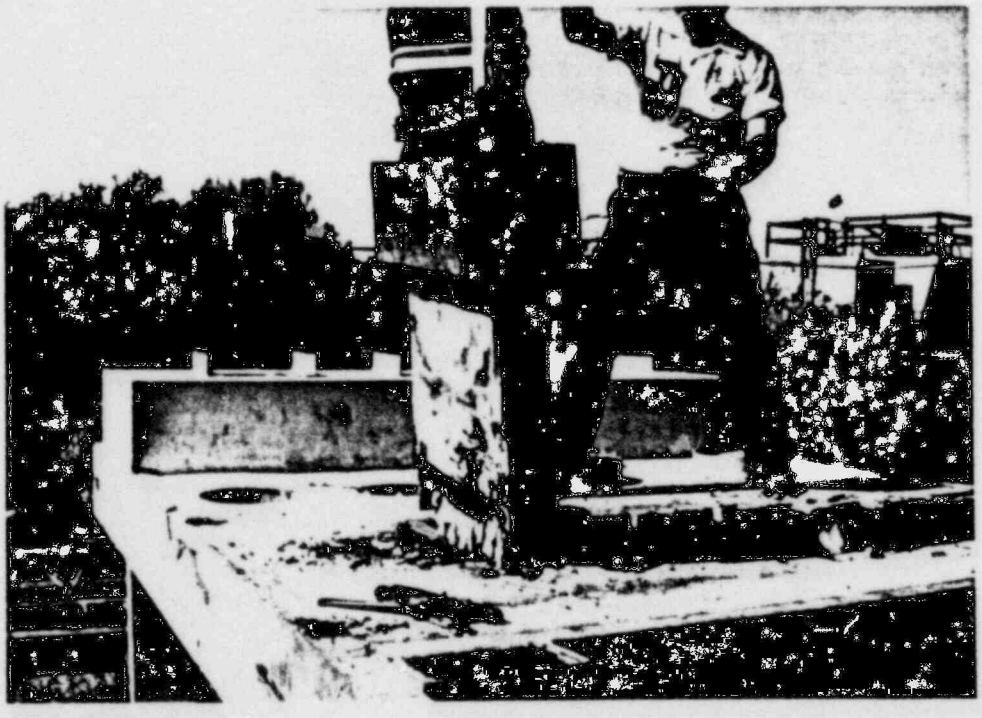


Figure II-36. Cable Tray 6 being removed from test slab

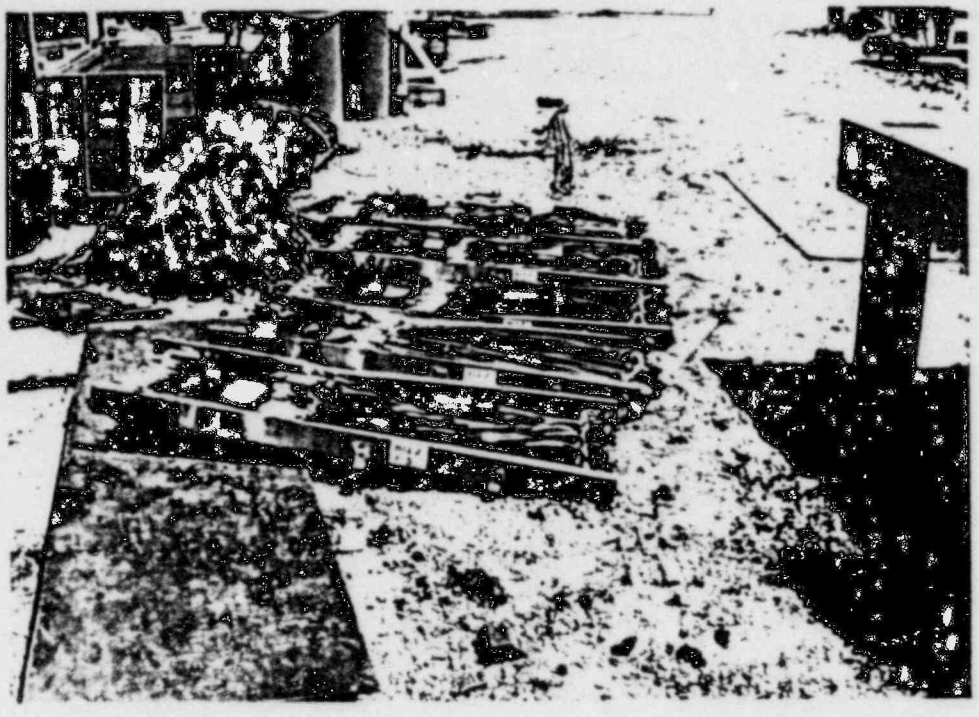


Figure II-37. Cable Trays 1 through 5 after removal from Test Slab

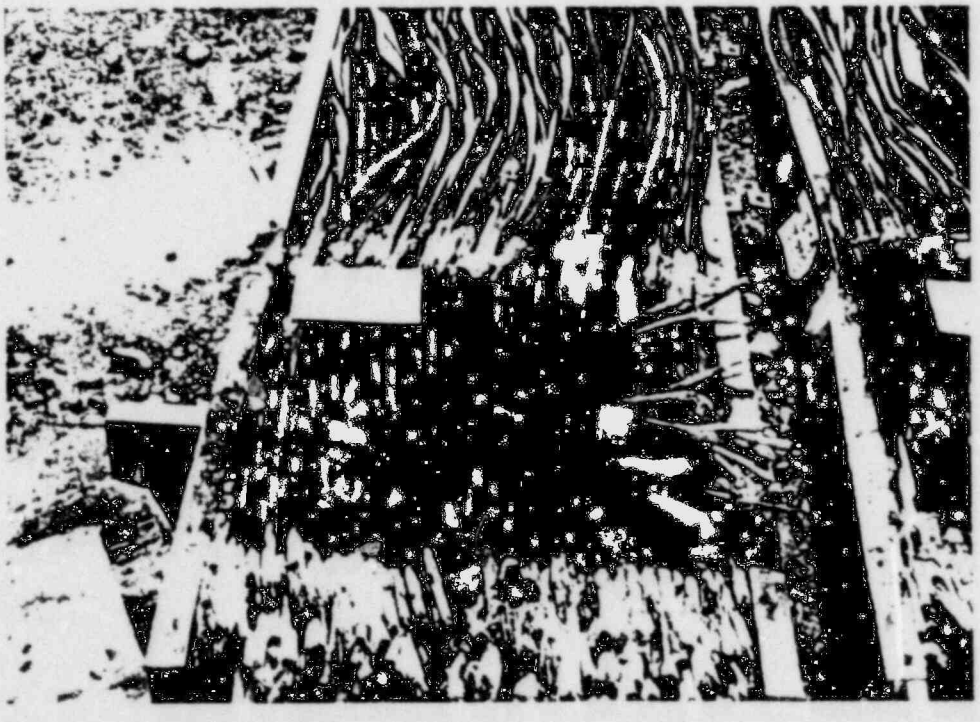


Figure II-38. Close-up of Cable Tray 1, after removal from test slab

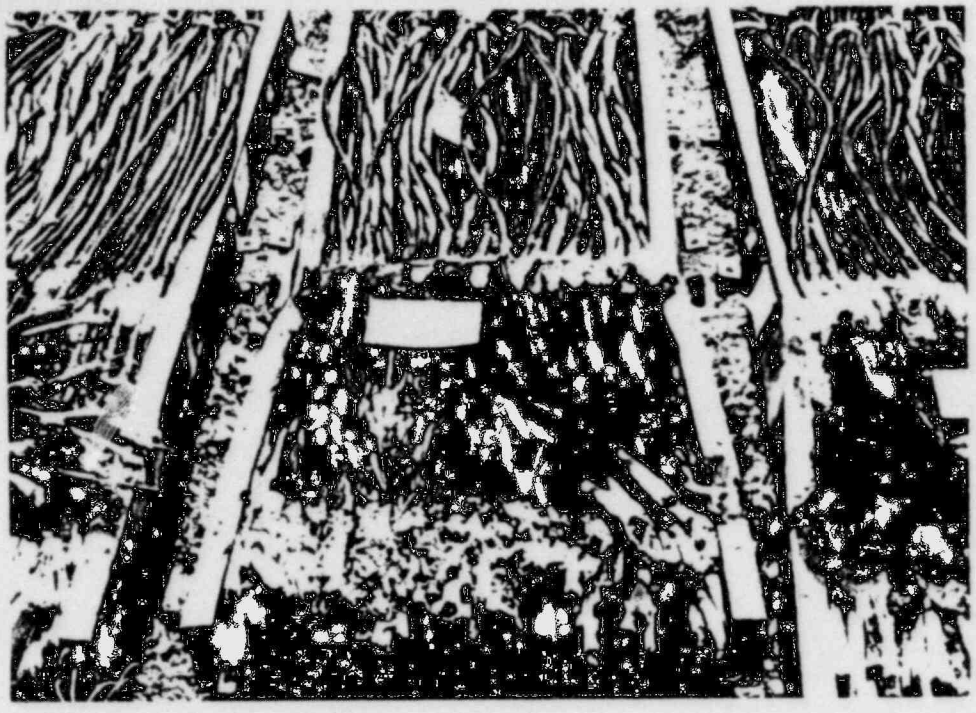


Figure II-39. Close-up of Cable Tray 2, after removal from test slab

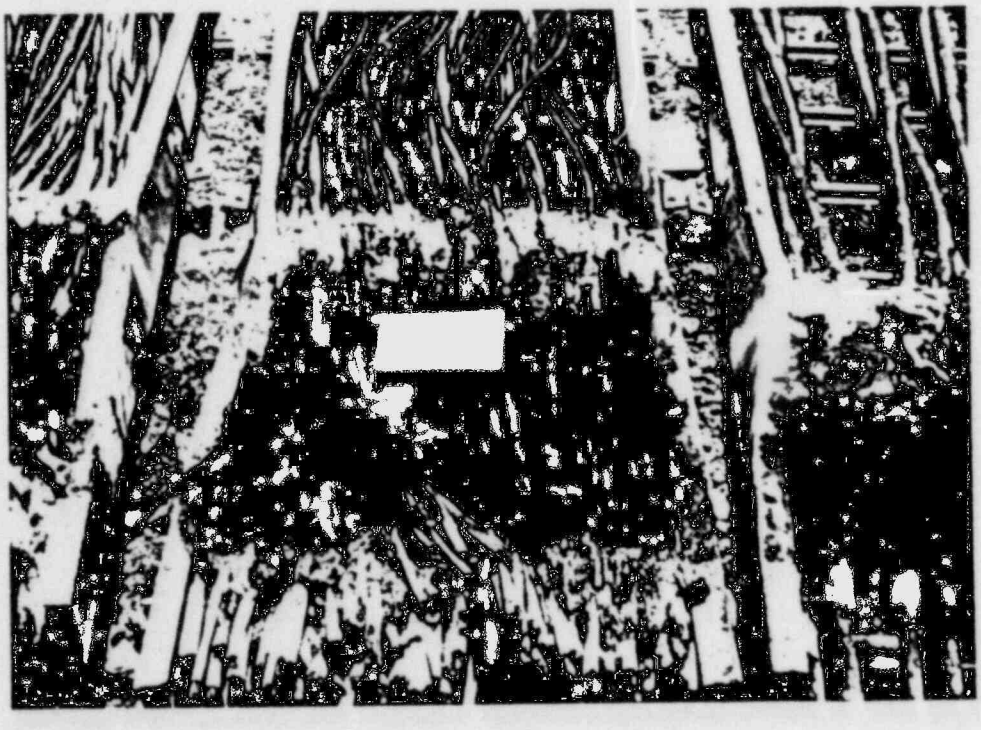


Figure II-40. Close-up of Cable Tray 3, after removal from test slab

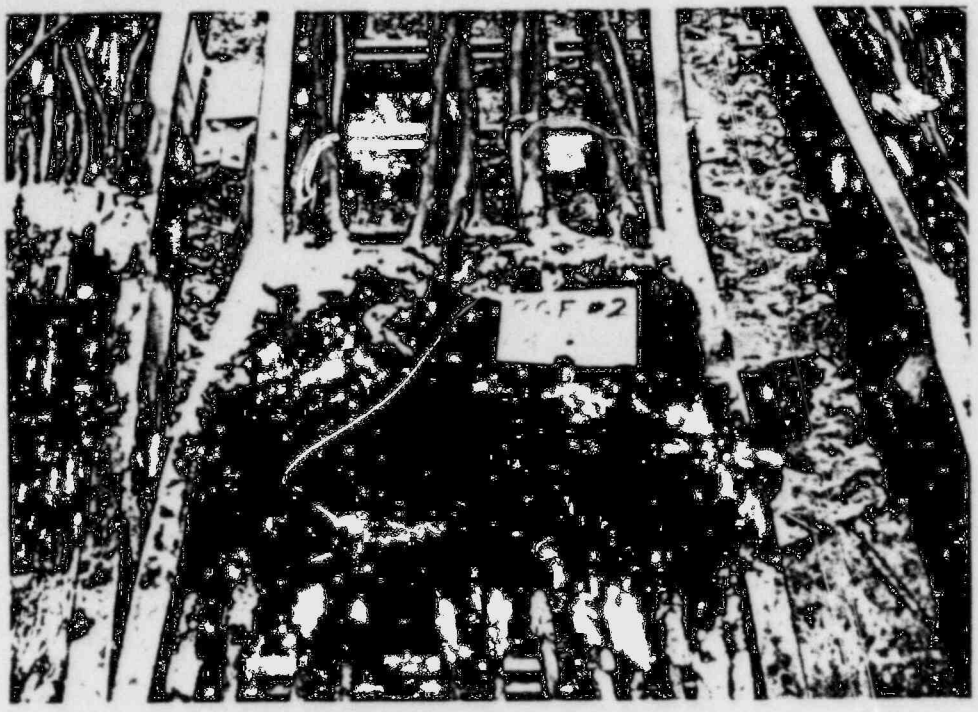


Figure II-41. Close-up of Cable Tray 4, after removal from test slab

Figure II-42. Close-up of Cable Tray 5, after removal from test slab

Figure II-43. Removing foam from Tray 6 in order to be able to remove steel cover

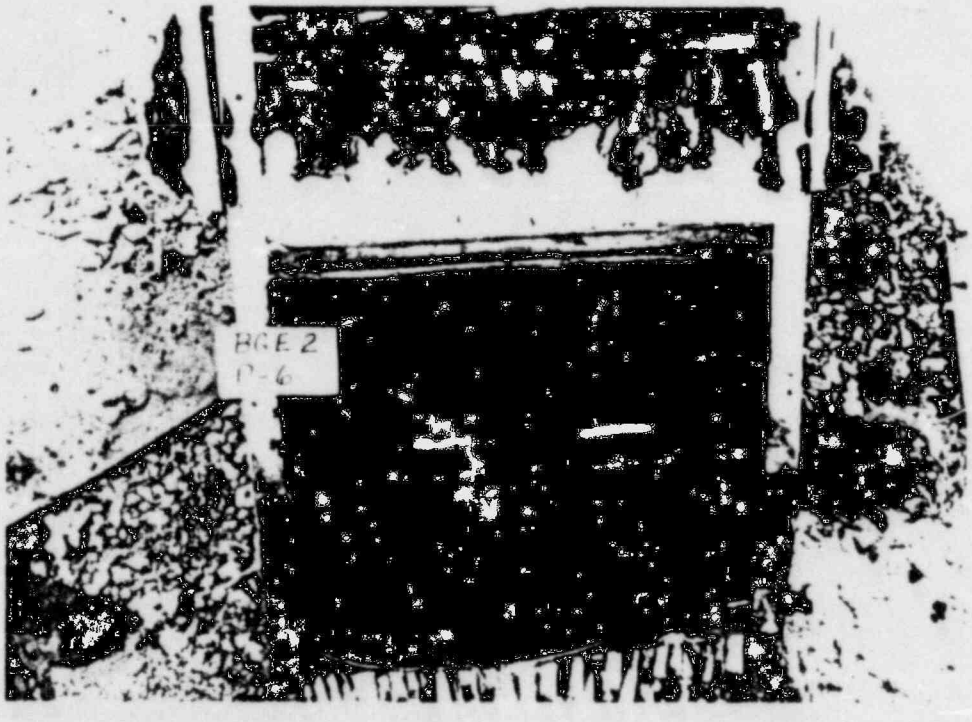


Figure II-44. Cable Tray 6, with steel cover and foam from unexposed side removed

APPENDIX III

QUALITY CONTROL DOCUMENTATION (ICMS)

July 24, 1980

Mr. Michael D. Pish
Senior Research Engineer
Southwest Research Institute
6220 Culebra Road
P. O. Drawer 28510
San Antonio, TX. 78284

RE: B. G.&E. Test Installation and Quality Control Data

Dear Mr. Pish:

Enclosed please find the master copy of all installation and Quality Control data compiled by ICMS on the recent Baltimore Gas & Electric test conducted at your site.

Should you require any additional information, please feel free to call.

Sincerely,

Michael L. Stine
Quality Assurance Manager
ICMS

MLS/jc
Encl.

INSULATION CONSULTANTS & MANAGEMENT SERVICES, INC.
POST OFFICE BOX ONE / BARODA, MICHIGAN 49101 / 616 422-2112

QUALITY CONTROL DATA

Penetration 1 (Figure III-1)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 100% fill silicone rubber (90%) and non-silicone rubber cable (10%). The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; a 3" depth of Kaowool was packed onto both ends of the tray, 3" deep into the barrier.
7-16-80; 1/4" coat of Flamemastic 71A applied over the Kaowool installation on both the exposed and unexposed sides of the penetration.
7-17-80; a second 1/4' coat of Flamemastic 71A was applied to the penetration on both the exposed and unexposed side of the seal.
7-18-80; a final 1/4" coat of Flamemastic 71A was applied to the seal on both the exposed and unexposed sides of the penetration.

Penetration 2 (Figure III-2)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 50% fill silicone rubber (90%) and non-silicone rubber cable (10%). The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; a 3" depth of Kaowool was packed into both tray ends exterior of the barrier.
7-16-80; 1/4: coat of Flamemastic 71A applied over the Kaowool installation on both the exposed and unexposed sides of the barrier
7-17-80; a second 1/4" coat of Flamemastic 71A was applied to the penetration on both the exposed and unexposed sides of the barrier.
7-18-80; a final 1/4" coat of Flamemastic 71A was applied to the seal on the exposed and unexposed sides of the penetration.

Penetration 3 (Figure III-3)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 100% fill silicone rubber (90%) and non-silicone rubber cable (10%). The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; 9" of Kaowool was packed into each end of the tray, leaving a 6" deep area void of any sealing material in the center of the penetration.
7-16-80; 1/4" coat of Flamemastic 71A applied over Kaowool installation both exposed and unexposed sides.
7-17-80; a second 1/4" coat of Flamemastic 71A applied to the seal on both the exposed and unexposed side of the penetration.
7-18-80; a final 1/4" coat of Flamemastic 71A was applied to the exposed and unexposed sides of the seal.

Penetration 4 (Figure III-4)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 50% fill of non-silicone (medium voltage HTK-KERITE) cable. The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; a 3" depth of Kaowool was packed into each end ot the tray, 3" deep into the barrier.
7-16-80; 1/4" coat of Flamemastic 71A applied over the Kaowool installation on both the exposed and unexposed sides.

QUALITY CONTROL DATA - Page 2

7-17-80; a second 1/4" coat of Flamemastic 71A applied to the seal on both the exposed and unexposed sides of the penetration.
7-18-80; a final 1/4" coat of Flamemastic 71A applied to the seal on both the exposed and unexposed sides of the penetration.

Penetration 5 (Figure III-5)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 50% fill silicone rubber (90%) and non-silicone rubber (10%) cables. The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; a 3" depth of Kaowool was packed into the ends of the tray, 3" deep into the barrier.
7-16-80; 1/4" coat of Flamemastic 71A applied over the Kaowool installation on both the exposed and unexposed side of the seal.
7-17-80; a second 1/4: coat of Flamemastic 71A applied to the penetration on both the exposed and unexposed sides of the seal.
7-18-80; a final 1/4" coat of Flamemastic 71A was applied to the seal on both the exposed and unexposed sides of the penetration.

Penetration 6 (Figure III-6)

Description: 24"x4"x72" galvanized ladder back cable tray containing a 100% fill silicone rubber (90%) and non-silicone rubber cable (10%). The tray has 24" covers extending 6" on each side of the slab.
Seal: 7-15-80; a 3" depth of Kaowool was packed into both ends of the tray, 3" deep into the barrier.
7-16-80; two, 1/4" coats of Flamemastic 71A were applied, one in the early morning, the other in late afternoon.
7-17-80: a final 1/4" coat of Flamemastic 71A was applied to the seal on both the exposed and unexposed sides of the penetration. A "U" shaped piece of galvanized sheet metal measuring 24"x10"x9" was secured around the unexposed side of the cable tray exterior of the barrier utilizing two 27" lengths of all-thread rod (see Figure6). The configuration was injected with silicone foam having an average density of 17.685 $lb.FT^3$.
7-18-80; a "U" shaped piece of galvanized sheet metal measuring 24"x10"x9" was secured around the exposed side of the cable tray, exterior of the barrier, utilizing two 27" lengths of all-thread rod (see Figure 6). The configuration was injected with silicone foam having an average density of 18.275 $lb.FT^3$.

The above mentioned installations were witnessed and documented by ICMS Quality Control.

Michael L. Stine
Quality Assurance Manager
ICMS

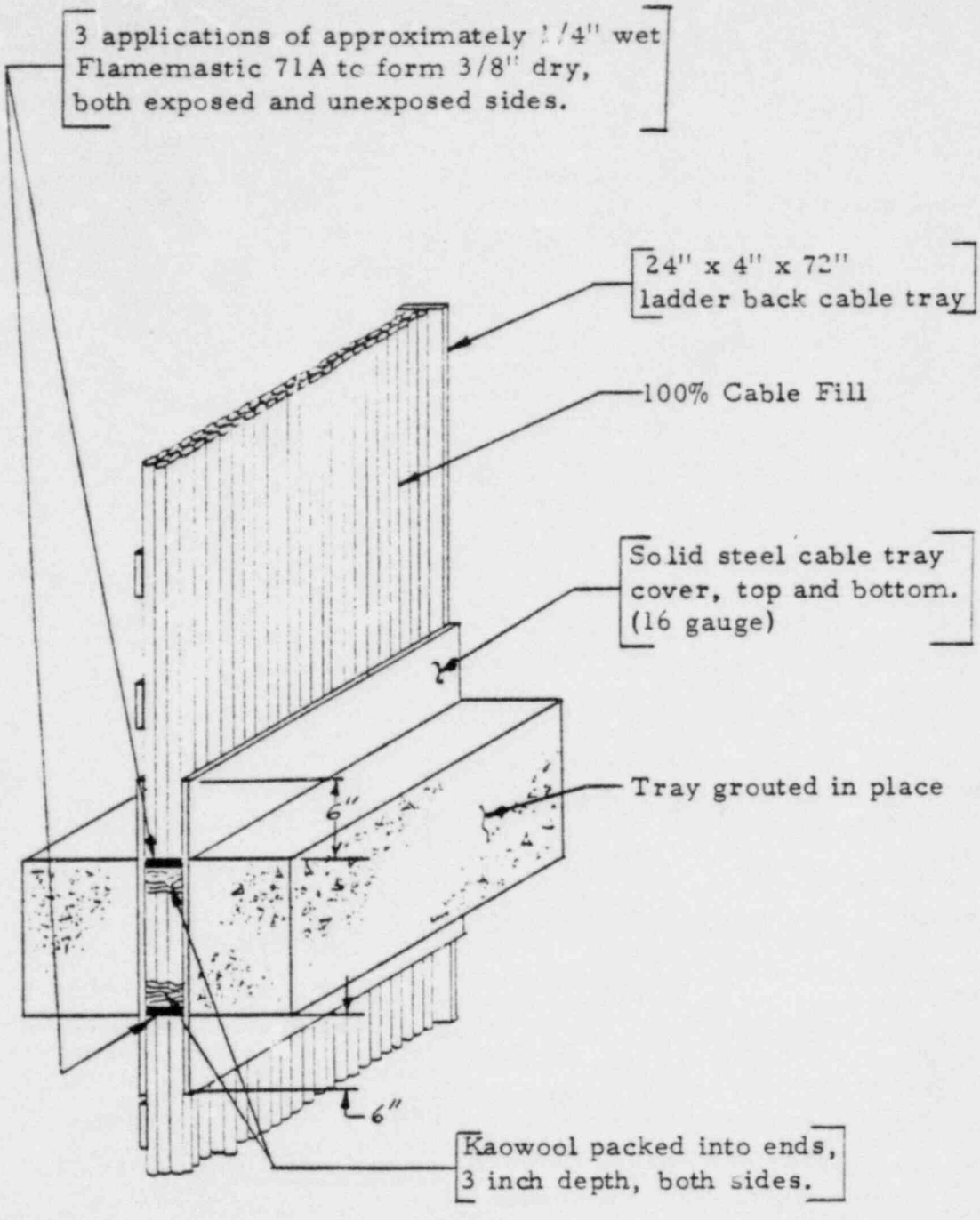


Figure III-1. Penetration 1

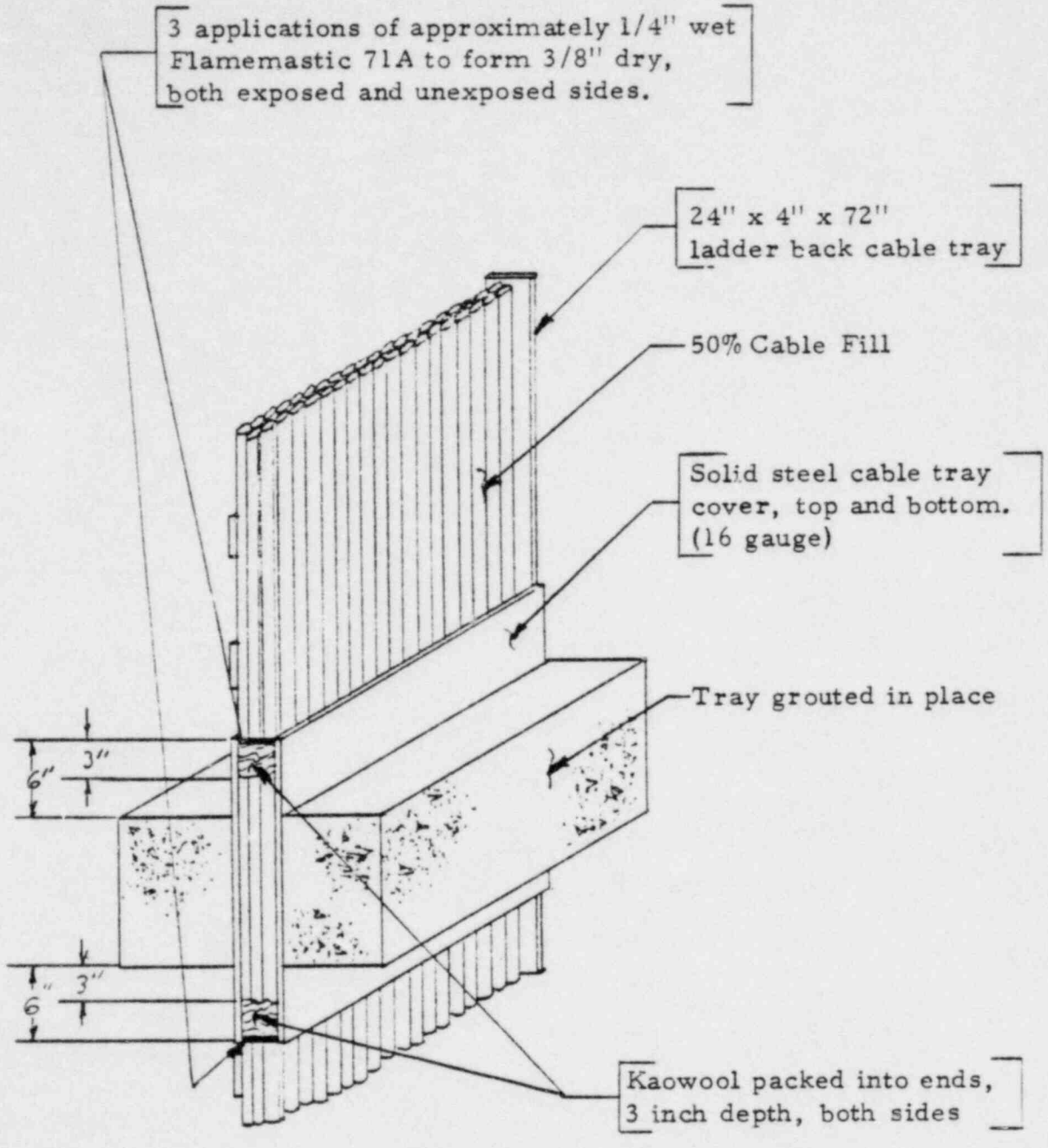


Figure III-2. Penetration 2

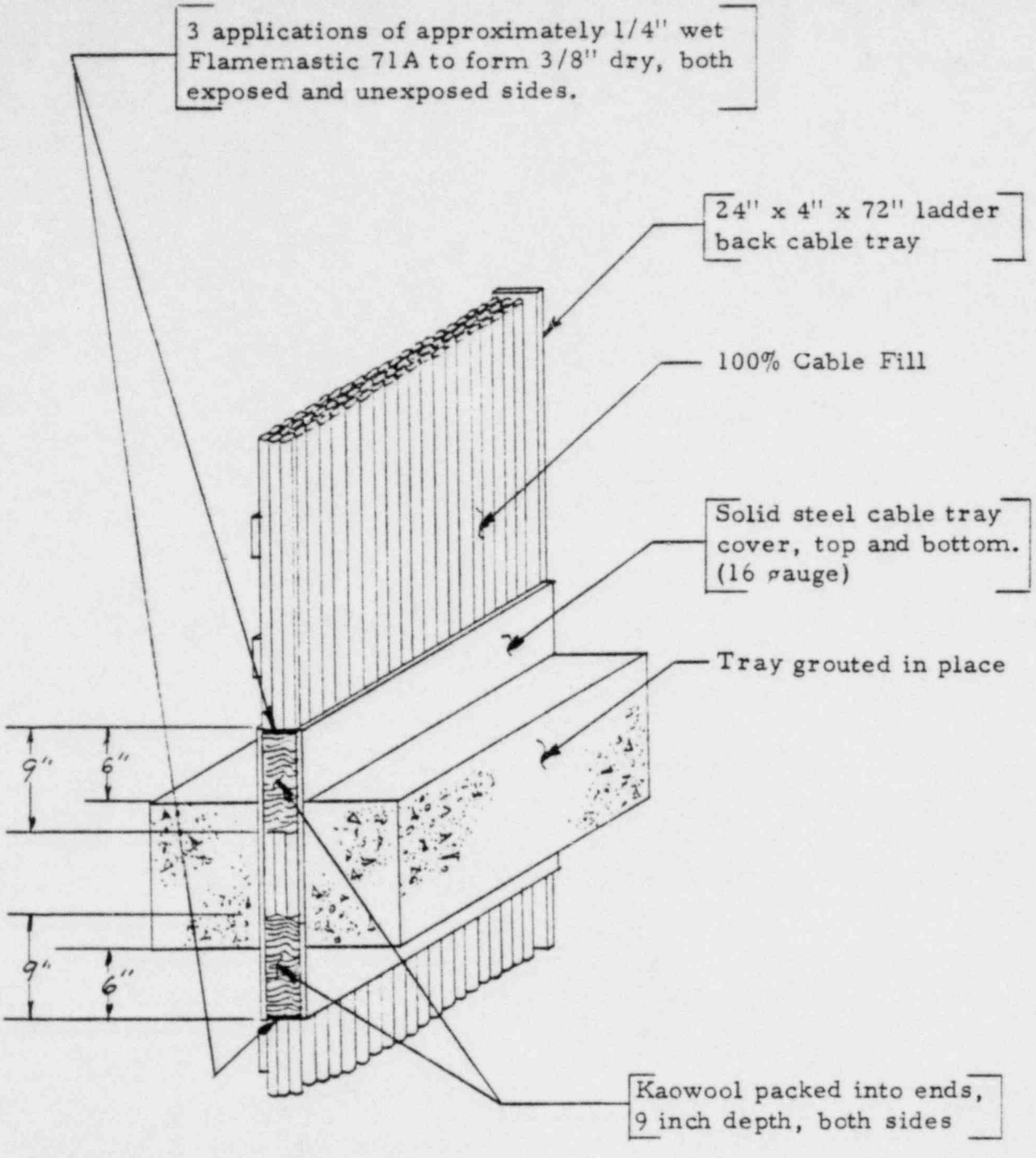


Figure III-3. Penetration 3

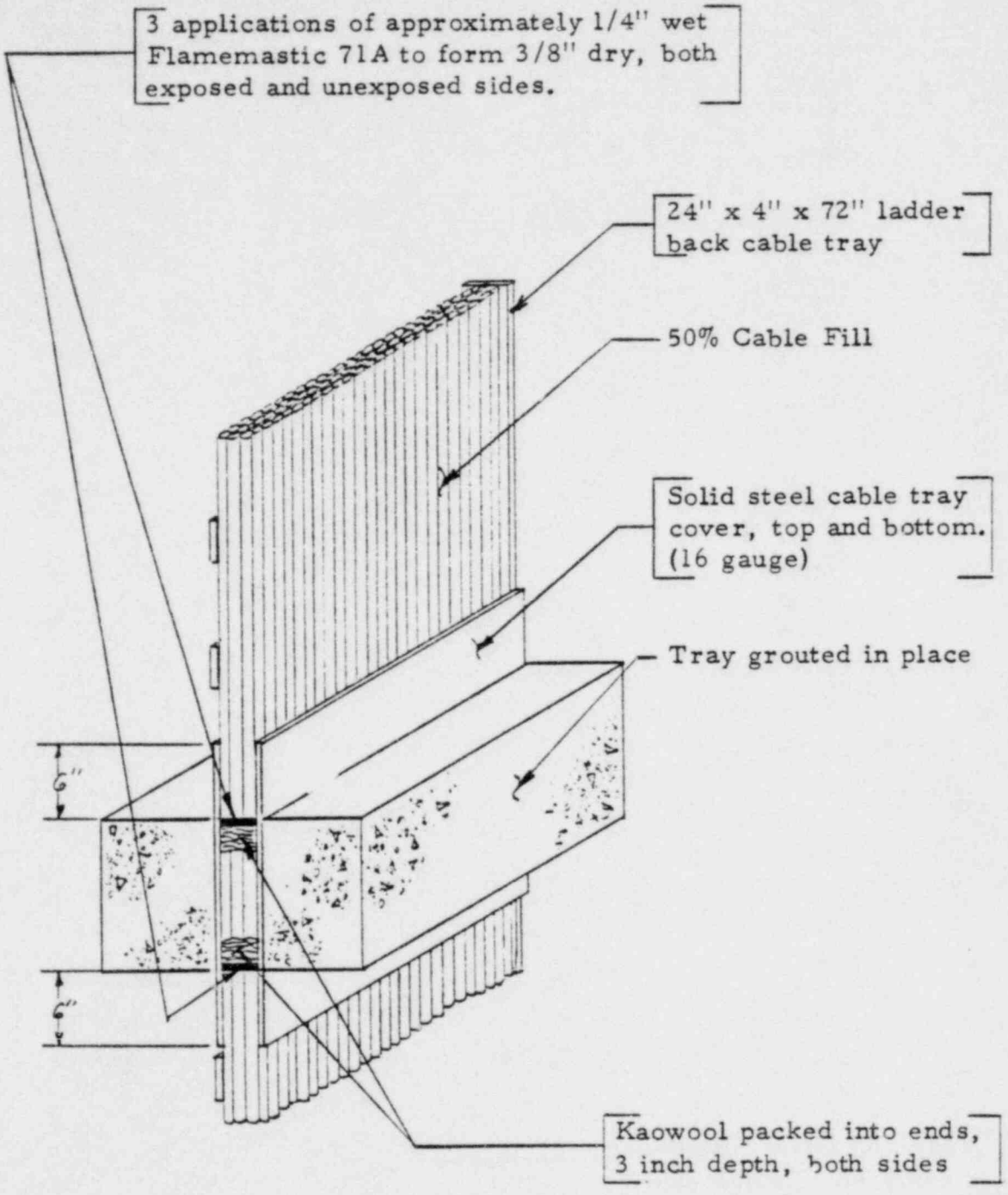


Figure III-4. Penetration 4

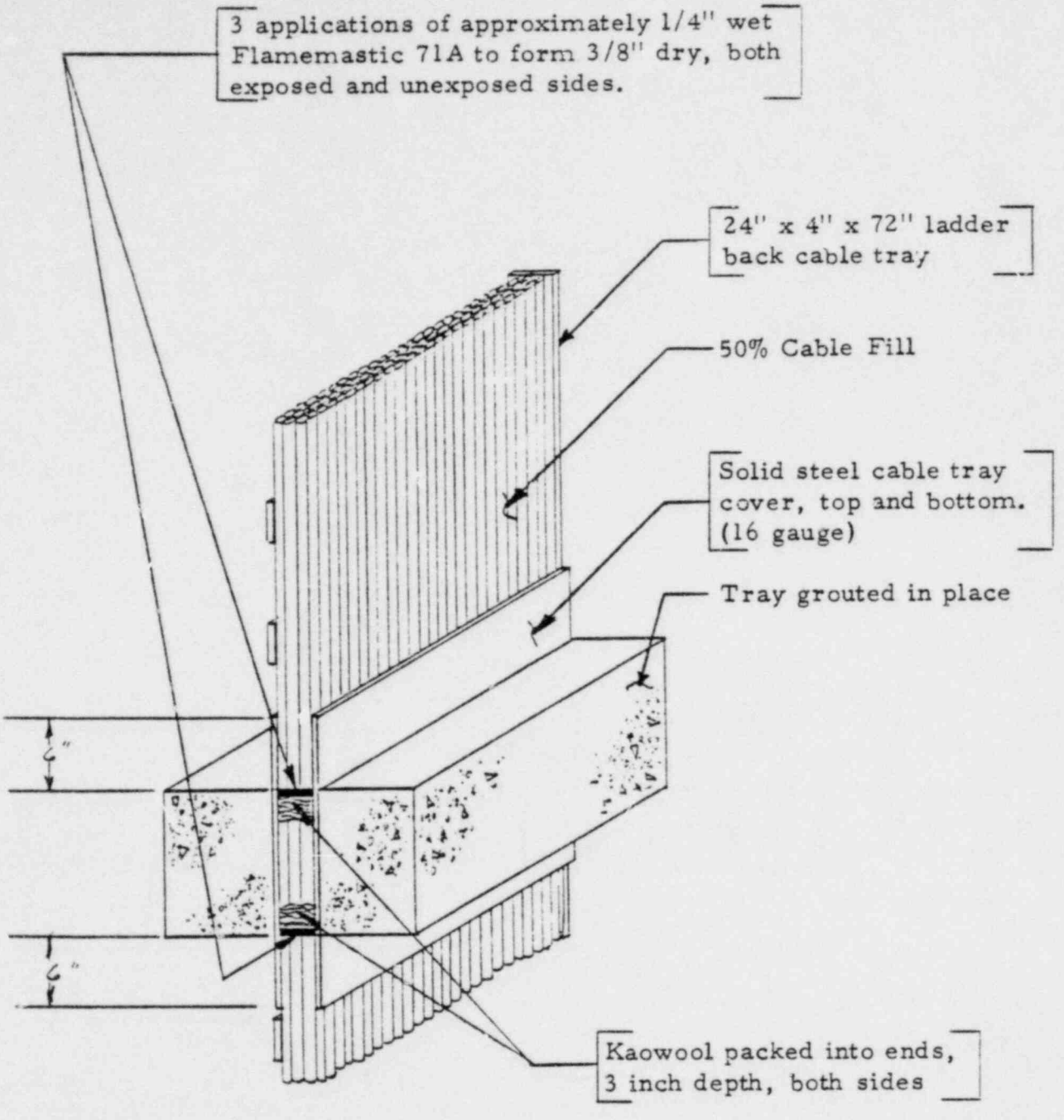


Figure III-5. Penetration 5

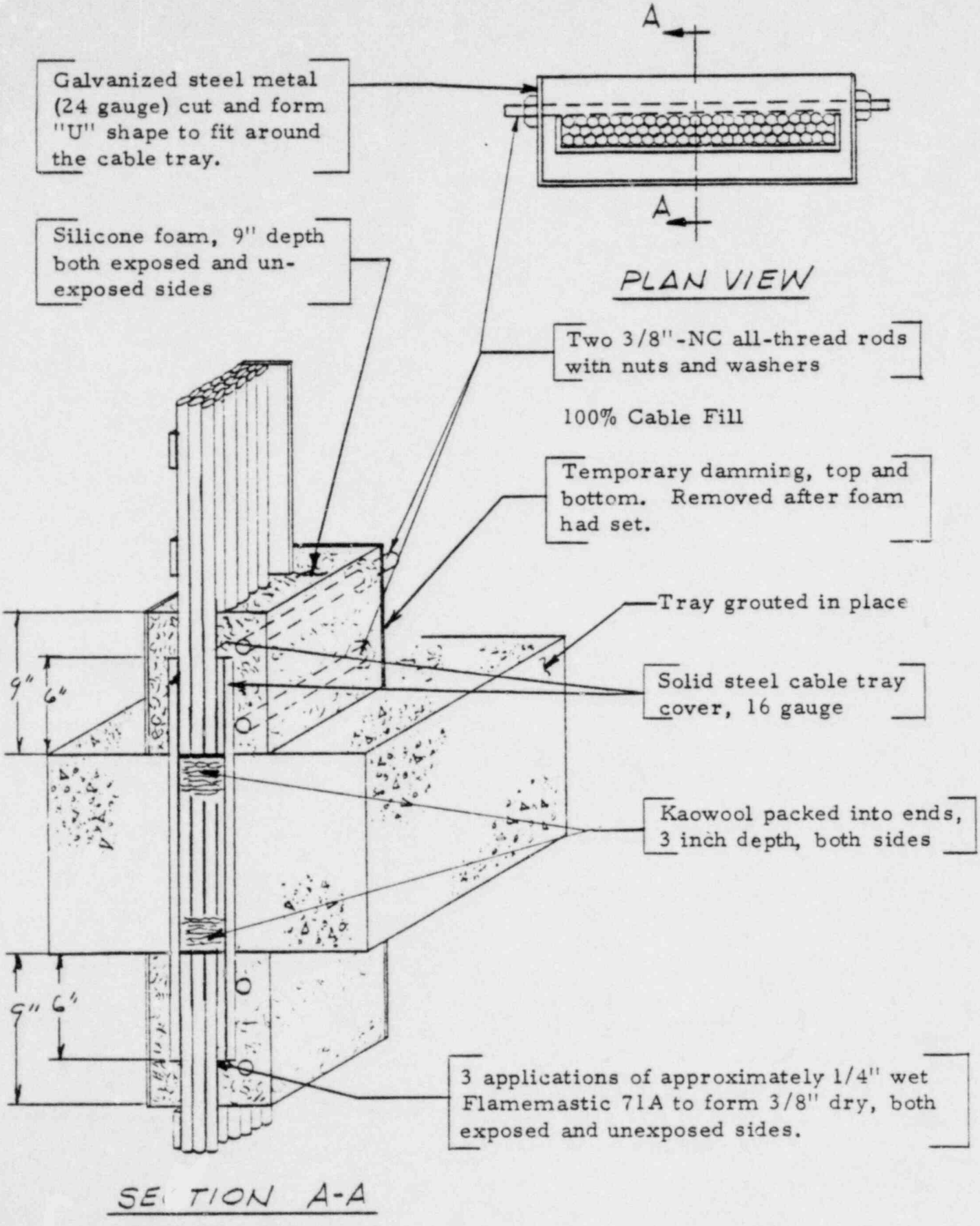


Figure III-6. Penetration 6

FORM FR-

FOAM & LEAD-FILLED SILICONE RUBBER

FIELD TAKEOFF, INSTALLATION & INSPECTION RECORD

SITE SwRI ROOM/AREA Test Slab ELEVATION N/A

NETRATION NUMBER	OPENING SIZE	PERCENT OBSTRUCT	DRAWING NUMBER	DETAIL DWG. #	BATCH NUMBER	FILL DEPTH	TYPE SEAL	INST. DATE	ACCEPT	REJECT RCA-1 NO.	INSPECTOR INITIAL	INSP. DATE
Pene. 1	24"x4" CT	100	Figure 3	N/A	3 lbs. Top 2 lbs. Bottom	3" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 1	24"x4" CT	100	Figure 3	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 2	24"x4" CT	50	Figure 5	N/A	2.5 lbs. Top 3 lbs. Bottom	3" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 2	24"x4" CT	50	Figure 5	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 3	24"x4" CT	100	Figure 4	N/A	2.25 lbs. Top 1.5 lbs. Bottom	9" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 3	24"x4" CT	100	Figure 4	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 4	24"x4" CT	50	Figure 3	N/A	3 lbs. Top 3.25 lbs. Bottom	3" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 4	24"x4" CT	50	Figure 3	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 5	24"x4" CT	50	Figure 3	N/A	2.5 lbs. Top 2.75 lbs. Bottom	3" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 5	24"x4" CT	50	Figure 3	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 6	24"x4" CT	100	Figure 6	N/A	2.5 lbs. Top 2.5 lbs. Bottom	3" T & B	KAO Wool	7-15-80	DAM / N/A	N/A		7-15 / N/A
Pene. 6	24"x4" CT	100	Figure 6	N/A	040210	3/8"	71A	*	N/A / Seal	N/A		N/A / 7-18
Pene. 6	24"x4" CT	100	Figure 6	N/A	ED040507-B S001 EQ050584-A	9" T	SF	7-17-80	N/A / Seal	N/A		N/A / 7-17
Pene. 6	24"x4" CT	100	Figure 6	N/A	ED040507-B S002 EQ050584-A	9" B	SF	7-18-80	N/A / Seal	N/A		N/A / 7-18

TAKEOFF BY ME / 7-14-80
INITIAL DATE

* Flamemastic 71A was applied in three (3) 1/4" wet coats. The installation dates for this product was between 7-16-80 and 7-18-80. Final inspection was blanket as indicated in the appropriate columns.

Form DM-

BATCH SAMPLE DENSITY MEASUREMENT

BATCH NUMBER ED040507-B EQ050584-A	COMBINED WEIGHT (grams)		CUP WEIGHT (grams)		FOAM WEIGHT (grams)		CUP VOLUME (ml)		62.3 CONVERSION FACTOR		DENSITY (lbs./cu.ft.)	INSPECTOR INITIAL	DATE
S-001	70.7	-	5.2	=	65.5	÷	230	x	62.3	=	17.74	M.S	7-17-80
S-001	70.3	-	5.2	=	65.1	÷	230	x	62.3	=	17.63	M.S	7-17-80
AVE.		-		=		÷		x	62.3	=	17.685		
S-002	71.8	-	5.2	=	66.6	÷	230	x	62.3	=	18.03	M.S	7-18-80
S-002	73.6	-	5.2	=	68.4	÷	230	x	62.3	=	18.52	M.S	7-18-80
AVE.		-		=		÷		x	62.3	=	18.275		
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			
		-		=		÷		x	62.3	=			

FORM BT-1

BATCH TEST RECORD

SITE: SwRI

BATCH NUMBER	DATE MADE	COLOR/TEXTURE/CELL STRUCTURE ACCEPTANCE CRITERIA: QC- DENSITY	ACCEPT	REJECT	RCA-1 NUMBER	INSPECTOR INITIAL	INSP. DATE
ED040507-B EQ050584-A S-001	7-17-80	17.685 AVE.	X			MS	7-17-80
ED040507-B EQ050584-A S-002	7-18-80	18.275 AVE.	X			MS	7-18-80

INSULATION CONSULTANT AND MANAGEMENT SERVICE INC.

Certification of

TEST & INSPECTION

Quantity	Part No.	Description	Date
1	#7	O'Haus Triple Beam Scale	4-4-80

Equipment Used:

O'Haus 211-01 Class F Weights Certification #20782

Method:

Scale was calibrated against weight with traceability to National Bureau of Standards.

Results:

1. Beam one gram to ten gram intervals. OK
2. Beam one hundred gram to five hundred gram at one hundred gram intervals. OK
3. Bear ten gram to one hundred gram at ten gram intervals. OK

THE PARTS ABOVE HAVE BEEN CAREFULLY TESTED IN ACCORDANCE WITH ABOVE METHODS.

INSPECTOR

Sworn to and Subscribed before Me

This 4th Day of April, 1980

in and for Berrien County, Michigan.

Elizabeth T. Fabbe

Notary Public

No. 117

III-15

I.C.M.S., INC. MATERIAL PACKING LIST
P. O. Box 1
Baroda, Michigan 49101

SHIPPING REPORT

DATE: 6-23-80 JOB NO. 356

DELIVER TO: Southwest Research Institute, San Antonio, Texas

INVENTORY ITEM/NUMBER	AMOUNT SHIPPED	DESCRIPTION	LOT/P.O. NUMBER	INVENTORY PRICE/ITEM
	150 lbs	Dow Corning 3-6548 Silicone RTV Foam	ED040507-B EQ050584-A	

DELIVERED BY: Roadway Express RECEIVED BY:

Distribution
Job Site, Billing Dept., Inventory,
Job Folder, Master File, Warehouse

DATE:

DOW CORNING

RECEIVED
JUN 13 1980
ICMS

CERTIFICATION OF ANALYSIS (TEST REPORT)

TO: Insulation Cons & Mgmt. Serv.
9007 First St.
Baroda MICH 49101

Attn: Mike Stine/Insul./P.O. Box 1/Baroda, MI 49101

PRODUCT: DOW CORNING® 3-6548 RTV Foam A&B

LOT NO: EQ050586/EQ050585/EQ050584 Part A DATE OF SHIPMENT 6 / 5 / 80

QUANTITY: 2 x 450#(EQ050586) 1 x 450#(EQ050585) 3 x 450#(EQ050584)

CUSTOMER P.O. NO. 101-A-955 DOW CORNING INVOICE NO. ED812372 E2

DOW CORNING SALES SPECIFICATION DATED 6 / 14 / 79

CUSTOMER SPECIFICATION _____ REV. _____ DATE / /

ART A

TEST	ACTUAL LOT DATA	** SPECIFICATION REQUIREMENTS **	TEST METHOD
	EQ050586	EQ050585	EQ050584
Appearance	Black, uniform viscous liquid	Black, uniform viscous liquid	Black, unifor viscous liqui
Viscosity, Poise	46	49	50
Specific Gravity	1.05	1.07	1.07
Snap Time, min.	1 min. & 17 secs.	1 min. & 32 sec.	1 min. & 21 s
Density	19.6	18.8	18.6

**SEE ATTACHED SALES SPEC. FOR SPECIFICATION REQUIREMENTS AND TEST METHOD

THIS MATERIAL MEETS REQUIREMENTS OF 10CFR PART 21

*Data marked with asterisks is not collected on each lot, but is run on an audit basis. The data shown on this certification for these tests was last determined on LOT NO. _____ on _____. This is to certify that the above designated material has been tested and did comply with listed specifications and requirements with the listed exceptions when supplied. The material is subject to the conditions listed on the Dow Corning invoice. The above information and lot acceptance data are on file and available for examination.

BY: Hubert F. Brooks DATE 6/10/80
QUALITY ASSURANCE REPRESENTATIVE

DOW CORNING

RECEIVED
JUN 13 1980
ICMS

CERTIFICATION OF ANALYSIS (TEST REPORT)

TO: Insulation Cons & Mgmt. Serv.
9007 First St.
Baroda MICH 49101

Attn: Mike Stine/INSUL Serv./P.O. Box 1/Baroda, MI 49101

PRODUCT:
DOW CORNING® 3-6548 RTV Foam A&B

LOT NO: ED040507/ED040510 Part B

DATE OF SHIPMENT 6 / 5 / 80

QUANTITY:
2 x 450#(ED040507) 1 x 450#(ED040510)

CUSTOMER P.O. NO. 101-A-955

DOW CORNING INVOICE NO. ED812372 E2

DOW CORNING SALES SPECIFICATION DATED 6 / 14 / 79

CUSTOMER SPECIFICATION _____ REV. _____ DATE / /

PART B TEST	ACTUAL LOT DATA	XSPECIFICATIONX **XREQUIREMENTSX	**XNSCXMXTHODX
	ED040507	ED040510	
Appearance	Off-white, uniform viscous liquid	Off-white, uniform viscous liquid	
Viscosity, Poise	68	50	
Specific Gravity	1.05	1.04	
Snap Time, min.	1 min. & 5 secs.	1 min. 10 secs.	
Density	17.1	17.8	

**SEE ATTACHED SALES SPEC. FOR SPECIFICATION REQUIREMENTS AND TEST METHOD

THIS MATERIAL MEETS REQUIREMENTS OF 10CFR PART 21

*Data marked with asterisks is not collected on each lot, but is run on an audit basis. The data shown on this certification for these tests was last determined on LOT NO. _____ on _____. This is to certify that the above designated material has been tested and did comply with listed specifications and requirements with the listed exceptions when supplied. The material is subject to the conditions listed on the Dow Corning invoice. The above information and lot acceptance data are on file and available for examination.

BY: Hubert F Brooks DATE 6/10/80
QUALITY ASSURANCE DEPARTMENT

DOW CORNING

DOW CORNING® 3-6548
Silicone RTV Foam
Parts A & B

New Date June 14, 1979
Supersedes Oct. 28, 1976

SALES SPECIFICATIONS

PROPERTIES	LIMITS	TEST METHODS DOW CORNING	TEST METHODS OTHER
Appearance		CTM 0176	Visual
Part A	Black, uniform viscous liquid		
Part B	Off-white, uniform viscous liquid		
Viscosity, poise Brookfield Model HAF Spindle #3 @ 10 rpm		CTM 0050	ASTM D 1084 Method B
Part A	35 - 55		
Part B	50 - 70		
Specific Gravity @ 25 C		CTM 0097	ASTM D 1475
Part A	1.03 - 1.09		
Part B	1.03 - 1.09		
Mix 1 part of Part A with 1 part of Part B			
Snap Time, minutes	1.0 - 2.0	CTM 0092A	
Density, minimum confinement foaming hand mixed, lbs/ft^3	14 - 20	CTM 0854A	

SHELF LIFE: 12 months from date of shipment

— Denotes changes

Dow Corning corporate test methods are based, when appropriate, on standard methods in ASTM or other compendia, but may not be exactly equivalent. Dow Corning methods are available on request.
Refer to the technical data sheet for typical properties and performance characteristics of this product.

CERTIFICATION

Flamemaster

CUSTOMER NAME: SOUTHWEST RESEARCH INSTITUTE

CUSTOMER PURCHASE ORDER#: 100563

SHIPPER NUMBER: 8870

SHIPPING DATE: 6/25/80

BATCH NUMBERS: 040200/040210

SPECIFICATIONS:

THE FLAMEMASTER CORPORATION certifies that the 71A "MASTIC" material supplied on the above purchase order has been manufactured to meet the specifications set forth in our technical bulletin.

S. Samson

QUALITY CONTROL

TECHNICAL BULLETIN
April 1976 - 003

FLAMEMASTIC® 71A SYSTEM

PRODUCT DESCRIPTION

Flamemastic 71A System Coatings are compounded of waterbase thermoplastic resins, flame retardant chemicals and inorganic incombustible fibers. The Flamemastic 71A System is protected by one or more of the following patents: 3642531; 3928210 Great Britain 1297710; West Germany 2039969 or other patents pending.

TYPICAL PROPERTIES

FIRE PROTECTION

Flamemastic 71A prevents propagation of fire on grouped electrical cables. This fire protection has been demonstrated in a wide variety of tests and proven in industrial fires. Copies of these tests are available upon request.

EFFECT ON AMPACITY

Reduction in current carrying capacity varies with the size of the cable and the thickness of the coating. At the recommended coating thickness there is no significant effect on the ampacity of the coated cables.

PERMANENCE

Flamemastic 71A applications have provided permanent fire protection over a period of more than six years in all climatic conditions and have shown no adverse effect on any type of cable jacket.

WEIGHT PER GALLON

Flamemastic 71A Sprayable	11.0#/Gallon
Flamemastic 71A Mastic	11.4#/Gallon

SOLIDS

Flamemastic 71A Sprayable	64.4%
Flamemastic 71A Mastic	67.3%

Babcock & Wilcox

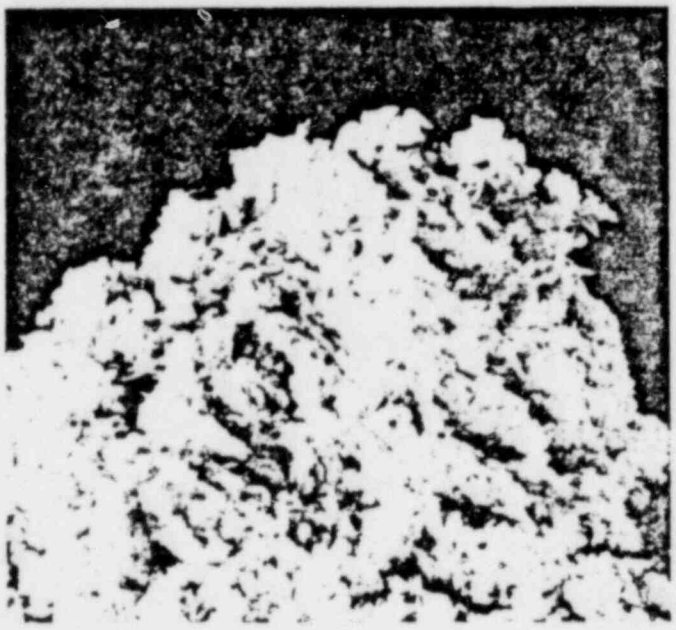
Kaowool® Ceramic Fiber Products

Basic fiber—bulk

B&W Kaowool ceramic fiber is the basic fiber from which the Kaowool family has grown. The raw material is kaolin, a naturally occurring, high purity, alumina-silica fireclay. Kaowool has a melting point of 3200F, a normal use limit of 2300F, but can be used at even higher temperatures in certain applications. B&W Kaowool has fiber lengths up to 10 in., average lengths of 4 in. These long fibers, thoroughly interlaced in the production process, provide Kaowool blanket, bulk, and strip products with unsurpassed strength without the addition of a binder system. Other forms are processed from basic Kaowool ceramic fiber.

B&W Kaowool bulk fiber is available in many forms:

1) Bulk A—Lubricated fiber for ease of handling.
2) Bulk B—Unlubricated fiber for processing into other forms.
3) Bulk C—Unlubricated short fiber for processing into other forms.
4) Chopped Fiber—Unlubricated shorter fiber for processing into other forms.
5) Washed Fiber—Water cleaned to obtain a finer diameter unlubricated fiber free of shot.
6) High-Purity Fiber—For reducing conditions or where low percentages of iron oxide and titania are required in the fiber.



Physical properties:

Kaowool ceramic fiber is a highly efficient insulator. Kaowool's low shot content gives more usable fiber for your insulating dollar. Kaowool's longer fibers give it the high tensile strength and resiliency to withstand vibration and physical abuse. Kaowool is self-supporting—will not separate, sag or settle. Kaowool has low thermal conductivity, low heat storage, and is extremely resistant to thermal shock.

	Bulk A & B, High Purity	Bulk C, Chopped
Color	White	White
Fiber Diameter	2.8 microns average	2.8 microns
Fiber Length	Up to 10" (4" average)	shorts to ½"
Specific Gravity	2.56	2.56
Specific Heat at 1800F mean	0.255 Btu/lb/F	0.255 Btu/lb/F
Tensile Strength, Fiber	1.9×10^3 lbs/sq in.	1.9×10^3 lbs/sq in.
Tensile Modulus, Fiber	16.8×10^6 lbs/sq in.	16.8×10^6 lbs/sq in.
Recommended Continuous Use Temperature	To 2300 F	To 2300F
Melting Point	3200 F	3200F
Hardness:	6—MOH's scale 700-Knoop scale 100 gr. loading	

IMPORTANT: READ THIS FIRST

This sheet contains information on how to use EMBECO 636 GROUT to obtain the performance qualities described in Master Builders literature. The sheet also contains suggestions that highlight generally accepted successful field practice for precision grouting. These suggestions may be followed, modified or rejected by the engineer, owner or contractor since they, and not Master Builders, are responsible for planning and executing procedures appropriate to a specific installation. However, when the planned procedure differs from that discussed herein, the prospective user of EMBECO 636 GROUT is urged to contact the local Master Builders representative to ascertain whether the planned procedure requires additional or revised information on how to use EMBECO 636 GROUT.

EMBECO 636 GROUT is a factory-blended product specially formulated for general purpose precision support. EMBECO 636 GROUT is recommended for use in grouting of paper mill soleplates under hooded driers, rolling mills, turbines and other machines subject to thermal movement and/or repetitive dynamic loading, as well as equipment, crane rails, anchor bolts and other applications requiring non-shrink, high-strength precision grout.

WHERE NOT TO USE EMBECO 636 GROUT:

- for applications requiring considerable delays between mixing and placing
- where the base concrete cannot be completely saturated for 24 hours before grouting
- where thorough curing of all exposed portions of the grout is not possible
- for grouting heavy-duty equipment that must be started in 24 hours or less
- where the grout must be feather-edged
- for grouting steel anchorages, cables or bolts, stressed over 80,000 psi (552 MPa)

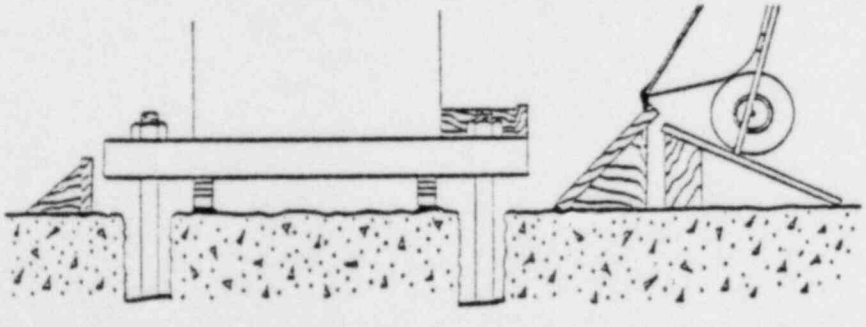
WARNING:

AS WITH OTHER PRODUCTS CONTAINING PORTLAND CEMENT, EMBECO 636 GROUT MAY CAUSE IRRITATION: AVOID CONTACT WITH EYES AND PROLONGED CONTACT WITH SKIN. IN CASE OF CONTACT WITH EYES, IMMEDIATELY FLUSH WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. CALL A PHYSICIAN. IN CASE OF CONTACT WITH THE SKIN, WASH SKIN THOROUGHLY. KEEP PRODUCT OUT OF REACH OF CHILDREN.

INFORMATION on using EMBECO* 636 GROUT & SUGGESTIONS on procedures for precision grouting

Before pumping or dry packing EMBECO 636 GROUT, discuss the condition with the local Master Builders field representative.

When grouting in environments below 50°F (10°C) or above 75°F (24°C), contact Master Builders for our Hot Weather or Cold Weather grouting bulletins and/or jobsite service.



Gravity grouting with flowable, non-shrink, self-leveling grout is the most common and accurate method of grouting.

*Registered Trademark

REQUIREMENTS FOR USING EMBECO* 636 GROUT

PREPARATION

Clean out bolt holes and have foundation area to be grouted thoroughly clean, rough but level. To achieve a good bonding surface, the use of a small chipping hammer is preferable to the use of a bushhammer.

Saturate the cleaned foundation and any bolt holes with water for 24 hours. **Just before** grouting, remove all free water.

Always grout the clean, saturated (no free water) bolt holes first. If all free water cannot be removed, contact your local Master Builders field representative for suggested placing methods.

Provide air relief holes in the base plate where necessary.

FOR BEST RESULTS WHENEVER PLATES OR EQUIPMENT ARE TO BE GROUTED BY POURING, RODDING, STRAPPING, PUMPING OR DRY PACKING, SUCH PLATES OR EQUIPMENT SHOULD BE RIGIDLY BOLTED DOWN ON SHIMS OR LEVELING SCREWS TO PREVENT THEIR MOVEMENT DURING INSTALLATION.

FORMS

Forms should facilitate rapid, continuous and complete filling of the space to be grouted.

Build strong, tight, well-braced forms.

On the grout-placing side, slant the form at an angle of approximately 45° outward and extend this form suitably high to provide a head of grout during placement. Grout should be poured directly on the sloped form to minimize entrapment of air during placement.

On other sides allow at least ½" (13 mm) horizontal clearance between base plate and forms and make forms at least an inch higher in elevation than underside of plate. Use methods of forming that will allow the grout to flow by gravity between the plate and the foundation and keep the grout in full contact with these surfaces until it has hardened.

TEMPERATURE

Store and mix grout so as to produce the desired mixed grout and placing temperatures under jobsite conditions. Consider using iced water in warm weather or warm water in cold weather.

Ideally, the foundation and base plate should be in the 55° to 65° F (13° to 18° C) range—but never below 45° F (7° C).

Where unavoidable conditions indicate high temperatures might be involved, contact your local Master Builders field representative for assistance.

	Temperature		
	Absolute Minimum	Ideal	Suggested Maximum
Foundation & Plates	45° F 7° C	55°-65° F 13°-18° C	85° F 29° C
Dry Grout Storage	35° F 2° C	60°-65° F 16°-18° C	100° F 38° C
Mixing Water	32° F 0° C	50°-60° F † 10°-16° C	80° F 27° C
Grout as mixed & placed	45° F 7° C	50°-60° F † 10°-16° C	70° F 21° C

†Use of iced water will reduce water required for a given consistency and increase strength and working time accordingly.

*Registered Trademark

When grouting at minimum temperatures, care must be taken to see that foundation, plate and grout temperatures do not fall below 45° F (7° C) for at least 24 hours and that the grout is protected from freezing (32° F or 0° C) until it has reached 4000 psi (27.6 MPa) compressive strength.

ESTIMATING DATA

55 lb (25 kg) of EMBECO* 636 GROUT mixed with 10.5 lb or 1.26 gal (4.76 litre) of water will yield approximately 0.43 cubic feet (12.2 litre) of grout. More or less water may be used to meet consistency requirements, thus increasing or decreasing this yield.

MIXING

Do not add cement, sand, pea gravel or other materials to this quality-controlled product and do not use the contents of packages that are damaged or broken.

Mix with drinkable water only.

DO NOT MIX BY HAND. Use 1 or more mixers to permit mixing and placing operations to proceed simultaneously without interruption.

Most grouting is performed at flow between 20 and 30 seconds depending upon distance grout must flow on its own.

The exact amount of water needed to produce a flow of 25 ± 5 seconds (CRD-C 79-77) will depend upon the temperature of the grout following mixing (45°-70° F) (7°-21° C) and the size of batch mixed. Use iced or cold water to lower mixed grout temperature and warmer water to raise it.

Do not use water in an amount or at a temperature that will produce a flow of less than 20 seconds or cause bleeding or segregation.

Put the water required in the mixer first, then slowly and steadily add the grout. Mix until smooth (2-3 minutes) and place at once.

DO NOT MIX MORE THAN CAN BE POURED IN APPROXIMATELY 10 MINUTES. Discard any material that becomes unworkable.

Do not retemper grout by adding water or remixing after it stiffens.

PLACING

All the grout in a batch should be in place before **any** becomes unworkable.

Place grout quickly and continuously.

Grout should be placed from only one side of a plate to avoid entrapment of air while grouting.

Make sure grout fills the entire space to be grouted and **remains in contact** with the plate throughout all of the grouting placement.

DO NOT VIBRATE.

CURING

Immediately after grout is placed, cover all exposed grout with clean wet rags (not burlap) and keep these moist until grout surface is ready to be finished or until final set. Never remove forms or cut back grout below underside of object grouted before grout has hardened sufficiently to prevent penetration with a pointed mason trowel. Following removal of moist rags, forms, or finishing of shoulders, coat exposed grout with Masterseal* or Masterseal* 66.

*Registered Trademark

SUPPLEMENTAL INFORMATION

GENERAL

Before grouting, determine if there is excess vibration of the foundation or base plate to be grouted caused by nearby operating equipment. Consider shutting down this source of vibration until after the newly-placed grout has taken final set. Excessive vibration can cause settlement and bleeding and disturb the set. Vibration can be determined by observing any disturbance of the surface of water in a pan resting on the base plate or foundation to be grouted.

Mix and place grout as close as possible to the plate being grouted. Have sufficient manpower, materials and tools to make mixing and placing rapid and continuous. Where grout must flow some distance, make the initial batch slightly more fluid than required; this lubricates the surfaces and avoids blockage of the grout that follows.

Place metal banding for straps under large base plates before grouting in case strapping becomes necessary to move grout into difficult areas. Do not strap grout which has already been satisfactorily placed and has thickened. Rapid and continuous mixing and placing will minimize or eliminate the need for strapping.

EMBECO* 636 GROUT must be cured. Grout shoulders may be finished and left in place, in which case they must be cured or they may be beveled or trimmed vertically (flush) with the base plate. Premature form removal or cutting back of excess shoulder grout can cause sagging of unhardened grout causing loss of bearing between grout and structural member it is intended to support.

Shims should not be removed or leveling screws backed off until the grout has attained sufficient load-bearing strength.

EMBECO 636 GROUT is not intended for use as a floor topping or in wide areas of exposed shoulder around base plates. Where exposed shoulders are used, the appearance of an occasional hairline crack should not be taken as a matter of concern. If they occur, these superficial cracks are usually caused by temperature and moisture changes which affect the exposed shoulder grout at a more rapid rate than the more massive base concrete and the grout beneath the base plate. These cracks are of no structural significance and do not detract from the nonshrink vertical support provided by the grout if the foundation preparation, pre-saturation, placing and curing procedures given in the foregoing instructions were properly carried out.

SAMPLING

Samples of mixed grout for flow or compressive strength cubes should be taken from the mixer in a manner to obtain uniform and representative samples. Details of testing methods such as those for flow, CRD-C 79-77, and compressive strength, ASTM C 109 (modified for premixed grout) and test method TP-G-CS, **Test Procedure For Determining Compressive Strength of Fluid & Flowable Grouts** are recommended and available from Master Builders.

FOR ADDITIONAL INFORMATION CONTACT:

MASTER BUILDERS

DIVISION OF MARTIN MARIETTA CORPORATION

CLEVELAND, OHIO 44118 • TORONTO, ONTARIO M6M 3E4

Form 5636G-1e
Printed in U.S.A. 679

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APPENDIX IV

UNEXPOSED SURFACE THERMOCOUPLE DATA

TABLE IV-1

THERMOCOUPLE - RECORDER ASSIGNMENT

Penetration Number	Type	TC No.	Recorder (Digistrip #)	Channel No.
Furnace Average			1	2
1	F	1	1	3
	I	2	1	4
	P	3	1	5
	E	4	1	6
2	F	5	1	7
	I	6	1	8
	P	7	1	9
	E	8	1	10
3	F	9	1	11
	I	10	1	12
	P	11	1	13
	E	12	1	14
4	F	13	1	15
	I	14	2	2
	P	15	2	3
	E	16	2	4
5	F	17	2	5
	I	18	2	6
	P	19	2	7
	E	20	2	8
6	F	21	2	9
	I	22	2	10
	P	23	2	11
	E	24	2	12

F = Field
I = Interface
P = Penetrant
E = Eng., grout surface

THERMOCOUPLE LOCATIONS

(DRAWINGS)

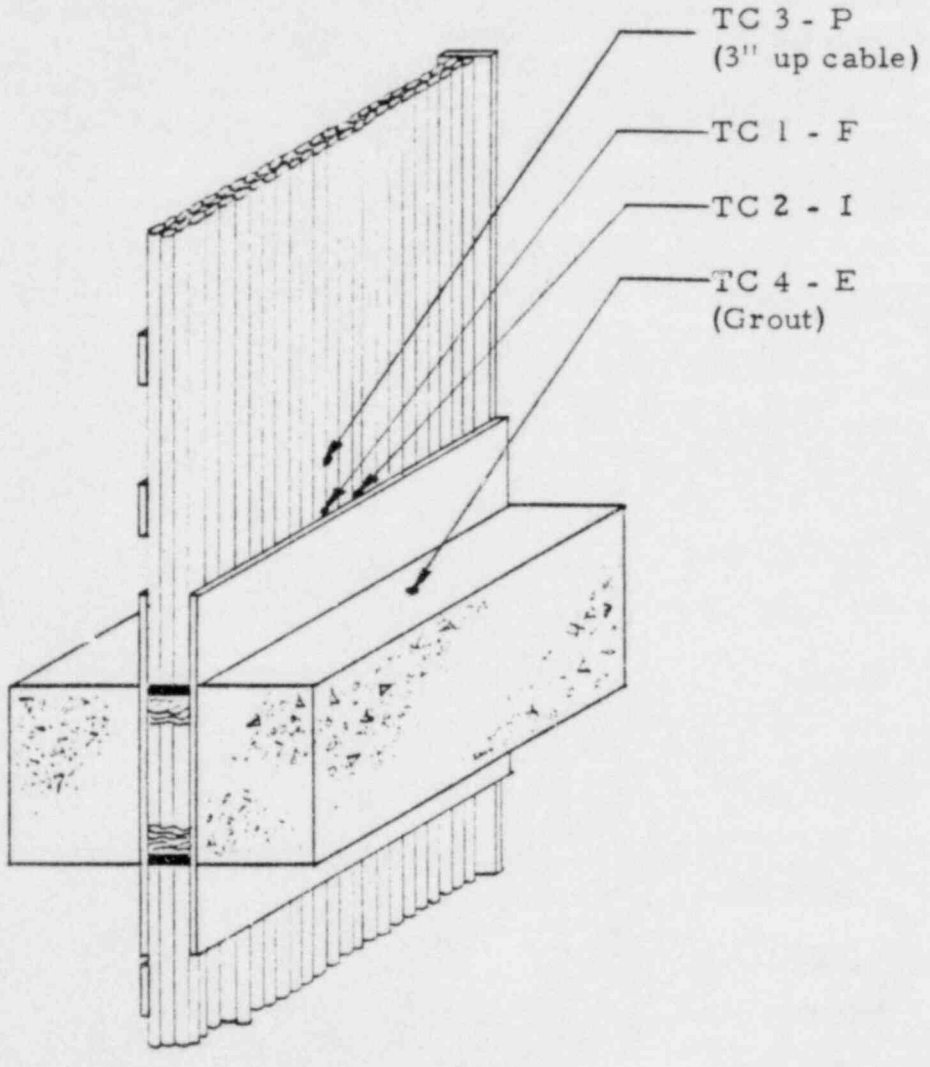


Figure IV-1. Cable Tray 1 Thermocouple location

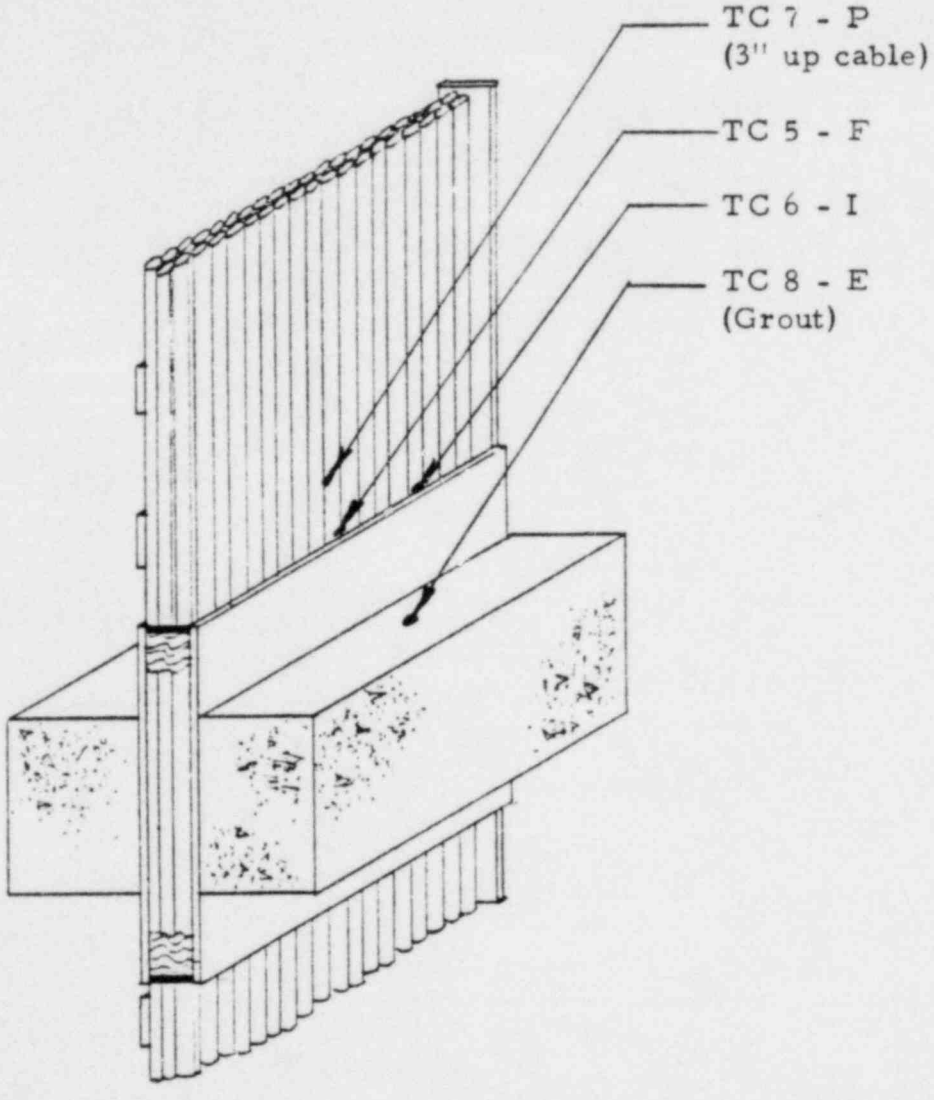


Figure IV-2. Cable Tray 2 Thermocouple location

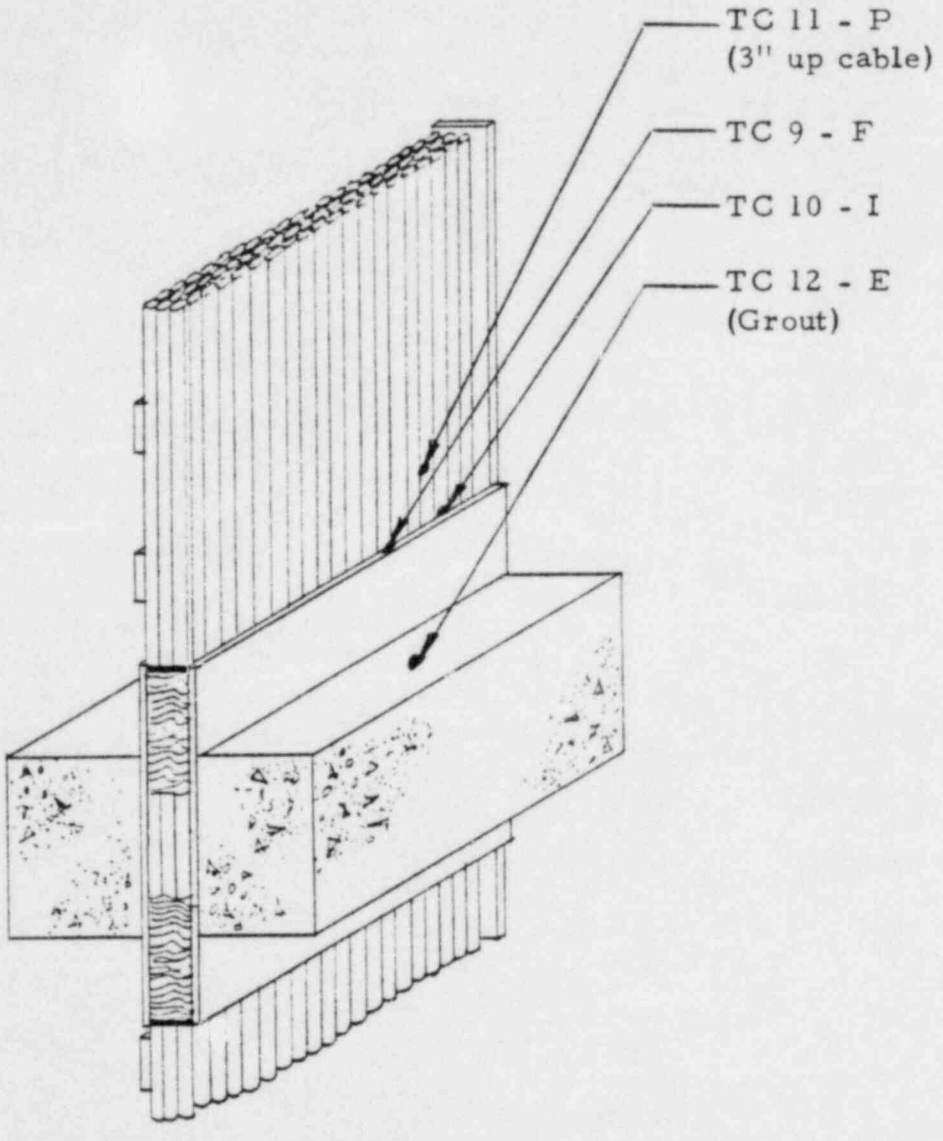


Figure IV-3. Cable Tray 3 Thermocouple location

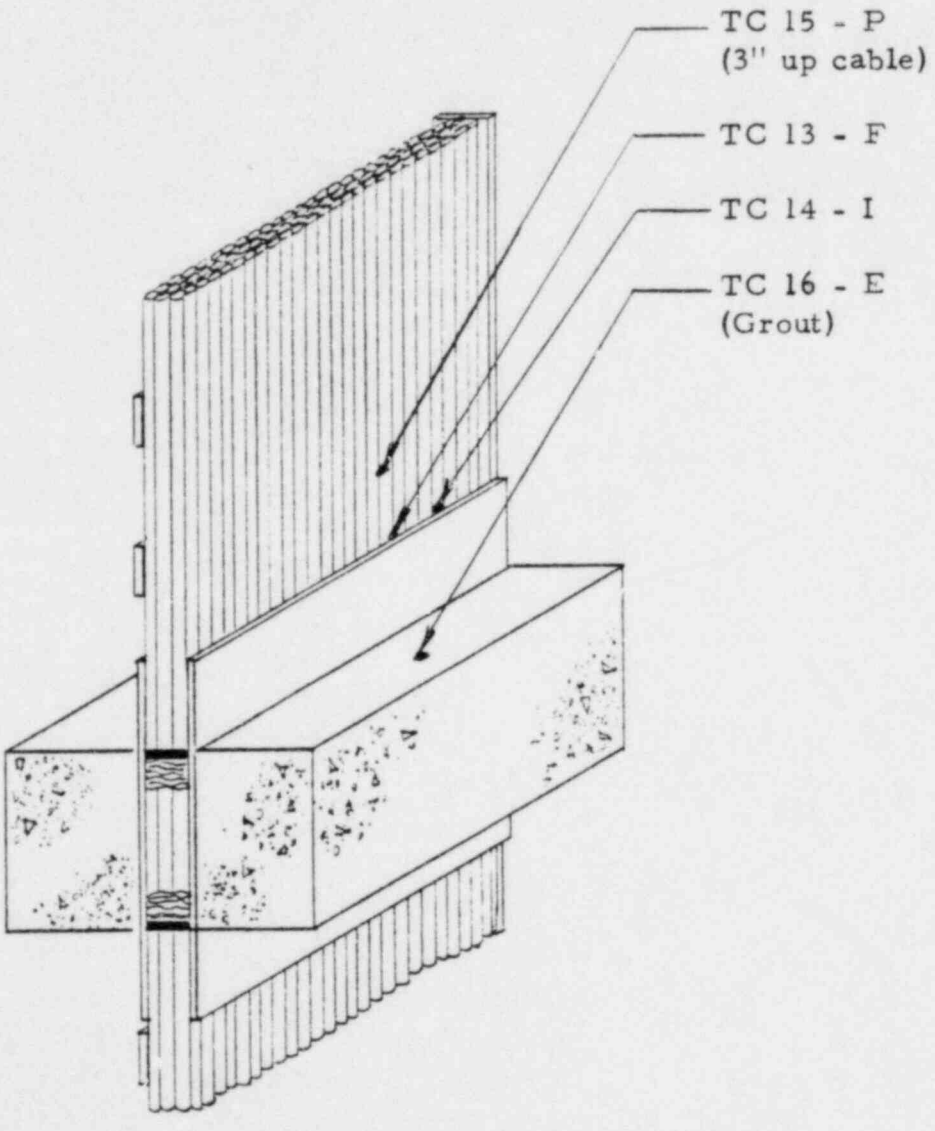


Figure IV-4. Cable Tray 4 Thermocouple location

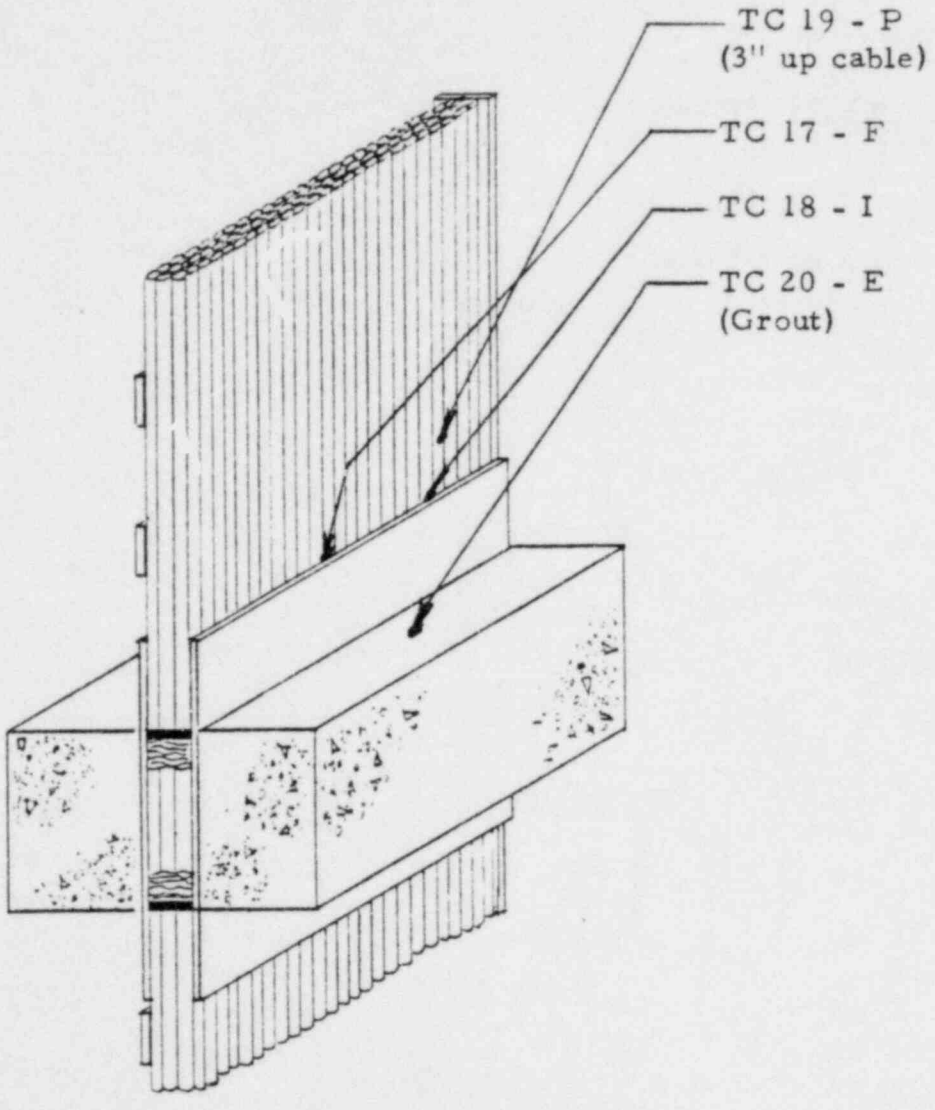


Figure IV-5. Cable Tray 5 Thermocouple location

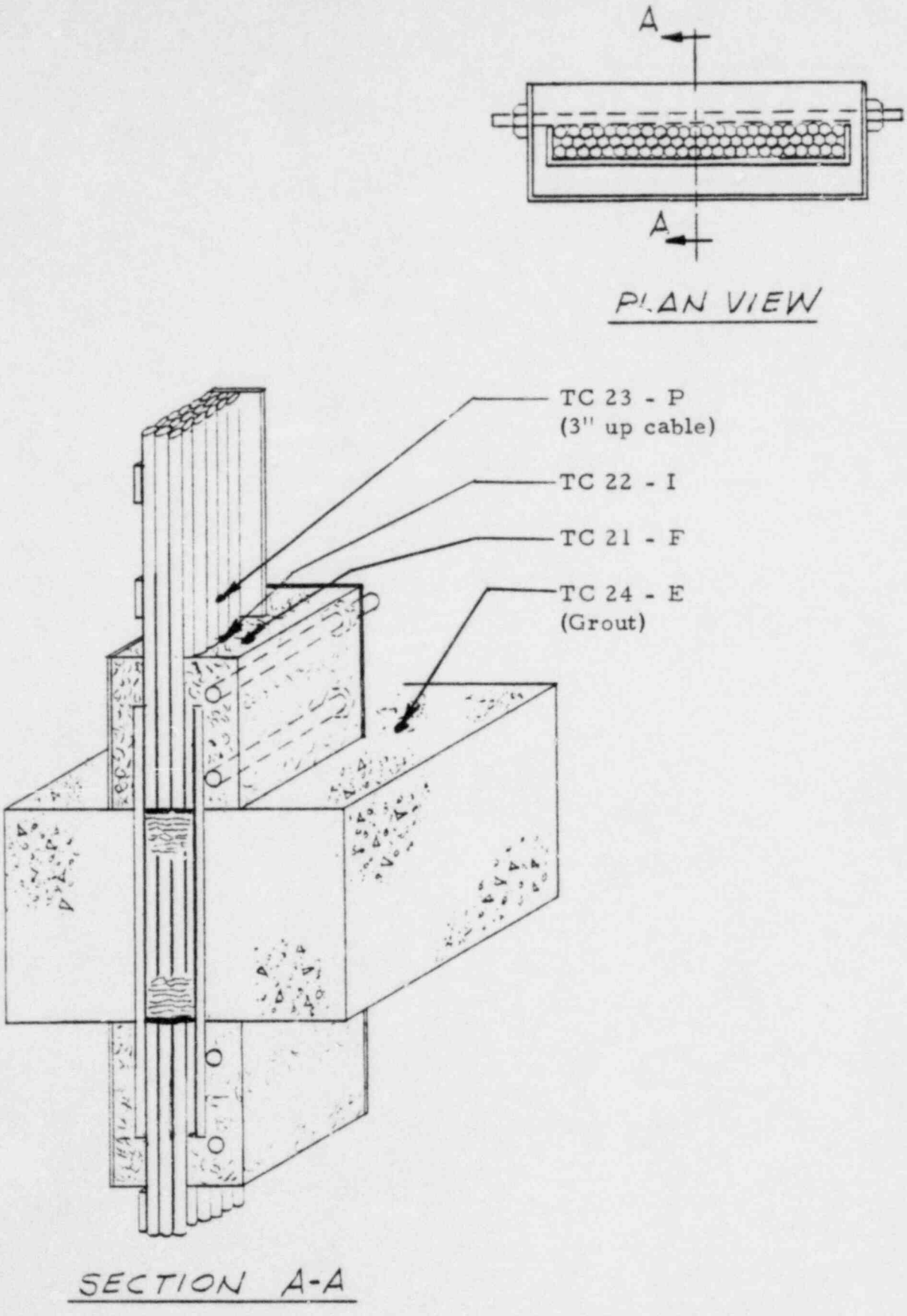
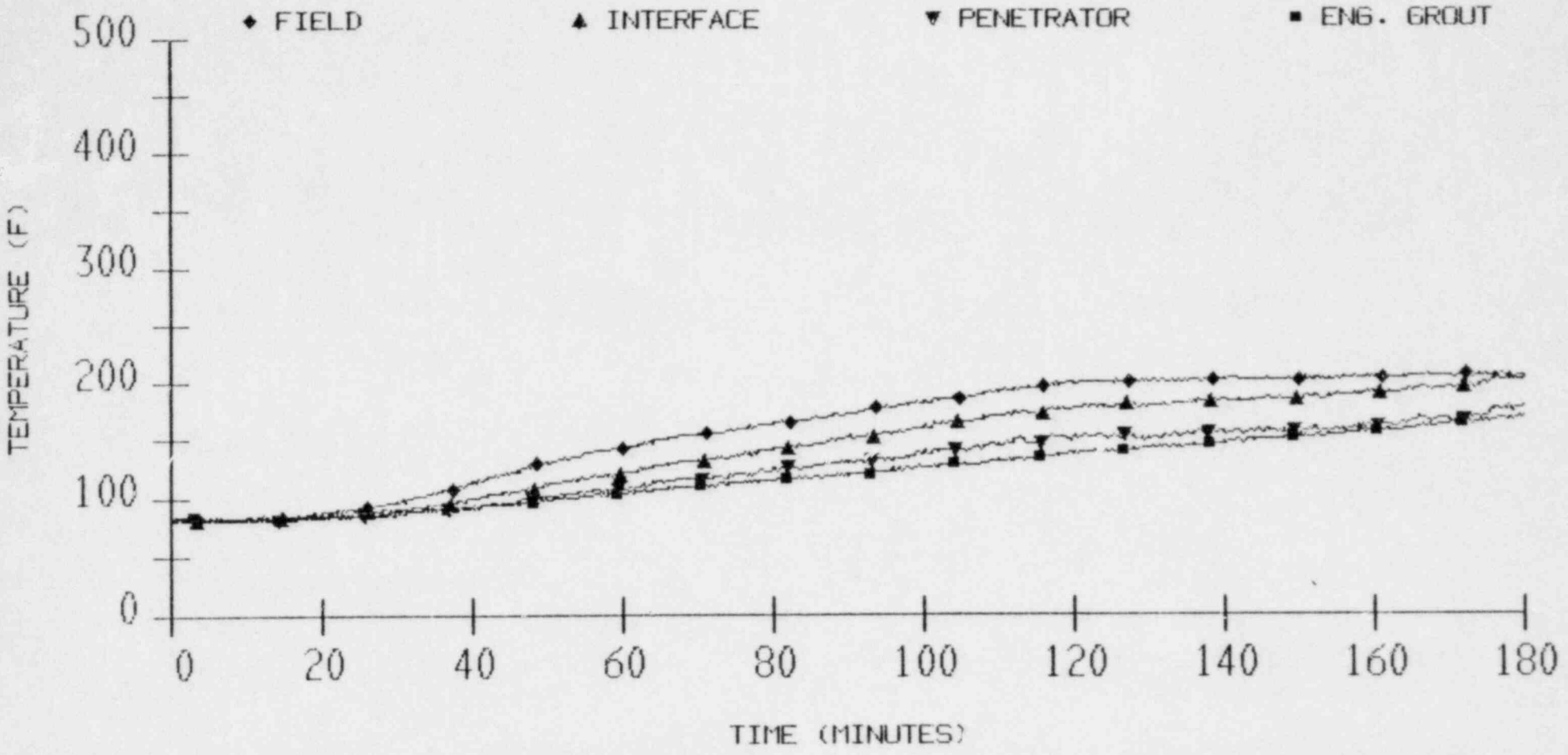


Figure IV-6. Cable Tray 6 Thermocouple location

TEST GRAPHS

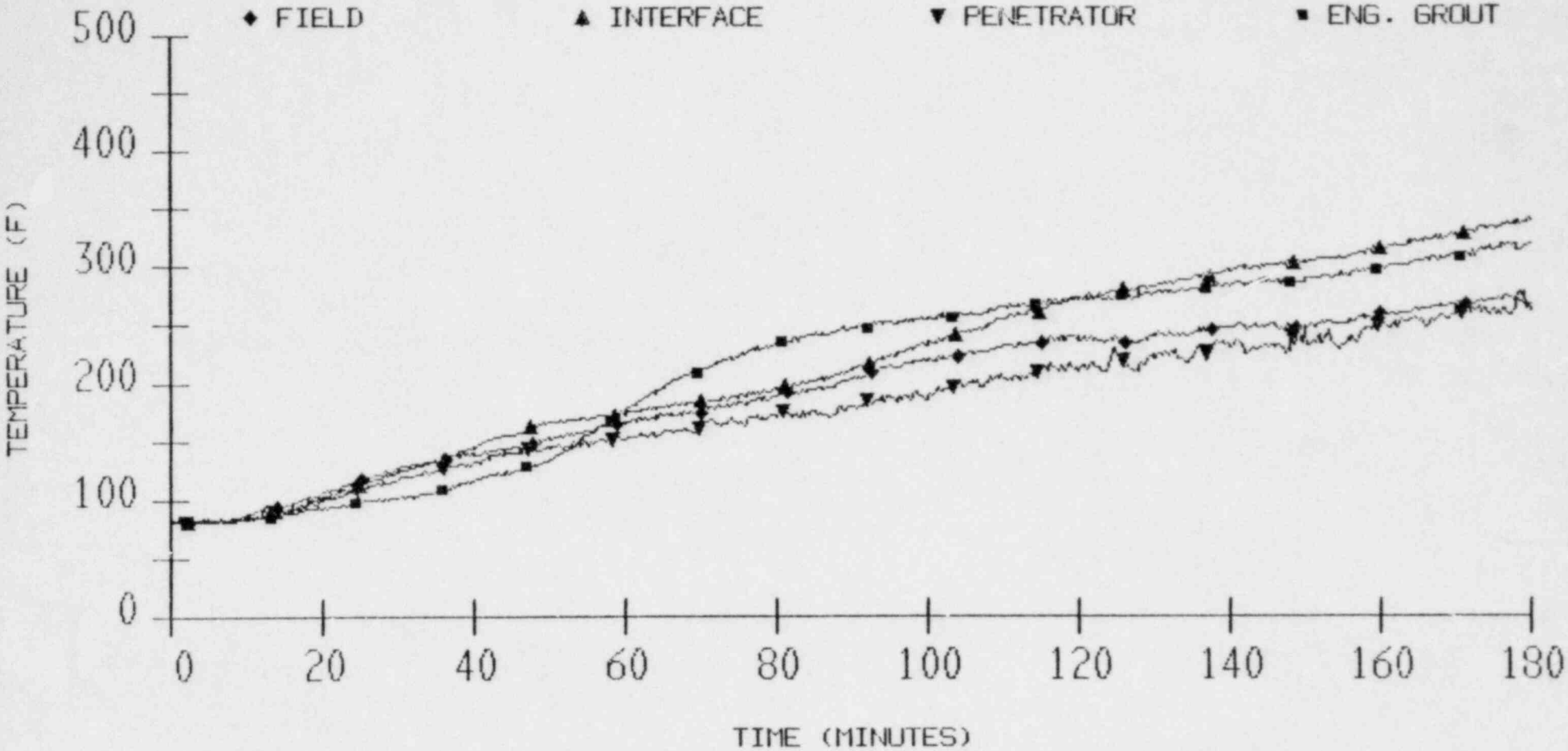
B G & E SLAB 2
TRAY 1



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

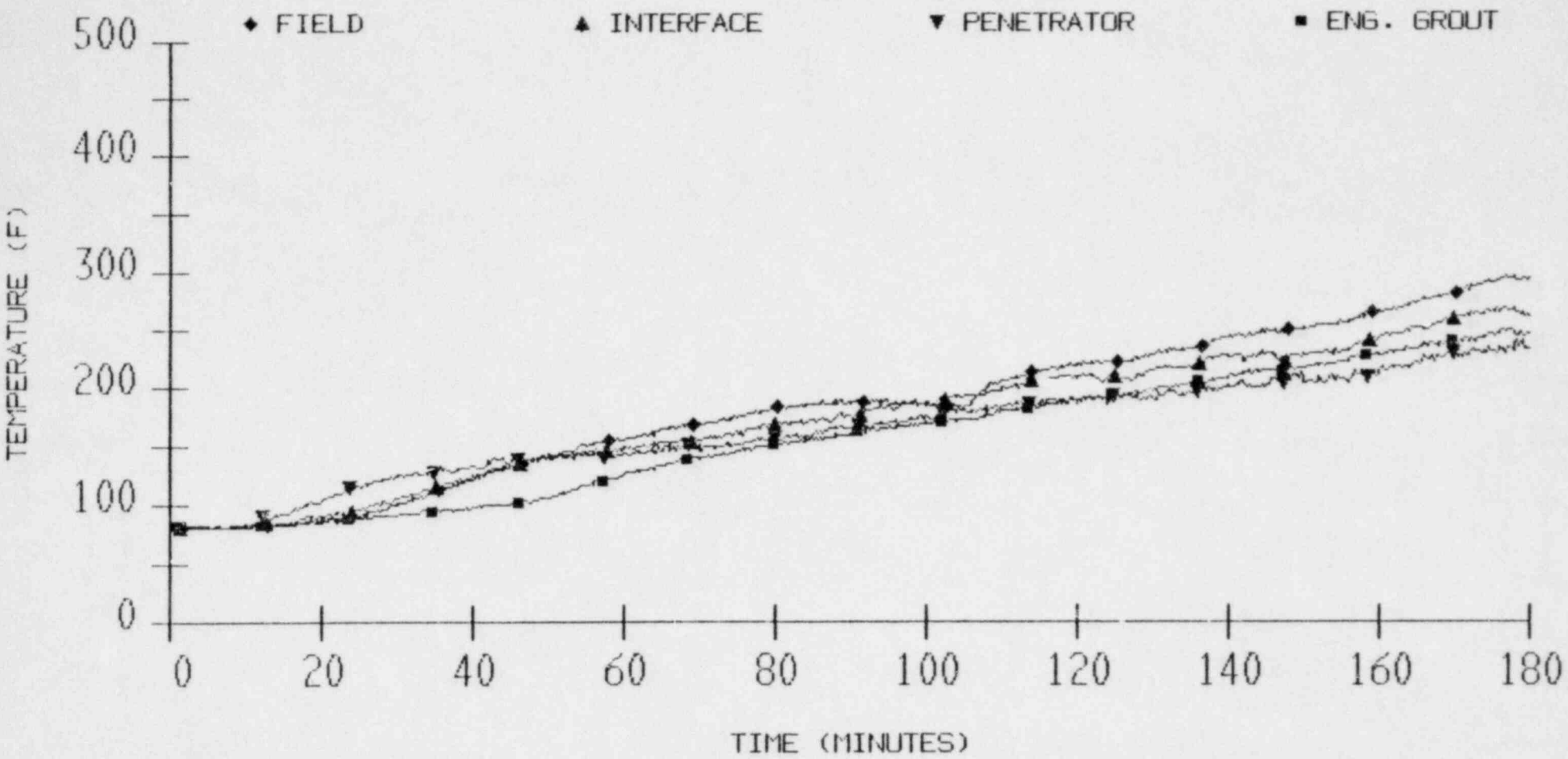
B G & E SLAB 2
TRAY 2



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

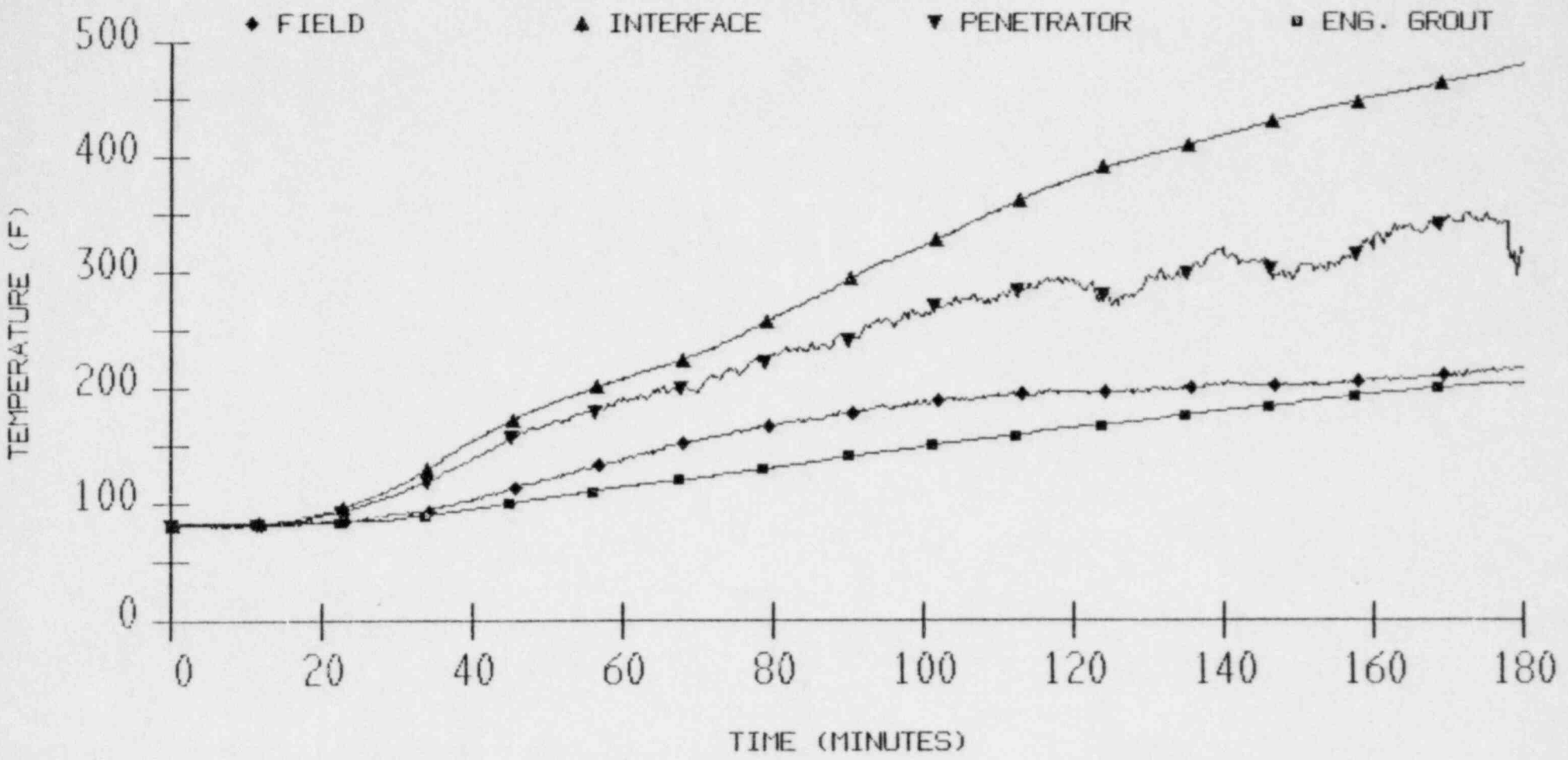
B G & E SLAB 2
TRAY 3



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

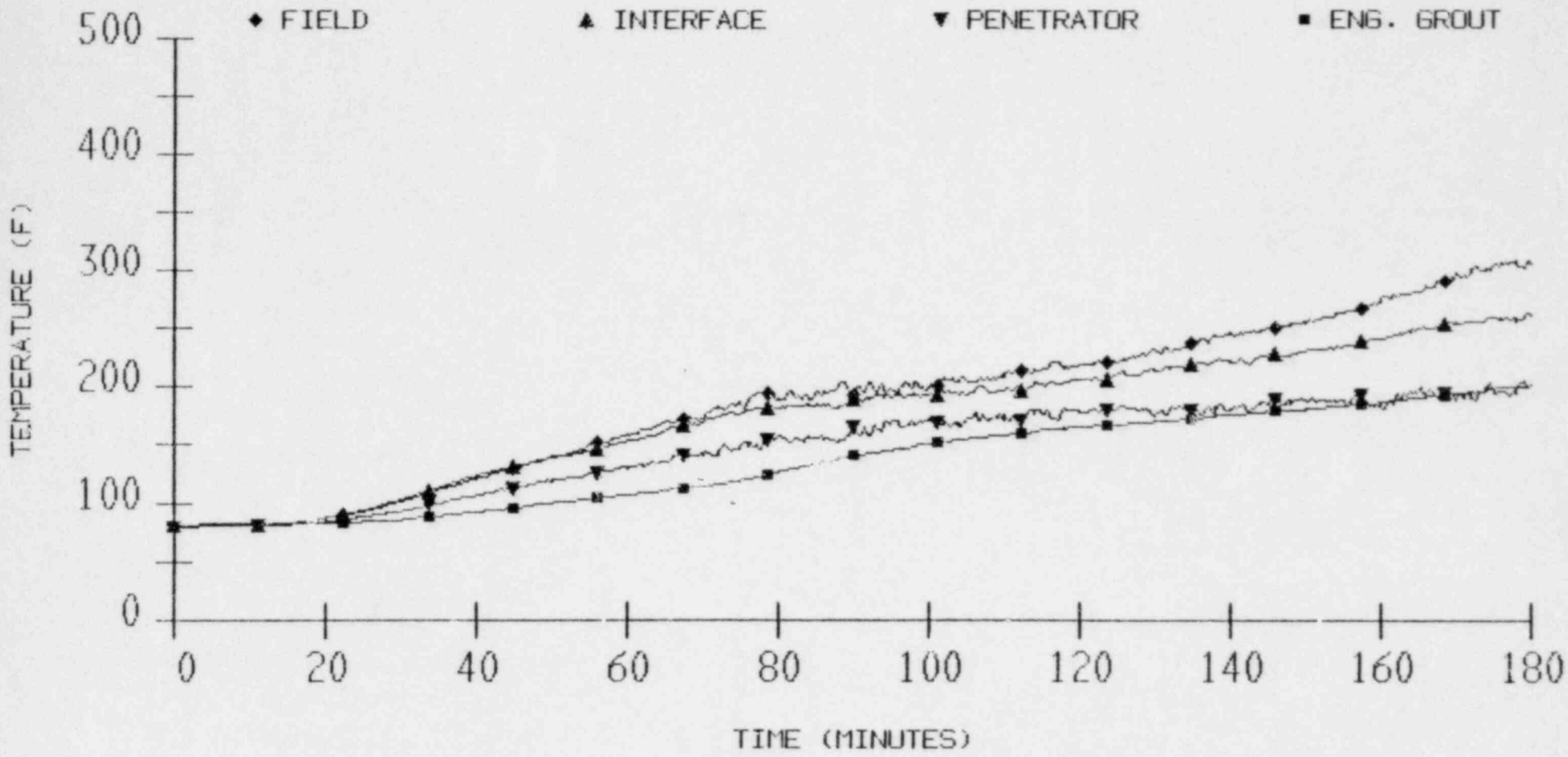
B G & E SLAB 2
TRAY 4



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

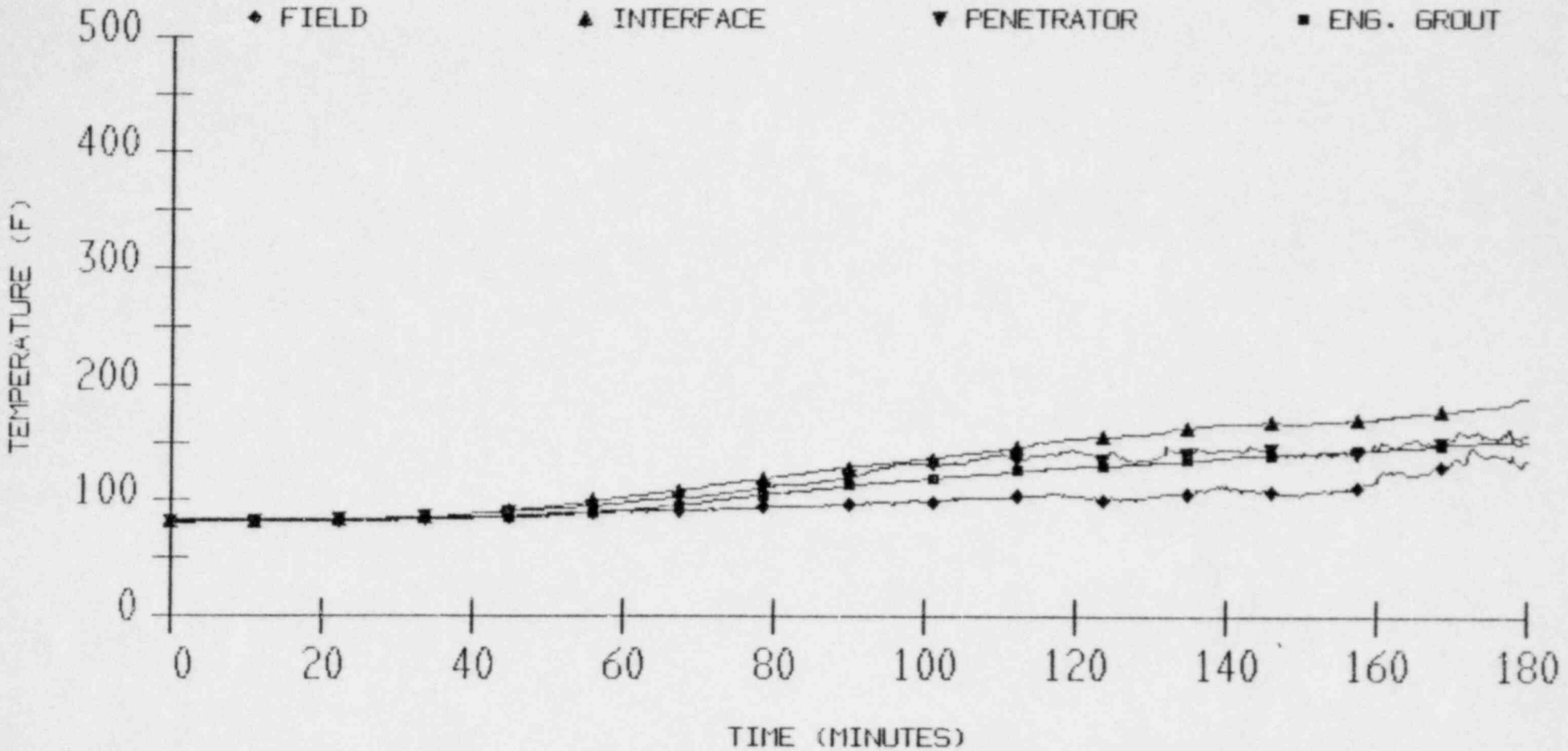
B G & E SLAB 2
TRAY 5



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

B G & E SLAB 2
TRAY 6



TEST DATE: 30 JUL 80

PROJECT NO.: 03-5980-003

TEST DATA

TRAYS 1; 2; 3

PAGE 1

B. G. & E. SLAB 2

DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
0	1	85	84	84	83	86	82	83	83	85	83	83	83	85
0	16	87	84	83	83	86	82	82	83	84	82	82	82	84
0	31	101	85	84	83	85	82	83	83	85	84	83	82	85
0	[illegible]	127	84	84	83	86	82	83	83	84	83	83	83	84
1	[illegible]	140	85	84	83	86	82	83	83	85	84	82	82	85
1	16	162	85	85	84	86	82	82	82	84	82	82	82	84
1	31	197	84	84	83	86	82	83	83	85	84	82	82	84
1	46	225	84	84	83	86	83	82	83	84	83	83	83	84
2	1	256	84	84	83	86	82	83	83	84	83	82	83	85
2	16	296	85	84	84	86	83	83	83	84	83	82	82	84
2	31	342	84	84	84	86	83	83	83	85	83	84	84	85
2	46	396	85	85	84	87	83	83	83	85	83	82	82	84
3	1	441	84	84	84	87	84	83	83	85	83	82	82	84
3	16	503	84	83	83	86	82	82	82	84	83	82	82	85
3	31	567	84	83	83	86	83	83	83	84	83	82	82	84
3	46	632	84	83	82	85	82	82	82	84	84	83	82	85
4	1	695	84	83	82	85	83	83	83	84	82	84	84	85
4	16	751	84	85	84	87	83	82	83	85	82	82	83	84
4	31	808	84	84	83	87	84	83	83	86	83	83	83	84
4	46	850	83	83	82	85	82	82	82	84	83	82	84	84
5	1	883	83	83	82	85	82	82	84	86	82	83	82	84
5	16	916	84	83	83	86	84	83	83	84	83	84	83	84
5	31	956	85	85	85	85	83	82	82	84	82	82	82	83
5	46	990	83	83	83	85	84	83	83	84	83	83	83	83
6	1	1023	83	83	83	86	84	83	83	84	82	83	83	84
6	16	1040	83	83	82	85	84	83	83	84	82	82	82	83
6	31	1062	85	84	83	85	84	83	83	84	84	83	83	84
6	46	1063	85	85	83	86	85	85	85	86	82	82	83	84
7	1	1071	85	85	83	85	84	83	83	84	82	82	83	83
7	16	1079	83	82	83	85	85	83	83	84	82	82	83	83
7	31	1079	83	82	82	85	85	83	83	84	82	83	83	83
7	46	1113	83	83	82	85	85	83	83	85	83	83	83	83
8	1	1116	83	82	82	85	86	83	83	85	83	83	84	83
8	16	1107	83	83	82	85	86	83	83	85	83	84	84	83
8	31	1116	83	82	82	85	86	84	83	85	82	83	84	84
8	46	1153	83	82	82	85	86	84	83	85	82	83	84	83
9	1	1199	83	82	82	85	87	84	84	85	83	83	84	83
9	16	1204	83	84	83	85	87	85	85	86	83	83	84	84
9	31	1179	85	85	82	85	88	85	84	85	83	84	84	83
9	46	1197	83	82	82	85	88	86	84	85	83	84	85	84
10	1	1228	84	85	84	86	89	85	84	85	82	84	86	86

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B. G. & E. SLAB 2

DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
10	16	1278	84	83	83	85	89	85	87	88	85	84	85	86
10	31	1303	84	85	85	87	90	86	85	88	85	84	85	83
10	46	1300	85	83	82	86	89	86	86	86	83	84	85	84
11	1	1302	84	83	83	85	90	86	85	86	83	84	86	84
11	16	1313	84	83	83	85	91	87	86	86	84	84	86	84
11	31	1324	85	84	83	86	92	88	87	87	84	85	86	84
11	46	1338	86	85	84	87	94	87	86	87	83	84	88	85
12	1	1321	84	83	82	85	92	88	88	87	85	87	90	84
12	16	1331	84	83	82	85	92	88	89	89	84	85	88	84
12	31	1361	84	84	84	88	95	91	88	87	83	87	91	85
12	46	1369	84	83	83	86	92	91	88	88	84	86	90	85
13	1	1382	84	83	83	86	94	90	89	87	84	85	89	84
13	16	1387	84	83	82	85	93	89	88	87	84	85	90	84
13	31	1395	84	83	82	86	93	90	92	88	84	86	90	85
13	46	1419	85	84	83	85	94	92	90	88	85	85	91	84
14	1	1410	84	83	83	88	95	91	91	89	84	86	92	85
14	16	1410	84	83	82	85	94	93	92	90	85	87	94	87
14	31	1416	84	83	83	86	96	91	91	89	85	87	92	85
14	46	1418	85	84	84	86	96	92	91	88	84	87	93	84
15	1	1430	85	83	82	85	96	92	91	89	84	87	93	84
15	16	1434	85	83	83	86	97	92	91	89	85	87	93	85
15	31	1441	85	84	83	85	97	93	92	89	85	87	94	84
15	46	1447	86	84	83	85	97	93	92	90	85	87	94	85
16	1	1449	85	84	83	86	98	94	92	90	85	88	95	84
16	16	1452	85	84	85	87	99	95	93	90	85	87	96	85
16	31	1462	85	84	83	86	99	94	93	90	86	87	97	85
16	46	1463	85	85	83	86	99	96	93	90	86	88	99	85
17	1	1474	86	85	85	88	100	96	94	91	87	88	98	87
17	16	1487	87	85	85	86	100	97	94	91	86	89	99	86
17	31	1482	86	85	84	87	102	97	95	91	86	89	99	87
17	46	1487	85	84	85	86	103	97	96	93	87	89	100	87
18	1	1493	86	86	84	87	103	99	98	93	87	91	101	87
18	16	1503	88	86	86	87	104	100	98	93	88	92	103	87
18	31	1504	88	86	86	88	105	100	99	93	88	92	102	86
18	46	1499	87	85	84	85	103	101	99	94	89	92	104	88
19	1	1526	89	87	85	88	105	100	98	93	88	91	103	88
19	16	1525	89	87	85	87	105	100	98	93	87	90	103	87
19	31	1521	87	86	85	87	105	102	99	95	88	90	102	87
19	46	1524	88	86	84	87	107	103	100	93	88	91	103	86
20	1	1523	89	86	85	87	108	104	101	94	88	91	104	87
20	16	1537	88	87	85	87	108	103	100	94	89	92	105	88

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DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
20	31	1531	89	86	85	87	109	105	102	95	89	91	107	88
20	46	1544	89	87	86	87	110	105	102	94	88	91	106	88
21	1	1546	89	86	85	88	109	105	103	95	90	93	108	88
21	16	1563	90	87	86	88	111	106	102	95	89	93	109	89
21	31	1557	90	87	86	88	111	105	102	95	89	92	109	89
21	46	1565	90	87	86	87	110	107	103	95	89	93	111	89
22	1	1577	91	87	86	87	111	108	104	96	90	94	110	87
22	16	1567	90	88	86	87	111	108	105	96	90	95	111	89
22	31	1573	91	87	85	87	111	109	104	96	89	95	111	88
22	46	1587	90	87	85	88	113	110	105	97	90	94	111	88
23	1	1583	91	88	86	87	113	110	107	97	91	95	112	89
23	16	1589	90	86	85	87	114	109	107	96	90	94	113	89
23	31	1605	92	88	86	88	115	110	108	97	91	96	114	90
23	46	1605	92	87	85	87	115	111	108	98	92	96	116	90
24	1	1594	91	88	87	88	116	111	108	98	92	96	116	90
24	16	1599	91	88	86	88	117	113	109	98	91	95	115	88
24	31	1614	92	89	87	87	117	114	110	99	93	96	116	88
24	46	1616	92	89	87	87	118	114	110	99	93	98	117	90
25	1	1622	93	89	87	88	117	114	110	99	92	97	117	90
25	16	1632	92	89	87	89	119	116	111	99	92	97	116	90
25	31	1633	94	89	87	89	119	116	112	100	94	99	118	90
25	46	1645	94	89	87	89	121	115	112	100	94	98	119	91
26	1	1640	94	89	87	89	120	117	113	100	94	99	118	91
26	16	1647	94	90	88	89	121	117	112	100	95	99	119	90
26	31	1653	94	89	87	88	121	118	114	101	95	100	119	90
26	46	1643	94	89	86	88	121	117	113	100	95	101	119	90
27	1	1646	94	89	87	88	123	119	114	101	96	100	121	91
27	16	1660	95	89	87	89	123	120	115	100	96	102	122	91
27	31	1656	95	89	87	89	124	120	116	102	97	102	121	91
27	46	1671	96	90	87	88	123	119	114	101	95	101	122	91
28	1	1670	95	90	87	88	125	122	116	101	97	102	122	91
28	16	1684	96	91	88	88	125	122	117	101	98	104	123	91
28	31	1669	96	91	87	88	126	123	116	102	98	104	123	91
28	46	1674	97	91	87	88	125	122	116	101	97	103	123	91
29	1	1665	97	90	88	88	125	123	116	102	99	103	123	91
29	16	1667	97	91	88	89	125	123	117	103	100	103	125	92
29	31	1657	98	90	87	89	126	123	118	103	100	105	124	91
29	46	1658	98	91	87	89	128	125	118	102	100	106	125	92
30	1	1636	98	92	89	89	129	125	119	103	101	106	126	92
30	16	1634	99	92	89	89	129	126	119	103	102	106	125	92
30	31	1626	98	91	88	89	130	126	121	104	102	107	126	94

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DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
30	46	1620	99	92	89	89	130	127	121	104	103	108	126	93
31	1	1611	100	92	88	88	130	127	121	103	102	108	125	93
31	16	1597	98	91	88	90	130	126	121	104	103	109	127	94
31	31	1603	100	92	89	89	131	128	121	105	104	109	126	94
31	46	1600	100	92	89	90	132	128	121	105	105	110	126	94
32	1	1588	101	92	89	90	132	128	122	104	105	109	126	93
32	16	1588	101	93	90	90	132	129	122	103	106	110	127	94
32	31	1582	102	93	90	90	132	130	123	105	107	111	128	94
32	46	1584	102	94	90	90	133	131	123	105	107	111	128	94
33	1	1583	103	94	90	90	132	130	123	104	107	111	127	94
33	16	1585	103	94	90	89	133	130	124	106	108	112	126	96
33	31	1584	103	94	90	91	134	132	126	107	107	113	127	97
33	46	1585	103	94	91	91	134	132	125	106	109	114	128	97
34	1	1580	104	94	90	91	134	132	124	107	110	113	127	96
34	16	1573	104	95	90	90	134	132	124	107	110	114	128	96
34	31	1572	104	95	91	91	134	134	125	107	111	114	130	96
34	46	1571	104	94	90	91	134	134	125	107	110	113	129	95
35	1	1560	106	96	91	91	136	134	126	108	112	116	129	96
35	16	1565	104	95	91	90	135	134	127	108	112	116	131	96
35	31	1562	107	96	91	91	137	136	127	109	113	117	130	97
35	46	1552	106	96	91	91	137	137	128	110	113	116	132	96
36	1	1548	106	97	92	92	138	137	129	109	113	116	131	97
36	16	1542	108	97	90	92	138	136	129	109	114	118	133	97
36	31	1553	108	97	92	92	137	138	131	111	115	119	132	97
36	46	1554	108	97	92	91	139	139	130	111	116	120	131	97
37	1	1553	109	96	92	92	138	139	130	111	116	120	131	97
37	16	1552	110	96	93	91	139	140	131	113	116	120	129	97
37	31	1549	109	97	92	91	140	140	130	112	117	119	129	96
37	46	1544	110	98	92	91	140	141	131	113	117	121	131	97
38	1	1538	109	97	91	92	138	141	132	114	118	122	132	97
38	16	1541	111	99	93	92	140	143	133	115	119	121	131	98
38	31	1542	112	99	92	92	140	143	132	115	120	123	133	98
38	46	1543	112	99	93	93	141	144	132	115	119	122	132	97
39	1	1537	111	98	94	92	139	143	131	115	119	121	132	97
39	16	1542	112	98	94	91	141	146	133	117	121	124	133	99
39	31	1550	114	100	93	92	140	145	131	116	122	123	133	98
39	46	1559	114	100	94	92	141	145	132	117	122	124	134	98
40	1	1554	115	101	94	93	142	147	135	117	122	125	134	99
40	16	1554	114	100	94	93	140	146	134	118	122	126	135	99
40	31	1556	116	101	95	92	139	147	134	119	123	125	134	99
40	46	1546	114	100	94	93	140	149	135	120	125	127	133	99

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DATE OF TEST: 30 JUL 80 PROJECT NUMBER: 03-5980-003

MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
41	1	1563	117	101	94	92	140	149	132	119	124	126	133	100
41	16	1553	116	102	95	94	142	150	136	121	126	127	133	99
41	31	1555	116	103	96	95	143	151	136	122	125	127	133	100
41	46	1552	117	103	96	95	142	152	138	122	127	129	135	100
42	1	1557	118	103	96	95	144	152	137	123	128	130	137	101
42	16	1551	119	104	96	95	144	153	139	123	128	130	139	101
42	31	1553	119	104	96	95	144	153	140	123	129	131	137	101
42	46	1552	120	104	97	95	144	154	139	124	129	132	139	101
43	1	1553	120	105	97	95	144	155	140	124	130	133	141	101
43	16	1556	121	105	97	96	145	155	140	125	131	133	140	101
43	31	1548	120	104	95	95	145	155	141	124	130	132	139	100
43	46	1556	122	105	96	95	145	156	140	124	130	132	139	101
44	1	1555	121	104	96	95	145	156	140	124	131	133	141	101
44	16	1547	122	106	97	95	144	156	141	125	132	135	141	101
44	31	1553	122	106	98	96	146	157	142	126	133	134	138	101
44	46	1546	123	106	97	95	145	157	141	124	132	133	137	101
45	1	1546	122	105	97	95	146	157	142	125	133	134	137	101
45	16	1559	124	106	97	95	147	157	142	125	134	134	138	102
45	31	1551	123	107	97	96	147	157	141	126	134	135	141	102
45	46	1548	123	107	98	97	147	158	142	126	134	135	141	102
46	1	1547	124	107	99	96	147	159	143	127	135	136	141	102
46	16	1554	125	106	98	95	146	159	141	126	135	136	140	101
46	31	1543	124	107	98	95	146	159	142	127	136	137	141	102
46	46	1552	126	109	100	98	148	161	145	129	137	138	139	103
47	1	1562	127	109	100	97	148	161	146	130	138	139	140	104
47	16	1573	127	109	100	98	150	163	146	130	138	139	140	104
47	31	1570	128	110	101	98	151	164	145	130	139	139	139	103
47	46	1558	126	109	99	97	149	162	145	130	138	138	138	103
48	1	1562	128	110	101	98	149	165	148	132	141	140	138	104
48	16	1562	128	109	100	98	151	164	147	131	139	138	140	104
48	31	1557	128	109	100	98	151	163	144	131	139	139	139	104
48	46	1566	130	110	101	98	152	165	143	132	141	140	138	105
49	1	1563	130	111	100	98	151	165	144	133	142	140	141	106
49	16	1563	130	111	101	99	153	167	146	135	143	142	141	107
49	31	1567	131	111	102	99	152	165	146	134	143	141	141	107
49	46	1570	132	113	103	100	155	167	148	135	142	140	140	106
50	1	1561	131	112	102	99	154	167	146	136	143	142	145	107
50	16	1562	132	112	102	99	153	167	147	136	143	143	143	107
50	31	1560	131	113	102	99	153	167	147	137	144	142	140	107
50	46	1564	132	113	102	99	154	168	148	138	144	142	140	108
51	1	1569	133	113	103	100	155	167	148	139	144	142	144	108

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
51	16	1566	133	113	103	100	155	168	149	140	144	143	142	109
51	31	1577	134	114	103	100	156	169	147	141	146	144	143	110
51	46	1580	134	114	104	100	155	168	146	142	146	143	143	110
52	1	1575	134	115	105	101	156	168	148	143	147	144	143	110
52	16	1585	135	115	104	100	156	168	148	144	147	144	141	112
52	31	1593	136	116	105	102	158	170	147	144	147	144	142	111
52	46	1588	135	115	104	100	157	169	148	146	147	144	142	112
53	1	1584	135	115	104	101	158	170	148	146	148	144	144	112
53	16	1587	136	115	104	101	157	169	150	147	148	145	142	113
53	31	1574	137	117	104	100	158	169	149	148	148	144	140	114
53	46	1571	136	115	104	100	159	169	149	150	149	145	144	113
54	1	1580	137	116	105	101	158	169	148	151	150	145	145	115
54	16	1591	137	117	106	101	159	171	150	152	150	146	146	116
54	31	1582	137	117	106	102	159	171	149	153	152	146	143	117
54	46	1590	138	119	107	102	160	172	151	156	152	147	143	118
55	1	1591	140	118	105	103	161	170	151	157	152	147	146	118
55	16	1593	139	118	106	102	160	170	148	156	151	146	143	117
55	31	1594	139	118	107	102	161	172	150	158	152	147	143	118
55	46	1591	140	119	107	103	161	171	149	159	153	148	143	119
56	1	1601	140	119	107	103	162	172	151	160	152	147	143	118
56	16	1597	140	120	108	103	162	172	151	162	154	148	147	121
56	31	1610	142	121	108	104	162	174	151	164	154	149	145	121
56	46	1613	142	120	108	104	163	173	152	164	154	148	143	121
57	1	1606	142	120	108	104	163	173	153	165	155	148	142	121
57	16	1611	142	120	107	103	164	173	152	165	154	147	143	121
57	31	1600	142	120	107	104	163	174	151	167	155	148	142	121
57	46	1604	142	121	108	103	163	174	152	168	155	147	142	122
58	1	1604	142	121	108	103	164	174	153	169	156	147	144	123
58	16	1600	142	120	107	104	164	174	153	170	155	148	143	123
58	31	1603	142	121	109	105	165	174	153	171	155	148	142	123
58	46	1609	143	120	108	104	165	174	151	174	157	148	143	124
59	1	1611	144	121	109	105	166	175	154	174	157	149	142	124
59	16	1610	143	121	108	104	166	174	154	174	158	148	143	124
59	31	1621	143	120	109	104	167	176	152	176	157	149	144	125
59	46	1611	143	121	108	104	167	175	152	175	157	148	143	125
60	1	1611	144	121	109	105	168	175	153	177	157	150	145	126
60	16	1618	144	122	109	105	166	174	153	177	157	149	145	126
60	31	1620	145	123	109	105	167	176	154	181	159	150	145	128
60	46	1621	145	123	109	105	167	176	154	181	159	149	143	128
61	1	1632	145	123	110	106	169	177	154	183	159	150	144	128
61	16	1631	146	123	110	106	169	177	154	183	159	149	145	128

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
61	31	1627	145	123	109	105	168	177	155	183	159	149	145	128
61	46	1586	146	124	111	106	171	177	157	186	161	151	148	130
62	1	1587	146	124	111	106	171	178	158	187	160	151	147	129
62	16	1593	147	125	111	106	169	177	157	187	161	151	145	131
62	31	1603	148	126	111	107	170	179	157	188	161	151	145	130
62	46	1589	147	125	112	107	171	179	157	189	162	152	146	131
63	1	1601	149	126	113	108	170	179	155	189	162	151	146	130
63	16	1604	147	125	111	106	170	180	156	191	161	151	147	131
63	31	1608	149	126	112	107	171	179	159	193	162	152	147	132
63	46	1610	149	127	112	107	171	180	158	193	163	153	149	133
64	1	1607	150	128	113	106	170	178	154	192	161	151	145	131
64	16	1598	148	127	115	109	174	181	155	196	164	154	147	133
64	31	1626	150	128	114	108	172	181	156	195	164	153	146	134
64	46	1631	151	129	115	109	175	180	157	196	163	154	150	135
65	1	1632	151	129	115	109	174	181	159	198	165	154	148	135
65	16	1628	151	129	115	108	174	181	160	198	165	155	147	135
65	31	1626	151	128	114	109	175	182	161	200	166	155	150	135
65	46	1627	151	130	115	108	173	181	160	200	166	155	150	137
66	1	1641	151	129	115	108	173	182	161	202	167	155	150	137
66	16	1662	152	131	116	110	175	183	160	203	165	153	148	137
66	31	1487	152	130	116	110	174	183	159	205	167	155	149	137
66	46	1487	153	130	116	109	173	184	160	205	166	155	150	137
67	1	1494	153	130	116	110	174	182	161	204	166	154	147	138
67	16	1488	152	131	117	110	175	183	160	206	167	155	150	138
67	31	1500	154	132	117	110	174	184	161	207	168	156	149	139
67	46	1518	154	132	117	110	176	183	162	208	169	156	151	139
68	1	1564	154	132	118	110	175	183	162	209	168	157	149	140
68	16	1592	154	132	118	110	175	184	161	209	169	155	149	139
68	31	1580	154	133	118	111	175	185	160	209	169	156	151	140
68	46	1581	155	133	118	111	176	184	160	210	169	155	153	140
69	1	1593	155	133	118	111	175	184	159	210	169	154	153	140
69	16	1632	155	132	117	110	175	185	159	210	169	155	153	141
69	31	1650	155	133	117	111	175	186	161	211	170	155	150	141
69	46	1655	155	133	117	111	175	185	162	213	170	156	151	141
70	1	1657	156	134	117	112	175	186	166	213	171	157	152	141
70	16	1654	155	133	117	110	175	185	168	213	170	157	148	140
70	31	1659	155	133	116	112	176	186	166	213	170	157	148	141
70	46	1660	155	133	116	111	176	184	167	213	169	158	150	142
71	1	1671	155	133	117	111	178	187	168	214	171	159	151	142
71	16	1673	156	134	118	112	180	187	170	216	171	159	150	143
71	31	1679	157	134	117	111	180	187	170	215	171	160	151	142

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
71	46	1689	156	135	118	112	179	187	168	217	171	159	150	142
72	1	1694	157	135	119	112	181	187	166	217	172	159	149	144
72	16	1695	157	135	118	112	181	187	166	219	172	160	150	143
72	31	1686	156	135	119	111	182	187	166	219	172	159	150	143
72	46	1698	157	136	119	112	181	187	164	220	173	160	151	143
73	1	1687	157	135	119	113	181	189	165	221	173	159	151	144
73	16	1698	157	136	119	113	181	188	166	222	175	161	151	146
73	31	1679	156	134	118	114	183	187	166	221	174	162	153	144
73	46	1689	158	135	118	112	181	188	170	223	174	162	154	144
74	1	1686	159	135	118	112	182	190	171	221	174	162	151	145
74	16	1694	158	135	119	113	183	190	171	223	175	162	152	146
74	31	1710	160	137	121	113	184	189	167	222	175	161	151	145
74	46	1704	158	136	120	113	183	190	168	224	176	162	153	146
75	1	1704	159	137	121	113	184	188	165	223	175	163	153	148
75	16	1707	161	138	121	114	184	191	167	225	176	162	152	148
75	31	1699	160	137	121	114	184	191	166	226	177	163	153	148
75	46	1704	160	138	121	113	183	190	164	225	177	161	153	149
76	1	1707	160	138	122	113	182	190	166	226	176	163	154	149
76	16	1699	161	138	122	114	185	191	169	227	177	164	155	147
76	31	1706	161	139	121	115	185	193	171	228	178	165	154	149
76	46	1703	161	138	120	113	186	192	172	228	178	165	154	149
77	1	1697	163	139	121	115	186	193	172	230	178	166	154	148
77	16	1691	161	137	120	114	187	191	171	228	178	166	156	149
77	31	1701	162	140	121	116	188	194	173	232	180	165	156	150
77	46	1709	162	138	122	115	188	192	169	229	178	168	158	150
78	1	1702	163	141	123	114	187	193	169	230	179	166	157	151
78	16	1698	163	140	123	115	188	193	171	231	181	168	158	151
78	31	1708	164	141	125	116	189	195	170	231	180	169	159	151
78	46	1703	164	141	125	116	187	194	169	233	180	169	156	150
79	1	1697	163	142	124	115	187	193	172	231	181	168	156	151
79	16	1708	164	141	124	116	188	194	174	233	181	169	158	152
79	31	1702	164	141	124	116	189	195	173	233	182	170	158	153
79	46	1704	163	141	124	116	190	197	174	235	183	170	158	152
80	1	1717	166	143	125	116	190	197	173	235	182	172	159	154
80	16	1708	164	142	126	116	189	196	172	234	182	170	157	152
80	31	1707	166	144	126	116	191	197	175	236	184	172	158	152
80	46	1714	166	143	124	117	192	197	175	236	183	171	157	153
81	1	1704	165	143	125	117	193	197	177	236	184	170	156	153
81	16	1716	167	144	126	117	193	199	176	238	185	172	159	155
81	31	1707	165	143	126	117	194	198	175	237	183	171	160	155
81	46	1705	166	144	127	117	192	198	173	237	184	170	160	153

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
82	1	1706	167	144	127	118	194	198	172	237	185	172	159	155
82	16	1714	167	144	127	118	192	198	173	237	184	170	159	155
82	31	1696	165	145	127	118	192	200	173	239	185	171	161	154
82	46	1710	166	145	127	118	193	199	175	239	185	172	160	155
83	1	1702	167	144	126	117	192	199	172	237	184	172	162	155
83	16	1707	168	144	126	117	193	200	171	239	185	172	159	155
83	31	1709	168	147	125	119	195	202	177	240	187	173	160	156
83	46	1713	168	145	125	117	194	201	172	240	185	170	158	155
84	1	1705	168	145	126	118	195	201	175	241	186	172	159	155
84	16	1715	168	145	126	117	194	201	175	241	185	172	160	156
84	31	1712	168	145	126	119	196	203	174	241	187	172	161	157
84	46	1708	168	145	126	118	195	202	176	242	187	173	159	157
85	1	1714	168	146	126	118	195	202	176	241	187	173	161	158
85	16	1713	169	146	126	118	195	203	176	243	187	174	162	157
85	31	1716	170	147	128	119	197	204	174	242	187	172	163	158
85	46	1713	171	147	128	119	197	205	175	242	186	174	162	156
86	1	1714	169	147	128	119	196	204	174	242	187	173	164	158
86	16	1715	169	147	128	120	198	206	174	244	187	173	163	159
86	31	1713	170	147	129	118	196	203	173	241	189	175	162	157
86	46	1714	169	147	128	118	197	206	174	242	186	174	163	158
87	1	1718	170	148	130	119	197	205	172	242	187	173	164	158
87	16	1718	170	149	130	119	197	206	172	243	187	171	165	159
87	31	1724	171	149	131	120	198	207	173	243	187	172	165	159
87	46	1715	171	150	130	119	198	208	174	244	187	174	165	159
88	1	1734	173	151	131	120	200	209	175	245	189	175	167	159
88	16	1718	172	150	130	120	201	209	178	245	187	175	165	162
88	31	1723	173	149	130	120	201	209	180	246	187	176	165	160
88	46	1732	174	151	131	121	203	211	180	248	189	178	167	160
89	1	1727	172	150	130	120	202	209	177	249	190	179	167	161
89	16	1723	172	151	132	121	202	210	177	246	187	175	165	160
89	31	1717	172	150	131	120	202	210	180	246	187	176	166	161
89	46	1729	174	152	132	121	204	212	181	248	188	177	166	161
90	1	1726	174	152	133	121	204	213	181	247	188	176	165	161
90	16	1722	173	152	131	120	204	212	181	247	187	176	166	162
90	31	1734	174	154	132	122	206	214	181	248	188	175	167	161
90	46	1726	174	151	131	121	205	214	179	248	188	176	168	162
91	1	1727	174	151	131	122	207	216	181	250	189	179	168	163
91	16	1723	174	152	132	121	205	215	181	249	188	178	168	162
91	31	1730	175	153	133	122	206	215	180	248	187	177	167	162
91	46	1730	175	153	132	122	207	216	184	248	188	179	167	163
92	1	1731	175	153	132	122	208	217	187	248	187	180	167	162

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92	16	1725	175	152	131	121	209	216	186	248	188	180	166	163
92	31	1735	176	152	131	122	210	217	185	248	187	180	167	165
92	46	1728	176	154	132	122	210	218	183	251	187	181	166	163
93	1	1726	176	153	132	122	211	218	185	252	189	181	167	165
93	16	1740	178	154	133	123	211	220	186	251	188	182	169	165
93	31	1743	178	153	134	123	212	221	187	252	189	182	169	164
93	46	1737	178	153	133	123	213	221	187	252	188	183	169	164
94	1	1735	179	155	134	123	213	222	189	253	189	184	170	165
94	16	1736	178	155	134	124	214	223	187	251	187	184	171	166
94	31	1735	178	154	134	123	213	222	185	252	188	183	169	166
94	46	1738	179	156	135	123	214	224	189	252	189	183	170	166
95	1	1731	178	156	133	124	215	223	189	252	189	185	169	165
95	16	1740	180	157	134	124	216	225	188	253	187	184	172	167
95	31	1731	179	156	134	123	214	223	188	250	186	182	171	165
95	46	1726	179	155	133	123	214	224	187	251	186	181	172	165
96	1	1724	179	156	134	126	214	227	188	251	186	182	174	168
96	16	1732	179	156	132	123	214	225	185	253	188	182	171	166
96	31	1733	179	156	135	124	214	226	190	253	187	183	170	167
96	46	1742	181	157	134	125	215	227	187	253	187	184	171	168
97	1	1742	181	158	135	126	217	227	190	253	188	186	172	168
97	16	1742	181	157	134	124	217	228	189	254	188	186	172	167
97	31	1740	181	157	135	125	217	228	189	253	186	186	172	168
97	46	1741	182	159	137	126	218	230	186	254	186	186	173	167
98	1	1760	181	158	136	126	217	229	188	255	188	186	175	169
98	16	1753	182	158	135	126	219	231	191	252	188	187	173	170
98	31	1745	182	158	136	125	219	230	193	255	187	187	173	168
98	46	1752	183	160	137	125	220	232	193	255	188	189	173	169
99	1	1756	183	161	137	127	219	232	189	255	186	185	173	168
99	16	1767	184	160	139	127	220	234	190	256	186	187	176	169
99	31	1758	183	161	140	128	222	234	188	254	186	186	176	169
99	46	1753	183	160	138	126	220	233	187	255	186	186	174	170
100	1	1753	183	161	138	126	220	233	187	255	185	186	176	170
100	16	1751	184	162	140	127	221	236	190	256	188	188	177	172
100	31	1765	185	163	141	127	221	236	191	257	187	188	175	170
100	46	1743	183	161	138	126	219	234	190	254	184	185	173	169
101	1	1745	183	161	138	126	219	234	192	254	184	186	173	169
101	16	1745	183	161	138	126	220	234	194	254	184	187	173	172
101	31	1766	186	165	142	129	224	238	197	258	185	188	177	171
101	46	1755	186	163	141	127	221	237	194	256	185	189	177	171
102	1	1764	185	163	141	128	224	237	195	260	187	192	180	172
102	16	1770	186	163	140	127	222	238	193	257	185	189	178	171

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102	31	1764	187	164	141	129	222	238	195	257	185	191	179	172
102	46	1766	186	165	142	128	222	239	196	258	186	190	180	174
103	1	1765	186	164	142	129	224	239	197	257	184	191	179	172
103	16	1763	187	164	142	128	224	240	194	257	184	191	180	173
103	31	1763	187	166	142	129	225	241	197	259	186	192	180	173
103	46	1773	187	165	142	129	226	242	199	259	187	194	180	173
104	1	1773	188	166	142	129	224	241	199	257	184	191	178	172
104	16	1758	186	165	141	130	225	243	203	260	185	193	181	174
104	31	1779	189	166	142	130	227	244	202	260	185	194	182	174
104	46	1765	187	165	142	128	225	243	198	258	184	191	180	173
105	1	1784	187	166	142	128	225	243	197	259	183	192	180	173
105	16	1763	187	166	141	128	225	244	199	258	185	193	180	173
105	31	1766	188	166	142	130	227	246	200	259	184	193	179	173
105	46	1763	187	165	140	129	226	244	201	261	185	193	178	174
106	1	1766	188	165	141	128	225	245	202	259	186	193	178	173
106	16	1764	188	165	141	129	226	245	200	259	188	193	180	174
106	31	1764	188	166	142	128	225	245	200	259	189	194	180	174
106	46	1767	188	166	143	129	226	246	202	259	191	194	179	174
107	1	1764	188	167	144	129	227	247	198	259	194	193	181	174
107	16	1769	189	168	145	129	226	246	197	259	195	193	182	175
107	31	1770	189	168	143	129	226	247	197	260	197	194	180	175
107	46	1772	189	167	142	130	227	248	201	260	198	194	180	175
108	1	1786	190	168	143	130	227	250	202	261	199	195	184	178
108	16	1796	192	171	146	131	227	249	200	261	200	195	181	176
108	31	1796	192	170	145	131	229	251	206	263	201	196	181	176
108	46	1788	191	170	146	131	229	251	203	262	204	197	182	177
109	1	1786	193	171	147	132	229	252	205	262	203	198	183	177
109	16	1795	192	171	147	132	231	254	206	263	204	198	185	179
109	31	1789	192	171	147	132	231	254	204	265	203	198	185	180
109	46	1801	193	172	145	133	230	255	209	265	204	198	183	179
110	1	1794	192	171	145	133	232	255	204	265	206	198	184	181
110	16	1806	194	172	147	134	233	255	204	266	207	200	185	180
110	31	1798	193	172	146	133	232	255	205	265	207	200	185	180
110	46	1796	193	172	146	132	232	256	202	264	206	199	185	180
111	1	1802	195	172	147	133	232	258	204	267	206	199	187	181
111	16	1799	194	174	149	133	232	258	202	265	208	200	187	180
111	31	1797	194	173	147	134	231	257	206	266	208	201	185	181
111	46	1806	194	172	148	133	231	259	206	266	208	202	186	180
112	1	1800	194	173	148	133	232	259	209	266	209	203	186	181
112	16	1809	196	175	150	135	235	260	207	268	211	203	188	182
112	31	1814	196	175	151	135	234	259	203	266	208	199	186	180

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112	46	1805	194	173	150	134	233	258	206	268	211	203	188	182
113	1	1812	195	173	152	134	232	258	204	268	210	202	187	183
113	16	1806	195	175	151	134	233	259	205	266	210	203	187	183
113	31	1807	195	175	151	133	235	262	208	266	209	202	185	182
113	46	1807	196	175	148	134	235	262	208	268	211	204	186	182
114	1	1804	195	173	148	134	234	261	206	269	213	206	187	184
114	16	1811	197	174	148	134	235	263	210	269	213	206	189	182
114	31	1804	195	173	148	134	234	260	209	268	212	206	185	184
114	46	1802	196	173	148	135	234	263	211	268	214	206	184	183
115	1	1804	195	174	147	134	234	261	213	267	215	204	186	183
115	16	1802	195	172	147	135	234	263	212	268	214	205	187	185
115	31	1809	196	174	149	137	235	264	214	270	215	207	189	185
115	46	1807	197	175	148	135	235	263	212	268	215	206	187	185
116	1	1810	197	174	148	136	236	265	216	270	215	207	188	186
116	16	1822	198	177	151	137	238	266	211	271	215	207	189	186
116	31	1813	197	174	149	137	239	268	218	272	216	208	190	186
116	46	1814	197	176	150	137	238	268	213	270	217	208	190	186
117	1	1823	198	176	152	136	237	267	213	272	217	208	189	187
117	16	1825	199	178	154	137	238	268	212	271	217	208	189	186
117	31	1830	198	177	153	137	237	267	211	270	216	208	188	187
117	46	1825	200	177	153	138	239	268	215	272	218	210	189	188
118	1	1823	199	178	153	138	239	269	214	271	219	210	188	187
118	16	1827	198	177	152	137	237	269	212	271	218	210	189	188
118	31	1821	199	177	152	138	237	269	211	271	218	210	190	188
118	46	1825	199	178	152	138	239	270	216	272	219	210	187	188
119	1	1824	199	177	152	138	239	272	218	273	220	211	187	188
119	16	1827	200	177	150	138	239	272	214	274	221	211	191	189
119	31	1830	200	177	150	139	239	273	212	272	220	209	191	189
119	46	1829	200	177	149	139	238	273	213	273	220	210	188	190
120	1	1834	199	178	152	138	237	271	211	273	221	210	188	189
120	16	1823	200	178	152	139	239	272	210	272	220	208	187	189
120	31	1820	199	178	154	140	237	274	214	274	222	210	189	190
120	46	1822	199	178	151	138	238	272	216	272	220	211	188	190
121	1	1829	200	178	153	139	240	274	215	274	223	212	191	191
121	16	1834	201	179	153	139	237	273	212	272	221	210	192	190
121	31	1827	201	180	154	139	238	276	213	271	221	210	192	191
121	46	1836	200	180	154	140	239	275	217	273	222	212	193	191
122	1	1835	200	179	152	139	238	274	217	273	222	210	190	190
122	16	1827	200	179	153	139	237	273	216	272	223	212	189	191
122	31	1826	201	180	153	139	238	274	214	273	222	210	190	191
122	46	1828	200	180	152	140	237	275	213	273	223	209	191	192

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123	1	1825	200	181	153	141	237	277	213	274	224	209	193	192
123	16	1831	201	179	155	139	236	275	210	271	221	206	191	191
123	31	1828	200	180	154	139	235	275	210	272	221	205	190	191
123	46	1832	200	181	154	140	237	277	211	271	223	207	191	192
124	1	1829	200	180	153	140	236	276	215	273	223	208	189	192
124	16	1833	200	179	152	140	237	276	218	274	224	209	186	192
124	31	1833	201	180	152	141	238	278	219	272	223	210	188	192
124	46	1830	201	179	151	140	237	279	226	272	223	210	189	193
125	1	1836	200	179	152	140	239	279	231	274	224	213	193	193
125	16	1834	201	179	153	141	238	277	223	271	223	210	191	193
125	31	1836	199	179	154	140	236	278	222	273	224	209	193	194
125	46	1846	202	180	153	140	238	280	221	275	224	209	192	193
126	1	1845	200	180	153	141	237	278	220	274	224	209	193	194
126	16	1846	201	180	152	141	238	280	216	273	224	209	192	194
126	31	1845	201	180	151	140	235	279	218	273	223	208	195	194
126	46	1848	201	181	152	142	236	281	216	273	224	208	194	194
127	1	1842	201	181	154	141	236	279	212	273	224	208	193	195
127	16	1840	201	182	155	142	237	281	212	273	223	207	193	196
127	31	1847	201	181	154	141	234	279	210	273	224	207	192	195
127	46	1834	200	181	153	141	234	280	212	273	226	209	192	197
128	1	1837	201	182	154	142	235	279	211	274	225	210	195	197
128	16	1845	203	182	153	143	236	282	215	277	227	212	192	197
128	31	1845	202	180	151	142	236	282	218	275	225	212	189	196
128	46	1834	201	179	150	142	237	282	216	275	226	210	190	196
129	1	1838	201	179	150	143	238	282	216	276	226	211	192	198
129	16	1835	202	180	152	143	237	281	220	276	228	213	190	198
129	31	1837	201	181	149	143	239	283	223	276	227	214	192	197
129	46	1838	202	179	151	144	240	283	223	275	229	216	193	199
130	1	1835	201	180	152	143	240	282	222	277	229	216	192	198
130	16	1835	201	180	151	144	241	283	225	276	229	216	192	198
130	31	1833	201	180	150	143	240	283	222	276	229	216	190	199
130	46	1842	202	180	152	145	243	284	225	278	230	217	190	198
131	1	1839	202	180	152	143	241	284	225	278	232	218	195	200
131	16	1835	201	180	153	143	242	285	224	277	230	217	193	200
131	31	1838	201	181	151	145	240	287	226	278	231	218	193	200
131	46	1855	202	180	151	143	240	285	225	278	232	219	196	200
132	1	1848	203	182	155	145	242	287	223	279	232	218	197	200
132	16	1856	202	182	153	145	243	286	223	277	230	218	197	200
132	31	1841	201	181	154	145	241	287	226	279	234	219	197	199
132	46	1838	201	181	153	144	239	285	225	277	232	218	198	200
133	1	1837	201	181	153	144	240	287	228	277	234	218	197	201

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
133	16	1838	203	182	155	146	241	288	222	278	233	218	196	202
133	31	1841	201	182	156	145	240	288	221	278	233	218	194	201
133	46	1842	201	182	155	144	241	288	222	280	233	217	193	203
134	1	1836	202	182	154	145	241	288	220	279	234	218	196	202
134	16	1835	202	182	153	145	241	288	219	279	233	218	193	202
134	31	1840	201	182	153	144	240	288	217	278	233	217	193	203
134	46	1833	201	182	154	144	240	288	218	278	234	217	195	203
135	1	1831	202	182	154	145	241	288	221	280	235	219	197	205
135	16	1835	201	183	156	145	242	289	221	280	235	218	196	204
135	31	1832	203	184	154	146	244	291	226	280	234	218	196	203
135	46	1830	202	183	154	145	244	291	229	280	235	221	197	204
136	1	1836	203	184	155	146	244	290	232	280	236	220	198	206
136	16	1837	202	185	157	147	247	292	232	279	236	222	197	204
136	31	1836	202	183	156	145	244	290	227	282	238	222	199	205
136	46	1834	202	186	159	146	247	294	226	283	237	221	199	204
137	1	1830	201	185	158	145	243	291	220	280	236	221	200	205
137	16	1838	201	184	158	146	244	291	226	283	239	225	198	205
137	31	1833	202	184	155	146	244	291	230	281	238	226	201	206
137	46	1843	203	184	156	147	245	292	233	282	240	226	199	207
138	1	1837	202	184	156	148	247	293	232	283	240	225	197	206
138	16	1839	203	184	156	147	247	294	234	285	242	227	199	208
138	31	1842	202	185	157	147	247	294	236	282	241	226	199	207
138	46	1844	203	185	158	147	247	294	234	284	242	227	198	208
139	1	1849	203	186	157	147	247	294	235	282	241	227	199	208
139	16	1850	202	185	157	148	248	296	237	283	243	228	199	209
139	31	1840	203	185	158	148	248	296	233	284	243	229	201	209
139	46	1841	203	186	159	148	248	298	234	284	243	228	201	209
140	1	1853	203	187	159	148	248	296	233	283	244	228	201	209
140	16	1842	204	186	159	149	248	297	230	283	244	226	202	211
140	31	1841	203	186	155	148	248	295	231	285	245	227	201	212
140	46	1839	204	185	156	149	248	298	232	285	244	226	200	212
141	1	1842	205	185	156	149	249	298	236	286	246	229	201	211
141	16	1845	204	185	157	149	251	299	237	286	246	229	202	211
141	31	1848	204	185	158	149	250	299	235	286	247	229	203	212
141	46	1848	205	185	158	150	249	299	232	285	246	229	207	212
142	1	1851	203	187	159	150	249	301	229	285	245	227	205	213
142	16	1836	203	185	158	150	247	298	225	283	246	224	207	212
142	31	1843	203	185	157	149	246	299	225	284	244	223	202	213
142	46	1834	203	185	155	148	247	298	227	283	246	227	201	213
143	1	1834	203	185	156	149	248	298	229	286	248	227	202	215
143	16	1843	203	184	156	150	249	299	231	285	246	227	200	212

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
143	31	1834	203	185	158	151	250	299	229	286	246	228	201	213
143	46	1839	203	186	159	150	248	299	228	286	247	227	201	215
144	1	1828	202	185	157	149	248	298	231	288	248	228	200	213
144	16	1832	203	185	157	150	248	298	230	286	248	229	201	215
144	31	1835	203	186	158	150	249	300	230	286	247	228	201	214
144	46	1843	203	187	160	150	248	299	232	289	251	232	203	215
145	1	1844	203	186	159	150	249	300	232	286	248	229	201	215
145	16	1848	203	186	157	150	249	300	230	290	250	231	203	215
145	31	1842	203	187	157	151	250	301	233	287	249	230	202	215
145	46	1840	204	188	160	151	250	301	233	286	249	230	208	216
146	1	1844	203	188	160	151	250	301	231	286	249	230	208	215
146	16	1842	203	188	159	151	250	301	233	287	249	229	208	215
146	31	1843	203	187	158	150	247	301	233	288	251	229	209	215
146	46	1848	203	187	159	150	246	300	232	288	248	225	208	214
147	1	1842	202	187	159	151	247	302	231	285	248	224	204	215
147	16	1842	203	186	157	150	246	301	230	288	251	227	207	216
147	31	1844	203	188	158	151	246	301	225	285	248	223	[illegible]	215
147	46	1842	203	186	156	151	250	304	228	285	248	224	205	216
148	1	1847	203	187	157	153	249	304	227	288	250	226	211	216
148	16	1850	203	187	160	151	249	303	233	287	251	226	212	216
148	31	1847	203	187	157	152	247	302	240	287	250	228	206	218
148	46	1856	204	187	158	151	246	302	232	287	251	229	212	217
149	1	1847	203	186	157	152	247	301	236	287	250	228	212	216
149	16	1848	203	187	157	152	247	304	245	287	250	228	212	217
149	31	1849	202	187	158	151	247	302	236	287	251	228	209	218
149	46	1835	203	187	156	151	247	302	234	287	250	227	214	217
150	1	1826	203	185	154	152	247	303	247	287	251	228	210	217
150	16	1828	203	187	155	153	249	305	243	289	252	231	205	217
150	31	1835	204	186	155	152	248	303	233	289	251	229	205	218
150	46	1825	203	187	158	152	249	304	232	290	251	229	207	219
151	1	1842	206	190	159	154	250	304	235	290	252	230	207	219
151	16	1829	203	189	159	153	249	304	236	289	253	230	206	220
151	31	1825	205	188	160	152	248	305	234	289	252	230	205	220
151	46	1822	203	189	158	153	250	306	239	290	254	230	205	221
152	1	1835	205	188	161	153	250	306	241	290	254	231	207	220
152	16	1845	203	189	162	153	250	306	235	290	254	230	210	221
152	31	1853	204	189	162	154	253	306	235	292	254	230	208	222
152	46	1855	205	188	159	154	251	306	240	291	254	230	205	221
153	1	1848	203	187	156	153	253	306	240	291	254	232	205	220
153	16	1844	204	187	158	153	253	306	245	291	254	233	207	221
153	31	1848	203	187	159	153	252	307	236	290	254	231	209	222

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
153	46	1841	203	188	158	154	251	306	234	290	254	230	212	221
154	1	1840	203	188	156	154	250	307	232	291	255	229	210	221
154	16	1843	204	189	156	154	250	306	232	291	254	230	208	222
154	31	1841	203	188	158	154	251	307	231	292	255	234	206	222
154	46	1843	203	189	159	154	251	308	229	291	255	231	210	223
155	1	1845	205	190	160	154	250	307	233	295	258	231	209	223
155	16	1844	205	192	160	154	250	307	233	291	256	232	208	223
155	31	1847	203	189	159	155	250	307	235	293	256	232	208	224
155	46	1853	204	190	160	155	251	308	236	292	256	233	207	223
156	1	1853	204	190	160	155	255	309	239	292	256	233	205	224
156	16	1849	206	189	159	155	252	308	236	294	258	234	206	225
156	31	1858	205	189	159	156	253	310	239	295	258	235	208	227
156	46	1852	204	189	160	156	252	311	237	296	259	237	211	226
157	1	1852	205	190	161	157	255	311	235	297	260	238	215	227
157	16	1851	205	190	161	157	256	312	239	296	260	238	212	228
157	31	1860	206	191	162	157	256	312	242	296	261	240	212	227
157	46	1854	205	190	161	157	258	312	245	298	263	238	212	226
158	1	1849	204	189	161	156	255	311	246	296	263	239	213	227
158	16	1864	205	192	163	158	258	312	247	296	261	240	211	227
158	31	1866	205	190	161	158	257	313	248	297	262	241	211	229
158	46	1862	205	191	163	158	256	313	248	297	263	241	211	228
159	1	1852	204	191	161	157	255	312	246	297	263	241	214	228
159	16	1868	206	193	163	159	257	317	249	299	265	243	215	228
159	31	1864	205	192	163	158	257	314	246	298	263	244	214	229
159	46	1880	207	194	165	158	259	314	249	296	263	242	210	230
160	1	1870	205	194	163	159	259	315	255	301	267	243	212	229
160	16	1878	205	192	163	160	260	315	250	298	267	244	216	231
160	31	1877	206	193	163	158	258	315	250	299	266	246	218	229
160	46	1872	205	192	162	158	259	316	251	298	266	246	219	229
161	1	1871	205	191	161	158	259	316	249	299	267	247	216	230
161	16	1868	205	191	163	158	259	318	248	300	267	247	216	231
161	31	1874	206	192	163	159	260	318	248	300	267	246	218	232
161	46	1875	206	192	163	160	260	317	250	300	267	248	219	232
162	1	1873	205	192	163	159	259	319	253	300	270	247	218	232
162	16	1870	206	193	164	160	259	320	249	300	269	247	220	231
162	31	1866	205	192	163	159	259	317	248	300	268	247	219	232
162	46	1865	205	192	162	159	260	318	251	301	269	248	219	232
163	1	1869	205	192	162	159	260	317	254	300	270	247	219	232
163	16	1870	205	192	162	159	260	318	252	301	270	248	218	232
163	31	1867	205	192	163	159	260	318	252	301	271	249	219	233
163	46	1870	205	194	165	159	260	319	252	301	271	250	219	236

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164	1	1871	205	194	165	160	261	323	255	302	272	249	217	234
164	16	1874	206	194	165	161	261	319	255	302	274	250	219	234
164	31	1866	205	193	164	161	262	322	255	303	274	252	220	235
164	46	1875	206	195	166	161	263	323	257	305	275	252	222	235
165	1	1878	206	195	165	161	263	322	255	305	274	252	223	235
165	16	1875	207	194	167	161	262	321	252	304	275	252	223	235
165	31	1854	206	195	167	161	263	323	254	304	275	252	221	236
165	46	1850	207	196	167	162	264	322	252	305	276	252	223	237
166	1	1843	206	196	170	162	263	325	247	307	277	252	228	239
166	16	1850	207	196	171	162	263	325	247	306	278	250	226	238
166	31	1840	206	197	170	162	263	323	249	307	277	250	226	238
166	46	1845	207	197	170	163	264	323	251	305	276	251	225	237
167	1	1848	207	197	169	162	265	324	254	308	277	252	225	239
167	16	1855	208	196	167	162	265	325	253	308	279	254	228	239
167	31	1859	207	196	167	163	266	326	255	307	279	255	224	238
167	46	1854	206	194	166	162	265	323	256	305	279	257	228	238
168	1	1853	206	195	167	162	266	325	259	306	279	256	228	237
168	16	1849	206	196	167	162	268	327	258	309	280	257	229	240
168	31	1854	206	195	167	162	265	324	259	307	279	257	227	239
168	46	1850	206	195	169	163	265	325	257	307	280	258	226	238
169	1	1854	206	196	169	163	265	325	255	308	281	260	229	240
169	16	1850	206	196	169	163	267	326	255	308	281	258	231	240
169	31	1858	206	196	170	164	267	328	258	310	282	259	232	240
169	46	1867	207	197	169	164	267	327	258	310	283	260	231	242
170	1	1869	206	197	170	163	267	327	259	310	283	260	230	241
170	16	1872	206	197	168	164	267	328	262	310	284	261	234	240
170	31	1874	207	197	167	165	269	325	265	311	283	260	232	238
170	46	1868	205	195	166	165	269	328	265	309	284	262	227	238
171	1	1868	205	195	166	163	266	326	261	311	286	262	228	241
171	16	1876	206	197	170	164	269	323	261	309	285	262	227	240
171	31	1854	206	197	169	164	268	330	260	312	286	262	231	243
171	46	1835	207	198	170	165	269	331	264	311	288	264	229	243
172	1	1822	206	197	167	165	268	330	264	310	286	263	228	242
172	16	1823	207	198	171	165	270	331	260	308	285	262	231	240
172	31	1823	208	200	169	165	268	330	263	313	289	265	232	244
172	46	1802	205	196	171	167	268	328	262	309	288	264	234	242
173	1	1818	207	199	171	165	269	331	264	312	288	266	232	240
173	16	1821	205	197	169	164	269	334	266	313	290	266	232	244
173	31	1840	207	196	171	166	271	334	261	315	290	264	233	244
173	46	1818	206	198	171	166	269	334	263	313	289	263	230	244
174	1	1790	206	198	171	165	269	333	263	314	292	264	231	244

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MIN	SEC	FURNACE AVERAGE	TRAY 1 F	TRAY 1 I	TRAY 1 P	TRAY 1 E	TRAY 2 F	TRAY 2 I	TRAY 2 P	TRAY 2 E	TRAY 3 F	TRAY 3 I	TRAY 3 P	TRAY 3 E
174	16	1798	208	199	171	166	270	334	263	316	291	265	232	245
174	31	1807	207	199	170	167	272	333	261	316	292	267	231	245
174	46	1809	207	200	172	166	272	334	259	317	293	268	237	247
175	1	1819	208	200	171	167	271	334	262	314	292	265	232	247
175	16	1828	207	199	172	168	272	334	263	313	292	268	232	247
175	31	1856	207	200	174	166	271	333	258	315	292	266	233	246
175	46	1831	207	202	176	168	273	335	262	316	293	269	231	247
176	1	1833	206	203	177	167	272	335	259	316	294	267	233	249
176	16	1844	208	204	178	168	272	335	259	320	293	266	236	248
176	31	1848	208	205	179	168	272	337	264	319	296	268	235	250
176	46	1839	205	204	178	169	275	337	264	318	296	270	234	250
177	1	1852	208	203	177	169	275	338	261	319	298	270	231	249
177	16	1853	208	203	177	169	274	337	258	319	296	267	236	250
177	31	1799	207	203	178	169	273	337	259	318	296	268	236	251
177	46	1797	207	204	177	168	272	336	262	319	295	268	234	251
178	1	1787	208	205	181	170	272	339	264	319	297	268	233	249
178	16	1791	206	203	180	168	272	336	272	314	295	269	240	249
178	31	1825	207	206	179	169	272	339	275	313	293	266	241	246
178	46	1808	205	202	175	168	270	336	278	314	294	266	237	246
179	1	1797	205	205	179	169	270	338	275	315	293	264	239	249
179	16	1799	207	203	179	170	268	338	278	317	295	265	241	246
179	31	1793	206	203	179	171	270	338	263	318	295	262	234	246
179	46	1796	206	202	178	170	268	342	268	319	294	263	234	248
180	1	1797	207	204	180	172	268	340	262	320	295	262	234	247

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
0	1	85	83	82	82	84	82	82	81	83	80	83	82	84
		87	82	82	82	84	82	82	81	83	80	83	82	84
0	31	101	82	82	82	84	82	82	81	83	80	83	82	84
0	46	127	82	82	82	84	82	82	81	83	80	83	82	84
1	1	140	82	82	82	84	82	82	81	83	81	83	82	84
1	16	162	82	82	82	84	82	82	81	83	81	83	82	84
1	31	197	82	82	82	84	82	82	81	83	81	83	82	84
1	46	225	82	82	82	84	82	82	81	83	81	83	82	84
2	1	256	82	82	82	84	82	82	81	83	81	83	82	84
2	16	296	82	82	82	84	82	82	81	83	81	83	82	84
2	31	342	83	82	82	84	82	82	81	83	81	83	82	84
2	46	396	82	82	82	84	82	82	81	83	[illegible]	83	82	84
3	1	441	82	82	82	84	82	82	81	83	81	83	82	84
3	16	503	82	82	82	84	82	82	81	83	81	83	82	84
3	31	567	82	82	82	84	82	82	82	84	82	83	82	84
3	46	632	84	82	82	84	82	82	82	84	82	83	82	84
4	1	695	83	82	82	84	82	82	82	84	82	83	82	84
4	16	751	82	82	82	84	82	82	82	84	82	83	82	84
4	31	808	83	82	82	84	82	82	82	84	82	83	82	84
4	46	850	83	82	82	84	82	82	82	84	82	83	82	84
5	1	883	82	82	82	84	83	82	82	84	82	83	82	84
5	16	916	83	82	82	84	83	82	82	94	82	83	82	84
5	31	956	81	82	82	84	83	82	82	84	82	83	82	84
5	46	990	82	82	82	84	83	82	82	84	82	83	82	84
6	1	1023	82	82	82	84	83	83	82	84	82	83	82	84
6	16	1040	81	82	82	84	83	83	82	84	82	83	82	84
6	31	1062	84	82	82	84	83	83	82	84	82	83	82	84
6	46	1063	82	83	82	84	83	83	82	84	82	83	82	84
7	1	1071	81	83	82	84	83	83	82	84	82	83	82	84
7	16	1079	81	83	82	84	83	83	82	84	82	83	83	84
7	31	1079	81	83	82	84	83	83	82	84	82	83	83	84
7	46	1113	81	83	82	84	83	83	82	84	82	83	83	84
8	1	1116	82	83	82	84	83	83	82	84	82	83	83	84
8	16	1107	82	83	82	84	83	83	82	84	82	83	83	84
8	31	1116	82	83	82	84	83	83	82	84	83	83	83	84
8	46	1153	81	83	83	84	83	83	82	84	82	83	83	84
9	1	1199	81	83	83	84	83	83	82	84	82	83	83	84
9	16	1204	81	83	83	84	83	83	82	84	83	83	83	84
9	31	1179	81	83	83	84	83	83	82	84	82	83	83	84
9	46	1197	82	83	83	84	83	83	82	84	82	83	83	84
10	1	1228	84	83	83	84	83	83	82	84	83	83	83	84

B. G. & E. SLAB 2

DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

TIME MIN SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
10 16	1278	82	83	83	84	83	83	82	84	83	83	83	84
10 31	1303	82	83	83	84	83	83	82	84	83	83	83	84
10 46	1300	82	83	83	84	83	83	82	84	83	83	83	84
11 1	1302	82	83	83	84	83	83	82	84	83	83	83	84
11 16	1313	82	84	83	84	83	83	82	84	83	83	83	85
11 31	1324	83	84	83	84	83	83	83	84	83	83	83	84
11 46	1338	83	84	83	84	84	83	83	84	83	83	83	84
12 1	1321	83	84	83	84	84	84	83	84	83	83	83	84
12 16	1331	82	84	84	84	84	84	83	84	83	83	83	84
12 31	1361	82	84	84	84	84	84	83	84	82	83	83	84
12 46	1369	83	84	84	84	84	84	83	84	82	83	83	84
13 1	1382	82	84	84	84	84	84	83	84	82	83	83	84
13 16	1387	82	85	84	84	84	84	83	84	82	83	83	85
13 31	1395	82	85	84	84	84	84	83	84	83	83	83	85
13 46	1419	82	85	84	84	84	84	83	84	83	83	83	85
14 1	1410	83	85	84	84	84	84	83	84	83	83	83	85
14 16	1410	82	85	84	84	84	84	83	84	83	83	83	85
14 31	1416	83	86	85	84	85	84	83	84	83	83	83	84
14 46	1418	82	86	85	84	85	85	83	84	83	83	83	84
15 1	1430	82	86	85	84	85	85	83	84	83	83	83	84
15 16	1434	82	86	85	84	85	85	83	84	83	83	83	84
15 31	1441	83	86	85	84	85	85	83	84	83	83	84	84
15 46	1447	83	87	86	84	85	85	84	84	83	83	84	85
16 1	1449	83	87	86	84	85	85	84	84	83	83	84	85
16 16	1452	83	87	86	84	85	85	84	84	83	83	84	85
16 31	1462	82	87	86	84	86	86	84	84	83	83	84	85
16 46	1463	85	88	86	84	86	86	84	84	83	83	84	85
17 1	1474	83	88	87	84	86	86	84	84	82	83	84	85
17 16	1487	83	88	87	85	86	86	84	84	82	83	84	85
17 31	1482	84	89	87	84	86	86	84	84	82	83	84	85
17 46	1487	85	89	87	84	86	86	84	84	82	83	84	85
18 1	1493	85	89	87	84	87	87	84	84	83	83	84	85
18 16	1503	85	89	88	85	87	87	84	84	83	83	84	85
18 31	1504	84	90	88	85	87	87	85	84	83	83	84	85
18 46	1499	86	90	88	85	87	87	85	84	83	83	84	85
19 1	1526	85	90	89	85	87	88	85	84	83	83	84	85
19 16	1525	84	91	89	85	88	88	85	84	83	83	84	85
19 31	1521	85	91	89	85	88	88	85	84	83	83	84	85
19 46	1524	85	92	90	85	88	88	85	84	83	84	84	85
20 1	1523	84	92	90	85	88	89	85	84	83	84	84	85
20 16	1537	86	92	90	85	89	89	86	84	83	84	84	85

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
20	31	1531	86	93	91	85	89	89	86	85	83	84	84	85
20	46	1544	86	93	91	85	89	89	86	85	83	84	84	85
21	1	1546	86	94	91	85	89	90	86	85	83	84	84	85
21	16	1563	86	94	92	85	90	90	86	85	83	84	84	85
21	31	1557	86	94	92	85	90	90	86	85	83	84	84	85
21	46	1565	86	95	92	85	90	91	86	85	83	84	84	85
22	1	1577	86	95	93	85	90	91	87	85	83	84	84	85
22	16	1567	86	96	93	85	91	91	87	85	83	84	84	85
22	31	1573	86	96	93	85	91	92	87	85	83	84	84	85
22	46	1587	87	97	94	85	91	92	87	85	83	84	84	85
23	1	1583	87	97	94	85	92	92	87	85	83	84	84	85
23	16	1589	86	98	95	85	92	93	88	85	83	84	85	85
23	31	1605	87	98	95	85	92	93	88	85	83	84	85	85
23	46	1605	87	99	96	85	92	93	88	85	83	84	85	85
24	1	1594	86	99	96	86	93	94	88	85	83	84	85	85
24	16	1599	86	100	96	86	93	94	89	85	83	84	85	85
24	31	1614	87	101	97	86	93	95	89	85	83	84	85	85
24	46	1616	86	101	97	86	94	95	89	85	83	84	85	85
25	1	1622	88	102	98	86	94	95	89	86	83	84	85	85
25	16	1632	87	102	99	86	94	96	90	86	83	84	85	85
25	31	1633	88	103	99	86	95	96	90	86	83	84	85	85
25	46	1645	88	104	99	86	95	97	90	86	84	84	85	85
26	1	1640	89	104	100	86	96	97	90	86	84	84	85	85
26	16	1647	88	105	100	86	96	98	90	86	83	84	85	85
26	31	1653	88	105	101	86	96	98	91	86	83	84	85	85
26	46	1643	88	106	102	86	97	98	91	86	83	84	85	85
27	1	1646	88	107	102	86	97	99	91	86	83	84	85	85
27	16	1660	89	107	102	87	98	99	91	86	83	84	85	85
27	31	1656	89	108	103	87	98	100	92	86	83	84	85	85
27	46	1671	88	109	104	87	99	100	92	86	83	84	85	85
28	1	1670	89	109	104	87	99	101	92	87	83	84	85	85
28	16	1684	89	110	105	87	99	101	93	87	83	85	85	85
28	31	1669	89	111	105	87	100	102	93	87	83	85	85	85
28	46	1674	89	111	106	87	100	102	93	87	83	85	86	85
29	1	1665	91	112	106	87	101	103	93	87	83	85	86	85
29	16	1667	91	113	107	87	101	103	93	87	83	85	86	85
29	31	1657	91	114	107	87	102	103	94	87	84	85	86	85
29	46	1658	91	114	108	88	102	104	94	87	83	85	86	85
30	1	1636	91	115	109	88	103	104	94	87	83	85	86	85
30	16	1634	92	116	109	88	103	105	94	87	84	85	86	85
30	31	1626	92	117	110	88	103	105	95	88	84	85	86	85

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
30	46	1620	92	118	110	88	104	106	95	88	84	85	86	85
31	1	1611	92	118	111	88	104	106	96	88	84	85	86	85
31	16	1597	92	119	112	88	105	107	96	88	84	85	86	85
31	31	1603	93	120	113	89	105	107	96	88	84	85	86	85
31	46	1600	92	121	113	89	106	108	97	88	84	85	86	85
32	1	1588	92	122	114	89	106	108	97	88	84	85	86	85
32	16	1588	94	123	115	89	107	109	97	88	84	85	86	85
32	31	1582	94	124	115	89	107	110	98	89	84	86	86	85
32	46	1584	94	125	116	89	108	110	98	89	84	86	86	85
33	1	1583	94	126	117	89	108	111	98	89	84	86	86	86
33	16	1585	94	127	117	90	108	111	99	89	84	86	86	86
33	31	1584	93	128	118	90	109	112	99	89	84	86	87	86
33	46	1585	94	129	119	90	109	112	100	89	84	86	87	86
34	1	1580	95	130	119	90	110	113	100	90	84	86	87	86
34	16	1573	96	131	120	90	111	113	100	90	84	86	87	86
34	31	1572	94	132	121	91	111	114	100	90	84	86	87	86
34	46	1571	96	133	122	91	112	114	100	90	84	86	87	86
35	1	1560	97	134	122	91	112	114	101	90	84	86	87	86
35	16	1565	97	135	123	91	113	115	101	90	84	86	87	86
35	31	1562	97	136	124	91	113	116	101	90	84	87	87	86
35	46	1552	97	137	125	92	114	116	102	91	84	87	87	86
36	1	1548	97	138	126	92	114	116	102	91	84	87	87	86
36	16	1542	99	139	127	92	115	117	102	91	85	87	87	86
36	31	1553	99	141	128	92	115	117	103	91	85	87	87	86
36	46	1554	99	142	129	93	116	118	104	91	85	87	87	86
37	1	1553	99	143	129	93	116	119	104	91	85	87	88	86
37	16	1552	99	144	130	93	116	119	104	92	85	87	88	86
37	31	1549	99	145	131	93	117	120	104	92	85	87	88	86
37	46	1544	100	146	132	93	117	120	105	92	85	87	88	86
38	1	1538	100	147	132	94	118	121	106	92	85	88	88	86
38	16	1541	101	148	133	94	118	121	106	92	85	88	88	86
38	31	1542	102	149	134	94	119	122	106	93	85	88	88	86
38	46	1543	102	150	135	95	119	123	106	93	85	88	88	86
39	1	1537	103	151	136	95	120	123	106	93	85	88	88	86
39	16	1542	103	152	137	95	121	123	107	93	85	88	88	86
39	31	1550	103	153	137	95	121	124	107	93	85	88	88	86
39	46	1559	103	154	138	95	122	124	107	93	85	88	88	86
40	1	1554	103	155	140	96	122	124	108	94	85	89	89	86
40	16	1554	105	156	140	96	123	125	108	94	85	89	89	87
40	31	1556	104	157	141	96	123	125	109	94	86	89	89	87
40	46	1546	105	157	142	97	123	126	109	94	86	89	89	87

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TIME MIN	SEC	FURNACE AVERAGE	TRAY 4 F	4 I	4 P	4 E	TRAY 5 F	5 I	5 P	5 E	TRAY 6 F	6 I	6 P	6 E
41	1	1563	106	158	142	97	123	126	109	94	86	89	89	87
41	16	1553	105	159	143	97	124	126	110	95	86	89	89	87
41	31	1555	106	160	144	97	124	127	111	95	86	89	89	87
41	46	1552	108	161	145	98	125	127	111	95	96	89	89	87
42	1	1557	108	162	147	98	126	128	111	95	86	90	89	87
42	16	1551	109	163	148	98	126	128	111	95	86	90	89	87
42	31	1553	109	164	148	98	126	128	111	96	86	90	89	87
42	46	1552	109	164	148	99	127	129	112	96	86	90	90	87
43	1	1553	110	165	149	99	127	129	112	96	86	90	90	87
43	16	1556	108	166	150	99	128	130	113	96	86	90	90	87
43	31	1548	110	167	151	99	129	130	113	96	86	90	90	87
43	46	1556	111	168	152	99	129	131	112	96	86	91	90	87
44	1	1555	111	169	153	100	130	131	113	97	86	91	90	87
44	16	1547	111	170	153	100	130	131	113	97	86	91	90	87
44	31	1553	112	170	154	100	130	131	114	97	86	91	90	87
44	46	1546	112	171	156	101	131	132	114	97	86	91	90	87
45	1	1546	113	172	156	101	131	133	114	97	86	91	90	87
45	16	1559	114	173	158	101	132	133	114	97	86	92	91	87
45	31	1551	113	174	158	101	132	134	114	98	86	92	91	87
45	46	1548	114	175	159	101	133	134	115	98	87	92	91	87
46	1	1547	116	175	160	102	133	134	115	98	87	92	91	87
46	16	1554	114	176	161	102	134	134	115	98	87	92	91	88
46	31	1543	115	177	162	102	135	134	115	99	87	92	91	88
46	46	1552	117	178	163	103	135	135	116	99	87	93	91	88
47	1	1562	117	179	162	103	135	135	117	99	87	93	91	88
47	16	1573	118	179	164	103	136	136	117	99	87	93	91	88
47	31	1570	117	180	165	103	136	137	117	99	87	93	92	88
47	46	1558	118	181	165	104	136	137	118	100	87	93	92	88
48	1	1562	118	181	166	104	137	137	119	100	87	93	92	88
48	16	1562	118	182	167	104	137	138	119	100	87	94	92	88
48	31	1557	118	183	166	104	137	138	119	100	87	94	92	88
48	46	1566	119	183	166	105	137	138	119	100	87	94	92	88
49	1	1563	120	184	166	105	138	138	120	101	87	94	92	88
49	16	1563	121	184	168	105	138	138	120	101	87	94	92	88
49	31	1567	121	185	168	105	139	139	121	101	88	94	92	88
49	46	1570	121	186	169	105	140	139	120	101	87	95	93	88
50	1	1561	122	187	170	106	141	140	120	101	87	95	93	88
50	16	1562	122	187	170	106	141	139	121	101	87	95	93	89
50	31	1560	122	188	170	106	141	140	121	102	88	95	93	89
50	46	1564	123	188	171	106	142	140	121	102	88	95	93	89
51	1	1569	123	189	173	107	142	141	121	102	88	95	93	89

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
51	16	1566	123	190	173	107	142	141	121	102	88	96	93	89
51	31	1577	125	190	173	107	142	141	122	102	88	96	93	89
51	46	1580	124	191	172	107	142	141	122	102	88	96	93	89
52	1	1575	125	191	172	108	143	142	123	103	88	96	93	89
52	16	1585	126	192	173	108	143	142	123	103	88	96	94	89
52	31	1593	125	193	174	108	143	142	123	103	88	97	94	89
52	46	1588	126	193	174	108	144	142	124	103	88	97	94	89
53	1	1584	126	194	174	109	145	143	124	103	88	97	94	89
53	16	1587	126	194	176	109	146	143	123	103	88	97	94	89
53	31	1574	127	195	177	109	146	143	123	104	88	97	94	89
53	46	1571	128	196	179	109	147	144	123	104	89	97	94	89
54	1	1580	129	196	179	109	148	144	124	104	89	98	95	89
54	16	1591	128	197	179	110	148	145	124	104	89	98	95	90
54	31	1582	130	197	178	110	148	145	125	104	89	98	95	90
54	46	1590	131	198	179	110	149	145	125	105	89	98	95	90
55	1	1591	132	198	181	110	150	146	126	105	89	99	95	90
55	16	1593	131	199	181	111	150	146	126	105	89	99	95	90
55	31	1594	131	199	180	111	150	147	126	105	89	99	95	90
55	46	1591	131	200	180	111	150	147	127	105	89	99	96	90
56	1	1601	132	201	182	111	151	147	126	105	89	99	96	90
56	16	1597	134	201	182	111	152	147	127	106	89	100	96	90
56	31	1610	134	202	181	112	151	147	127	106	89	100	96	90
56	46	1613	134	202	182	112	152	148	128	106	89	100	96	90
57	1	1606	134	203	184	112	153	149	128	106	90	100	96	90
57	16	1611	134	203	184	112	153	149	128	106	90	100	96	91
57	31	1600	134	204	183	112	153	149	128	107	89	101	97	91
57	46	1604	135	205	184	113	154	150	129	107	90	101	97	91
58	1	1604	136	205	186	113	155	150	129	107	90	101	97	91
58	16	1600	136	206	188	113	156	151	129	107	90	101	97	91
58	31	1603	136	206	187	113	156	151	130	107	90	101	97	91
58	46	1609	137	207	187	114	156	151	131	108	90	102	97	91
59	1	1611	137	207	187	114	157	152	131	108	90	102	98	91
59	16	1610	137	208	190	114	158	153	132	108	91	102	98	91
59	31	1621	138	208	191	114	158	153	132	108	91	102	98	92
59	46	1611	137	209	190	115	158	153	133	108	91	102	98	92
60	1	1611	138	209	192	115	160	154	132	108	91	103	98	92
60	16	1618	139	210	193	115	160	154	131	109	91	103	98	92
60	31	1620	140	210	191	115	159	154	132	109	91	103	99	92
60	46	1621	140	211	189	115	160	155	133	109	91	103	99	92
61	1	1632	141	211	192	116	161	155	132	109	91	104	99	92
61	16	1631	142	212	191	116	160	155	133	109	90	104	99	92

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61	31	1627	140	212	191	116	161	155	134	110	91	104	99	92
61	46	1586	142	213	193	116	163	156	134	110	91	104	99	93
62	1	1587	143	213	192	116	163	156	134	110	91	104	99	93
62	16	1593	144	214	194	117	164	157	133	110	91	105	99	93
62	31	1603	143	214	196	117	164	157	133	110	91	105	100	93
62	46	1589	144	215	194	117	163	158	134	110	91	105	100	93
63	1	1601	144	215	193	117	163	158	135	111	91	105	100	93
63	16	1604	145	216	191	117	163	158	136	111	90	105	100	93
63	31	1608	144	216	193	118	165	159	136	111	91	106	100	94
63	46	1610	145	217	195	118	166	159	135	111	91	106	100	94
64	1	1607	144	217	197	118	168	160	134	111	91	106	100	94
6.	16	1598	147	218	199	118	168	160	135	111	91	106	101	94
64	31	1626	146	218	198	118	167	161	137	112	91	107	101	94
64	46	1631	148	219	200	119	169	162	137	112	91	107	101	94
65	1	1632	148	219	198	119	170	162	136	112	91	107	101	95
65	16	1628	148	220	200	119	172	163	136	112	91	107	101	95
65	31	1626	147	220	202	119	172	164	136	112	91	107	101	95
65	46	1627	150	221	198	119	170	165	138	113	91	108	102	95
66	1	1641	151	221	198	120	170	165	140	113	92	108	102	95
66	16	1662	150	222	198	120	169	165	141	113	91	108	102	96
66	31	1487	150	222	199	120	170	166	141	113	91	108	102	96
66	46	1487	151	223	200	120	171	166	141	113	91	109	102	96
67	1	1494	151	223	200	121	172	166	142	113	91	109	102	96
67	16	1488	152	224	199	121	172	167	142	114	91	109	102	96
67	31	1500	152	224	200	121	173	168	142	114	92	109	102	96
67	46	1518	153	225	200	121	173	168	143	114	91	109	102	97
68	1	1564	154	225	201	121	174	168	143	114	92	110	102	97
68	16	1592	153	226	201	121	175	168	140	114	92	110	103	97
68	31	1580	154	227	202	122	175	169	141	115	92	110	103	97
68	46	1581	154	227	200	122	174	168	142	115	92	110	103	97
69	1	1593	155	228	199	122	174	169	142	115	91	110	102	97
69	16	1632	155	228	199	122	173	168	141	115	91	110	102	97
69	31	1650	155	229	199	122	172	168	142	115	91	111	102	98
69	46	1655	155	229	198	122	173	169	144	115	91	111	102	98
70	1	1657	155	230	198	123	173	170	142	115	91	111	103	98
70	16	1654	155	230	197	123	173	170	143	116	91	111	103	98
70	31	1659	157	231	200	123	175	172	145	116	91	111	103	98
70	46	1660	156	232	203	123	178	173	143	116	92	112	104	99
71	1	1671	156	232	206	123	179	173	143	116	92	112	104	99
71	16	1673	157	233	209	124	181	173	142	116	92	112	104	99
71	31	1679	158	234	210	124	183	174	142	117	93	113	105	99

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
71	46	1689	158	235	212	124	182	175	142	117	93	113	105	99
72	1	1694	158	235	212	124	184	175	142	117	93	113	105	100
72	16	1695	158	236	211	125	183	175	146	117	92	113	105	100
72	31	1686	158	237	211	125	182	175	147	118	92	114	105	100
72	46	1698	158	237	210	125	182	176	149	118	92	114	105	100
73	1	1687	159	238	209	125	180	176	150	118	93	114	106	100
73	16	1698	160	239	211	125	182	177	148	118	93	114	106	101
73	31	1679	160	239	213	126	185	178	147	119	93	114	106	101
73	46	1689	160	240	216	126	187	178	145	119	93	115	106	101
74	1	1686	160	241	215	126	186	178	147	119	94	115	107	101
74	16	1694	161	241	217	126	186	178	147	119	94	115	107	101
74	31	1710	161	242	217	126	185	177	148	120	93	116	107	102
74	46	1704	162	243	216	127	186	177	147	120	93	116	107	102
75	1	1704	164	244	217	127	188	177	147	120	93	116	108	102
75	16	1707	163	245	215	127	185	178	150	121	93	116	108	102
75	31	1699	163	245	212	127	183	179	152	121	93	116	108	102
75	46	1704	162	246	214	127	184	180	153	121	93	117	108	102
76	1	1707	163	247	216	128	188	181	152	122	93	117	108	103
76	16	1699	163	248	215	128	190	181	149	122	93	117	109	103
76	31	1706	163	249	217	128	191	180	152	122	94	117	109	103
76	46	1703	164	250	220	128	193	181	149	122	93	117	109	103
77	1	1697	164	251	223	129	194	182	149	123	94	118	109	104
77	16	1691	166	252	224	129	195	183	150	123	93	118	110	104
77	31	1701	166	252	225	129	195	183	148	123	94	118	110	104
77	46	1709	166	253	226	129	195	183	148	124	94	118	110	104
78	1	1702	166	254	224	129	194	182	153	124	94	119	110	104
78	16	1698	168	255	224	130	195	182	151	125	95	119	110	105
78	31	1708	167	256	227	130	195	182	150	125	95	119	110	105
78	46	1703	168	256	225	130	195	183	154	125	95	120	111	105
79	1	1697	167	257	223	130	195	183	155	126	96	120	111	105
79	16	1708	168	258	223	131	193	184	156	126	96	120	112	105
79	31	1702	168	259	228	131	193	183	155	126	95	120	112	106
79	46	1704	169	260	229	131	190	183	156	127	95	121	112	106
80	1	1717	168	261	229	131	189	183	158	127	96	121	112	106
80	16	1708	168	262	230	132	191	183	158	128	95	121	113	106
80	31	1707	168	263	230	132	189	183	158	128	95	121	113	106
80	46	1714	170	263	229	132	190	184	156	129	95	122	113	107
81	1	1704	170	264	230	132	189	183	157	129	95	122	113	107
81	16	1716	170	265	233	133	194	185	154	129	95	122	113	107
81	31	1707	171	266	235	133	197	185	152	130	95	122	113	107
81	46	1705	171	267	236	133	198	185	152	130	95	122	113	107

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82	1	1706	171	267	232	133	194	184	155	130	95	123	113	107
82	16	1714	171	268	235	133	196	185	154	131	96	123	114	108
82	31	1696	171	269	233	134	191	184	157	131	95	123	114	108
82	46	1710	171	270	234	134	193	184	156	131	96	123	114	108
83	1	1702	172	271	234	134	191	184	155	132	95	123	114	108
83	16	1707	173	271	233	134	190	184	155	132	96	124	114	108
83	31	1709	173	272	237	134	194	185	153	132	96	124	114	108
83	46	1713	172	273	235	135	193	186	156	133	95	124	114	109
84	1	1705	171	274	234	135	192	186	157	133	96	124	114	109
84	16	1715	174	274	232	135	190	185	158	133	95	124	114	109
84	31	1712	172	275	232	135	190	185	157	134	95	125	114	109
84	46	1708	174	276	233	136	192	184	157	134	95	125	115	109
85	1	1714	175	277	236	136	193	185	156	134	95	125	115	109
85	16	1713	174	278	240	136	198	186	157	135	95	125	115	110
85	31	1716	174	278	235	136	196	185	157	135	95	125	115	110
85	46	1713	174	279	235	136	194	185	159	136	96	125	116	110
86	1	1714	174	280	235	137	195	186	157	136	96	126	116	110
86	16	1715	174	281	236	137	197	186	155	136	96	126	116	110
86	31	1713	174	282	238	137	195	185	157	136	96	126	117	110
86	46	1714	174	283	238	138	196	186	156	137	96	126	117	111
87	1	1718	175	283	238	138	198	185	155	137	97	127	117	111
87	16	1718	176	284	237	138	198	183	154	137	97	127	117	111
87	31	1724	176	285	235	138	197	182	154	138	96	127	117	111
87	46	1715	176	285	237	138	199	182	153	138	97	127	118	111
88	1	1734	176	286	238	139	201	183	154	138	97	127	118	112
88	16	1718	178	287	240	139	202	184	153	139	97	128	118	112
88	31	1723	177	288	243	139	204	185	154	139	97	128	119	112
88	46	1732	177	289	245	139	204	185	154	139	98	128	119	112
89	1	1727	180	290	248	140	204	186	154	139	98	128	119	112
89	16	1723	179	291	246	140	199	187	158	140	98	128	120	112
89	31	1717	178	291	247	140	198	188	158	140	98	129	120	113
89	46	1729	179	292	245	140	195	189	162	140	97	129	121	113
90	1	1726	178	293	242	141	193	190	165	141	97	129	121	113
90	16	1722	181	294	242	141	193	191	165	141	97	129	121	113
90	31	1734	181	295	243	141	199	192	162	141	97	129	121	113
90	46	1726	179	296	243	141	200	190	160	142	97	130	121	113
91	1	1727	180	297	244	141	201	189	159	142	98	130	122	114
91	16	1723	180	298	244	142	197	188	161	142	98	130	122	114
91	31	1730	180	299	243	142	195	189	165	142	98	130	123	114
91	46	1730	180	300	247	142	200	191	161	143	98	130	123	114
92	1	1731	181	300	250	142	203	191	160	143	98	131	123	114

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92	16	1725	182	301	253	142	204	190	158	143	98	131	124	114
92	31	1735	181	302	254	143	205	191	159	143	99	131	125	114
92	46	1728	181	303	253	143	199	192	164	144	99	131	125	115
93	1	1726	182	304	253	143	197	193	167	144	98	131	126	115
93	16	1740	182	305	256	143	196	193	164	144	99	132	126	115
93	31	1743	182	306	257	144	199	194	163	144	99	132	126	115
93	46	1737	184	307	258	144	203	193	162	145	99	132	127	115
94	1	1735	184	308	260	144	200	192	165	145	99	132	128	115
94	16	1736	185	309	259	144	197	193	170	145	99	132	129	116
94	31	1735	184	309	257	145	196	193	172	146	99	133	129	116
94	46	1738	186	310	258	145	198	194	169	146	99	133	128	116
95	1	1731	184	310	260	145	199	192	168	146	99	133	129	116
95	16	1740	185	310	260	145	198	192	171	146	99	133	129	116
95	31	1731	183	311	259	145	197	193	171	147	99	133	130	116
95	46	1726	183	311	256	146	196	193	172	147	98	134	130	116
96	1	1724	185	312	255	146	195	193	171	147	98	134	130	116
96	16	1732	183	312	252	146	197	193	170	147	99	134	133	116
96	31	1733	185	313	255	146	200	193	166	148	99	134	134	117
96	46	1742	185	314	258	146	201	192	165	148	99	134	133	117
97	1	1742	185	314	258	147	204	192	165	148	99	134	133	117
97	16	1742	185	315	261	147	202	193	167	148	99	135	133	117
97	31	1740	187	316	265	147	202	193	168	148	99	135	133	117
97	46	1741	185	317	263	147	199	194	171	149	99	135	134	117
98	1	1760	188	317	261	147	200	194	170	149	99	135	133	118
98	16	1753	187	318	264	148	204	195	168	149	100	135	132	118
98	31	1745	186	318	267	148	205	193	167	149	100	136	132	118
98	46	1752	187	319	268	148	202	193	169	150	100	136	133	118
99	1	1756	187	320	264	148	199	192	171	150	100	136	133	118
99	16	1767	189	321	265	149	200	194	170	150	100	136	132	118
99	31	1758	186	321	264	149	198	194	171	150	99	136	132	118
99	46	1753	187	322	262	149	198	194	171	150	99	136	132	119
100	1	1753	188	323	264	149	200	194	172	151	99	136	133	119
100	16	1751	189	324	262	149	199	194	174	151	99	137	132	119
100	31	1765	189	325	266	150	202	195	171	151	99	137	133	119
100	46	1743	186	325	264	150	202	194	170	151	99	137	132	119
101	1	1745	186	326	264	150	200	193	173	152	99	137	132	119
101	16	1745	189	327	267	150	201	193	170	152	99	137	132	119
101	31	1766	188	328	271	150	206	196	167	152	100	137	131	119
101	46	1755	188	328	270	151	206	197	168	152	100	138	131	120
102	1	1764	190	329	272	151	209	196	168	153	101	138	131	120
102	16	1770	189	330	270	151	207	195	171	153	101	138	131	120

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TIME	FURNACE	TRAY 4				TRAY 5				TRAY 6			
MIN SEC	AVERAGE	F	I	P	E	F	I	P	E	F	I	P	E
102 31	1764	189	331	269	151	206	196	169	153	101	138	132	120
102 46	1766	191	331	270	152	206	197	167	153	101	138	132	121
103 1	1765	189	332	272	152	207	196	166	153	101	139	132	121
103 16	1763	191	333	273	152	208	195	167	154	101	139	132	121
103 31	1763	192	333	273	152	205	195	169	154	101	139	132	121
103 46	1773	191	334	272	153	205	195	169	154	102	139	133	121
104 1	1773	190	335	275	153	206	194	166	154	102	140	134	121
104 16	1758	192	336	275	153	205	194	169	154	101	140	133	121
104 31	1779	191	337	278	153	208	195	166	154	101	140	133	121
104 46	1765	190	337	275	153	208	195	169	155	102	140	133	122
105 1	1784	190	338	274	153	207	194	169	155	102	140	133	122
105 16	1763	191	339	276	154	205	194	173	155	102	141	133	122
105 31	1766	190	340	276	154	204	196	174	156	102	141	133	122
105 46	1763	191	341	277	154	205	196	174	156	102	141	135	122
106 1	1766	190	341	276	154	204	196	175	156	102	141	136	122
106 16	1764	190	342	277	155	205	198	177	156	102	141	136	122
106 31	1764	190	343	277	155	205	199	178	156	102	142	136	123
106 46	1767	190	344	280	155	207	200	172	156	103	142	136	123
107 1	1764	191	345	280	155	209	200	172	157	103	142	137	123
107 16	1769	191	345	275	155	207	200	176	157	102	142	137	123
107 31	1770	191	346	276	156	207	199	174	157	103	142	138	123
107 46	1772	192	347	277	156	209	197	172	157	103	143	138	123
108 1	1786	194	347	275	156	207	195	172	158	102	143	138	123
108 16	1796	191	348	273	156	207	195	173	158	102	143	138	123
108 31	1796	192	349	274	156	207	196	173	158	103	143	138	124
108 46	1788	194	350	276	157	209	196	173	158	102	143	139	124
109 1	1786	193	350	274	157	206	196	175	158	102	144	139	124
109 16	1795	193	351	276	157	209	197	173	158	102	144	140	124
109 31	1789	194	352	276	157	208	198	176	158	102	144	140	124
109 46	1801	193	353	275	157	209	198	175	159	103	144	139	124
110 1	1794	195	353	281	158	212	198	172	159	103	144	139	124
110 16	1805	194	354	280	158	209	197	176	159	103	145	140	124
110 31	1798	194	355	280	158	212	199	174	159	103	145	141	125
110 46	1796	193	356	283	158	214	199	172	159	103	145	140	125
111 1	1802	194	356	280	158	212	197	171	160	103	145	139	125
111 16	1799	194	357	278	159	212	197	175	160	103	146	138	125
111 31	1797	195	358	284	159	213	199	173	160	103	146	138	125
111 46	1806	195	358	287	159	215	201	171	160	104	146	138	125
112 1	1800	196	359	288	159	216	201	170	160	104	147	138	125
112 16	1809	197	360	289	159	216	200	171	160	104	147	138	126
112 31	1814	194	361	281	159	213	198	172	160	104	147	137	126

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112	46	1805	195	361	284	160	213	196	172	161	105	147	138	126
113	1	1812	196	362	285	160	215	198	173	161	105	148	137	126
113	16	1306	196	363	285	160	215	199	176	161	105	148	137	126
113	31	1807	194	364	285	161	212	201	180	161	105	148	137	126
113	46	1807	196	364	287	161	212	201	180	162	105	149	138	126
114	1	1804	196	365	286	161	213	202	180	162	105	149	139	126
114	16	1811	194	366	290	161	216	204	176	162	105	149	139	127
114	31	1804	194	367	289	161	214	204	180	162	105	149	140	127
114	46	1802	194	367	287	162	213	202	181	162	105	150	140	127
115	1	1804	194	368	287	162	213	202	181	163	104	150	140	127
115	16	1802	196	369	287	162	216	203	177	163	105	150	140	127
115	31	1809	197	370	292	162	216	201	177	163	104	150	140	127
115	46	1807	195	371	289	163	215	203	181	163	104	151	140	127
116	1	1810	198	371	292	163	218	204	179	163	105	151	140	127
116	16	1822	196	372	291	163	219	205	176	163	105	151	140	128
116	31	1813	197	373	293	163	221	205	174	163	106	151	141	128
116	46	1814	197	373	295	163	221	205	174	163	106	152	141	128
117	1	1823	199	374	291	163	221	203	174	164	106	152	141	128
117	16	1825	198	374	294	164	222	203	172	164	107	152	141	128
117	31	1830	197	375	291	164	222	203	174	164	107	153	140	128
117	46	1825	198	375	293	164	218	203	180	164	107	153	141	128
118	1	1823	197	375	295	165	218	204	182	164	106	153	141	129
118	16	1827	196	376	293	165	216	205	182	165	106	153	143	129
118	31	1821	198	377	293	165	217	205	180	164	105	153	143	129
118	46	1825	197	377	290	165	216	205	180	165	106	154	143	129
119	1	1824	197	378	295	165	218	206	180	165	105	154	143	129
119	16	1827	198	379	293	165	218	206	181	165	105	154	143	129
119	31	1830	198	379	292	166	218	206	181	165	105	154	145	129
119	46	1829	198	380	294	166	218	206	180	165	105	154	145	129
120	1	1834	198	380	294	166	220	206	180	166	104	154	144	129
120	16	1823	197	381	293	166	220	206	179	166	105	155	143	129
120	31	1820	197	382	290	166	220	206	178	166	105	155	143	130
120	46	1822	198	382	291	166	220	206	178	166	105	155	143	130
121	1	1829	198	383	290	167	220	207	179	166	104	155	144	130
121	16	1834	197	384	286	167	220	207	179	166	104	155	142	130
121	31	1827	197	384	284	167	219	207	180	166	103	155	141	130
121	46	1836	197	385	285	167	219	207	181	166	103	156	142	130
122	1	1835	197	385	288	167	219	208	182	167	103	156	142	130
122	16	1827	196	386	288	168	221	209	182	167	103	156	141	130
122	31	1826	196	387	290	168	222	208	180	167	103	156	141	130
122	46	1828	197	387	291	168	223	207	179	167	104	156	140	130

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B. G. & E. SLAB 2

DATE OF TEST: 30 JUL 80

PROJECT NUMBER: 03-5980-003

TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
123	1	1825	197	388	284	168	222	207	180	167	103	156	138	130
123	16	1831	198	388	278	168	222	206	180	167	102	156	137	130
123	31	1828	197	389	275	168	222	207	182	167	101	156	136	130
123	46	1832	197	389	279	168	222	207	181	167	101	156	136	130
124	1	1829	198	390	281	168	222	208	181	167	102	156	137	131
124	16	1833	197	391	283	169	225	210	179	168	103	156	139	131
124	31	1833	197	391	284	169	224	209	180	168	103	156	141	131
124	46	1830	197	392	282	169	224	211	180	168	103	157	143	131
125	1	1836	197	392	278	169	222	211	180	168	104	157	144	131
125	16	1834	197	393	272	169	222	212	182	168	103	157	143	131
125	31	1836	198	393	273	169	223	212	184	168	102	157	141	131
125	46	1846	198	394	276	170	224	214	184	168	102	157	139	131
126	1	1845	197	394	272	170	225	213	184	168	101	157	136	131
126	16	1846	198	395	275	170	224	212	184	168	101	157	138	131
126	31	1845	198	395	279	170	223	211	183	168	102	158	139	132
126	46	1848	197	395	276	170	225	211	182	169	102	158	138	132
127	1	1842	198	396	281	171	225	210	182	169	102	158	137	132
127	16	1840	199	396	280	171	226	210	182	169	102	158	136	132
127	31	1847	198	397	278	171	225	210	183	169	102	158	136	132
127	46	1834	199	397	280	171	226	210	181	169	102	158	135	132
128	1	1837	196	397	279	171	226	210	181	169	101	158	134	132
128	16	1845	199	398	280	171	226	210	181	170	102	158	135	132
128	31	1845	198	398	281	172	228	212	182	170	102	158	136	132
128	46	1834	199	399	282	172	228	213	181	170	102	158	136	133
129	1	1838	198	399	284	172	227	213	183	170	102	159	137	133
129	16	1835	198	399	285	172	228	214	181	170	103	159	137	133
129	31	1837	197	400	288	173	230	215	180	170	103	159	137	133
129	46	1838	199	400	294	173	233	216	177	170	104	159	137	133
130	1	1835	199	401	297	173	233	215	176	171	105	160	137	133
130	16	1835	198	401	298	173	233	213	175	171	105	160	137	134
130	31	1833	199	402	296	174	230	213	179	171	105	160	138	134
130	46	1842	200	402	296	174	230	214	178	171	105	160	138	134
131	1	1839	200	403	293	174	229	214	181	171	105	161	138	134
131	16	1835	200	403	294	174	230	216	181	171	105	161	139	134
131	31	1838	199	403	300	174	234	217	177	171	106	161	140	134
131	46	1855	200	404	302	175	234	217	177	172	107	161	142	134
132	1	1848	201	404	298	175	231	216	182	172	106	162	142	134
132	16	1856	199	405	295	175	231	218	183	172	106	162	149	134
132	31	1841	199	405	293	175	231	217	184	172	107	162	148	134
132	46	1838	199	405	297	175	232	217	183	172	106	162	146	134
133	1	1837	200	406	296	175	233	217	183	172	107	163	145	134

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
133	16	1838	199	406	294	176	233	218	184	172	106	163	144	135
133	31	1841	199	407	295	176	233	218	185	173	106	163	144	135
133	46	1842	199	407	298	176	234	218	183	173	106	163	144	135
134	1	1836	199	408	300	176	234	218	183	173	106	163	143	135
134	16	1835	199	408	297	176	234	217	183	173	106	163	143	135
134	31	1840	200	409	296	177	234	218	184	173	106	164	143	135
134	46	1833	199	409	297	177	234	219	182	174	106	164	142	135
135	1	1831	202	410	300	177	238	219	180	174	107	164	142	136
135	16	1835	200	410	299	177	237	218	181	174	107	164	142	136
135	31	1832	201	410	300	178	237	219	181	174	107	164	142	136
135	46	1830	201	411	303	178	239	221	180	174	107	164	143	136
136	1	1836	202	411	305	178	240	221	178	174	109	165	145	136
136	16	1837	201	412	307	178	241	221	177	174	110	165	148	137
136	31	1836	202	412	309	178	242	222	177	174	110	165	147	137
136	46	1834	200	413	308	179	242	221	178	175	110	166	146	137
137	1	1830	201	413	305	179	240	220	182	175	110	166	145	137
137	16	1838	201	413	305	179	238	220	184	175	109	166	145	137
137	31	1833	201	414	307	179	241	221	182	175	110	166	144	137
137	46	1843	204	414	312	179	243	222	179	175	111	166	143	137
138	1	1837	203	415	313	180	245	223	179	175	112	166	143	137
138	16	1839	203	415	314	180	244	223	184	176	112	166	143	137
138	31	1842	202	416	316	180	244	224	183	176	112	167	143	138
138	46	1844	203	416	316	180	243	225	186	176	112	167	143	138
139	1	1849	204	417	316	181	243	224	186	176	113	167	145	138
139	16	1850	203	417	319	181	244	224	184	176	112	167	146	138
139	31	1840	203	418	319	181	245	224	181	176	113	167	146	138
139	46	1841	204	418	319	181	246	223	181	176	112	167	145	138
140	1	1853	203	419	321	181	247	223	180	176	113	168	145	138
140	16	1842	205	419	315	181	245	222	182	176	112	168	145	138
140	31	1841	204	419	314	181	245	221	183	177	112	168	145	138
140	46	1839	206	420	312	182	244	221	184	177	111	168	145	138
141	1	1842	205	420	314	182	246	222	182	177	112	168	145	139
141	16	1845	205	421	316	182	246	223	184	177	112	168	145	139
141	31	1848	205	421	314	182	247	225	185	177	112	168	145	139
141	46	1848	204	422	313	182	246	224	186	177	111	168	145	139
142	1	1851	205	422	311	182	247	222	184	177	110	168	144	139
142	16	1836	205	422	307	182	247	221	183	177	109	168	143	139
142	31	1843	203	423	308	183	247	221	181	178	110	168	143	139
142	46	1834	204	423	310	183	248	220	179	178	110	168	145	139
143	1	1834	205	424	309	183	248	222	183	178	110	168	145	139
143	16	1843	203	424	308	183	249	224	182	178	110	168	149	139

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
143	31	1834	203	425	309	184	248	225	185	178	110	168	148	139
143	46	1839	203	425	310	184	248	225	187	179	110	168	148	139
144	1	1828	202	426	311	184	248	226	187	179	109	168	147	139
144	16	1832	203	426	311	184	249	227	188	179	109	168	147	139
144	31	1835	203	427	310	185	249	227	188	179	109	168	146	140
144	46	1843	203	427	309	185	249	227	188	179	109	168	145	140
145	1	1844	202	427	308	185	250	227	187	180	110	169	145	140
145	16	1848	202	428	311	185	251	228	187	179	110	169	145	140
145	31	1842	203	428	312	185	251	227	189	180	110	169	146	140
145	46	1840	203	429	310	185	251	228	190	179	109	169	146	140
146	1	1844	202	429	311	185	251	228	190	180	109	169	145	140
146	16	1842	204	430	306	185	251	228	190	180	109	169	145	140
146	31	1843	202	430	303	185	251	228	189	179	107	169	144	140
146	46	1848	202	431	293	185	252	227	189	179	106	169	142	140
147	1	1842	202	431	297	185	253	227	186	180	106	169	142	140
147	16	1842	205	431	297	186	252	227	186	180	107	169	141	141
147	31	1844	202	432	298	186	253	227	187	180	107	168	141	141
147	46	1842	203	432	301	186	253	227	189	180	107	168	142	141
148	1	1847	204	433	300	186	253	228	189	180	107	168	141	141
148	16	1850	203	433	299	187	254	227	187	180	107	168	140	141
148	31	1847	204	434	295	187	254	228	188	180	107	168	141	141
148	46	1856	203	434	299	187	255	229	189	181	107	168	142	141
149	1	1847	203	435	299	187	254	229	190	181	106	168	141	141
149	16	1848	202	435	294	187	255	231	190	181	106	168	140	141
149	31	1849	202	435	296	187	254	230	191	181	106	168	142	141
149	46	1835	202	436	301	188	256	230	189	181	105	168	141	141
150	1	1826	202	436	301	188	255	230	190	181	106	168	140	141
150	16	1828	202	437	303	188	256	231	190	182	107	168	141	141
150	31	1835	202	437	307	188	257	232	188	182	107	168	143	141
150	46	1825	203	437	307	189	258	233	189	182	108	168	142	142
151	1	1842	204	438	307	189	256	233	191	182	108	168	142	142
151	16	1829	203	438	306	189	257	233	190	182	108	168	141	142
151	31	1825	205	439	306	189	259	233	188	183	109	169	141	142
151	46	1822	205	439	306	190	258	233	190	183	109	169	141	142
152	1	1835	203	439	304	190	258	233	190	183	109	169	140	142
152	16	1845	204	440	301	190	259	232	189	183	108	169	141	142
152	31	1853	204	440	302	190	260	232	189	183	109	169	143	142
152	46	1855	203	441	303	190	260	232	189	183	109	169	142	143
153	1	1848	203	441	306	190	261	233	188	184	110	169	143	143
153	16	1844	203	441	305	191	260	235	190	184	110	169	143	143
153	31	1848	203	442	304	191	261	234	188	184	109	169	142	143

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153	46	1841	203	442	300	191	261	233	189	184	109	169	141	143
154	1	1840	204	443	303	191	262	234	190	184	109	169	140	143
154	16	1843	203	443	309	191	263	235	188	184	110	170	141	143
154	31	1841	204	443	308	192	263	236	188	184	110	170	141	143
154	46	1843	204	444	307	192	263	235	190	184	110	170	141	143
155	1	1845	204	444	305	192	263	235	190	185	110	170	141	143
155	16	1844	204	444	308	192	264	236	189	185	111	170	144	143
155	31	1847	205	445	307	192	265	236	186	185	111	170	144	143
155	46	1853	204	445	311	192	265	236	188	185	111	170	145	144
156	1	1853	205	445	314	193	265	237	188	186	112	170	143	144
156	16	1849	206	446	312	193	265	237	189	186	111	171	142	144
156	31	1858	206	446	312	193	265	236	192	186	111	171	143	144
156	46	1852	205	446	313	193	265	237	194	186	111	171	142	144
157	1	1852	206	447	312	193	265	238	194	186	111	171	142	144
157	16	1851	205	447	315	193	266	239	195	186	111	171	142	144
157	31	1860	206	447	315	194	267	240	193	187	112	171	142	145
157	46	1854	204	448	316	194	268	240	191	187	112	171	142	145
158	1	1849	205	448	315	194	268	240	189	187	112	171	142	145
158	16	1864	206	448	321	195	271	239	186	187	114	171	143	145
158	31	1866	206	449	321	195	270	240	188	187	115	172	144	145
158	46	1862	207	449	326	195	272	241	185	187	115	172	145	145
159	1	1852	206	450	325	195	272	241	186	187	115	172	145	145
159	16	1868	208	450	329	195	273	241	185	187	115	172	146	145
159	31	1864	209	450	325	195	272	241	187	187	116	172	147	145
159	46	1880	208	451	327	195	274	242	1[illegible]	188	117	172	150	145
160	1	1870	207	451	320	196	273	242	187	188	117	172	148	146
160	16	1878	209	451	328	196	277	242	184	188	120	173	148	146
160	31	1877	208	452	332	196	278	241	182	188	123	173	148	146
160	46	1872	208	452	334	196	279	242	183	188	125	173	152	146
161	1	1871	208	452	333	196	278	243	186	188	126	173	151	146
161	16	1868	209	453	326	197	277	244	188	189	125	174	151	146
161	31	1874	209	453	325	197	277	244	190	189	125	174	150	146
161	46	1875	211	453	334	197	281	245	186	189	126	174	149	147
162	1	1873	208	454	331	197	279	245	190	190	126	174	149	147
162	16	1870	208	454	333	197	278	245	192	190	125	175	148	147
162	31	1866	207	454	333	197	278	246	195	190	125	175	148	147
162	46	1865	209	455	337	197	281	247	190	190	127	175	148	147
163	1	1869	209	455	341	198	281	246	191	190	126	175	149	147
163	16	1870	209	455	337	198	280	248	195	190	126	175	149	147
163	31	1867	208	456	340	198	281	248	194	190	126	175	150	147
163	46	1870	211	456	338	198	281	249	195	191	125	175	152	147

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164	1	1871	208	456	338	198	280	248	198	191	124	175	152	147
164	16	1874	208	457	339	198	281	248	198	191	123	175	152	147
164	31	1866	209	457	340	198	283	250	195	191	124	175	152	147
164	46	1875	209	457	339	199	282	249	197	191	123	176	153	148
165	1	1878	209	458	341	199	283	250	196	191	123	176	155	148
165	16	1875	209	458	339	199	282	250	198	192	123	176	154	148
165	31	1854	209	459	337	199	282	251	200	192	123	176	154	148
165	46	1850	209	459	336	199	285	252	196	192	125	176	152	148
166	1	1843	210	459	336	199	287	251	195	192	125	176	151	148
166	16	1850	210	460	336	199	288	251	196	193	125	176	150	148
166	31	1840	210	460	334	199	287	250	198	193	125	176	150	148
166	46	1845	210	460	335	199	286	251	199	193	125	176	151	149
167	1	1848	211	461	337	200	286	250	198	193	125	177	152	149
167	16	1855	211	461	338	200	287	251	197	193	126	177	151	149
167	31	1859	210	461	343	200	291	252	193	193	129	177	151	149
167	46	1854	210	462	344	200	292	252	191	193	130	177	150	149
168	1	1853	210	462	342	200	291	252	193	194	130	177	150	149
168	16	1849	212	462	343	200	291	253	194	194	130	177	150	149
168	31	1854	211	463	340	201	290	254	199	194	130	178	150	149
168	46	1850	210	463	339	201	292	255	196	194	131	178	150	149
169	1	1854	211	463	341	201	293	256	197	195	131	178	150	150
169	16	1850	212	464	341	201	294	256	194	195	132	178	150	150
169	31	1858	212	464	347	201	295	256	192	195	133	178	151	150
169	46	1867	211	465	346	201	294	255	194	195	132	179	154	150
170	1	1869	212	465	348	201	297	256	191	195	134	179	154	150
170	16	1872	213	465	349	201	299	255	190	195	137	179	154	150
170	31	1874	211	466	347	201	298	255	193	195	138	179	154	150
170	46	1868	211	466	345	201	296	255	195	196	138	179	158	150
171	1	1868	214	466	344	202	296	255	196	196	138	180	162	150
171	16	1876	211	467	343	202	297	256	192	196	137	180	162	151
171	31	1854	213	467	344	202	296	256	195	196	135	180	160	151
171	46	1835	212	467	343	202	297	256	197	197	135	180	161	151
172	1	1822	212	468	344	202	299	257	193	197	136	180	158	151
172	16	1823	211	468	347	202	302	257	192	196	140	180	158	151
172	31	1823	212	468	350	202	303	257	191	197	144	181	158	151
172	46	1802	215	469	350	202	304	256	189	196	147	181	160	151
173	1	1818	212	469	351	203	304	256	191	197	147	181	160	151
173	16	1821	214	469	348	203	301	257	197	197	145	182	161	151
173	31	1840	214	470	345	203	300	257	198	198	144	182	162	152
173	46	1818	214	470	347	203	301	257	196	198	142	182	161	152
174	1	1790	215	470	343	203	301	258	197	198	141	182	158	152

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TIME MIN	TIME SEC	FURNACE AVERAGE	TRAY 4 F	TRAY 4 I	TRAY 4 P	TRAY 4 E	TRAY 5 F	TRAY 5 I	TRAY 5 P	TRAY 5 E	TRAY 6 F	TRAY 6 I	TRAY 6 P	TRAY 6 E
174	16	1798	216	471	344	203	302	259	200	198	141	182	157	152
174	31	1807	214	471	346	204	302	260	201	199	140	182	158	152
174	46	1809	215	472	344	204	301	260	204	199	139	182	158	152
175	1	1819	214	472	348	204	304	261	200	199	140	182	157	152
175	16	1828	216	472	351	204	307	260	196	199	142	183	156	152
175	31	1856	215	473	345	204	306	260	196	200	142	183	156	153
175	46	1831	216	473	346	204	305	259	197	200	141	183	156	153
176	1	1833	215	473	345	204	307	259	197	200	141	183	156	153
176	16	1844	217	474	346	204	309	260	197	200	141	183	155	153
176	31	1848	216	474	345	204	307	259	198	200	140	184	156	153
176	46	1839	214	474	341	205	308	260	197	200	140	184	157	153
177	1	1852	215	475	343	205	307	260	196	201	139	184	161	153
177	16	1853	216	475	342	205	309	259	194	201	139	184	159	153
177	31	1799	217	476	344	205	309	259	195	201	138	184	163	153
177	46	1797	217	476	343	205	308	260	197	201	137	185	164	153
178	1	1787	218	476	343	204	310	260	196	200	141	186	157	153
178	16	1791	218	477	326	204	307	257	199	199	139	187	153	152
178	31	1825	216	477	312	203	305	258	201	200	137	188	156	152
178	46	1808	216	478	312	204	305	259	204	200	135	188	157	151
179	1	1797	218	478	317	204	304	259	204	200	132	189	156	151
179	16	1799	217	479	297	204	302	260	206	200	131	189	154	151
179	31	1793	217	479	309	204	306	263	203	201	133	189	158	152
179	46	1796	218	479	321	205	311	264	201	201	137	189	158	152
180	1	1797	218	480	317	205	306	262	203	202	136	189	158	152

APPENDIX V

DATA SYSTEM

DATA SYSTEM

To record thermocouple data from the unexposed side of the test penetrations and the furnace temperature, a thirty channel system was used. This system was comprised of two digital temperature recorders; two paper tape punches; a paper tape reader; a minicomputer; and a large computer center.

Thermocouples were wired to Kaye Instruments Digital Multipoint Recorders. These units supply a data presentation of thermocouple output in degrees Farenheit in column format, and are paralled to paper tape recorders. There were a total of 27 data channels used. These were: 24 channels to record the unexposed surface thermocouple data; two channels were used to record elapsed time, one on each of the recorders; and one channel to record the average furnace temperature. For actual placement of thermocouple locations, see Figures IV-1 through IV-6, Appendix IV.

Two forms of data were taken from the recorders. One was a printed copy of listings of temperature at 15 second intervals and the other was an 8-level punch tape which is used as an input source to the Wang 2200T computer system. The Wang system accepts the 8-level punch tape data via a high speed tape reader, where it is stored on a permanent-type diskette as a permanent file. The Wang system listed the data tables contained in Appendix IV from a complete listing of time/temperature data stored internally on this disc.

The Wang also has the option to plot all temperature data on a 16 inch Digital Drum Plotter or access the Trinity University Computer

System Network. By using the data set (Model 4800 via telephone communications network) the Wang system communicates with Trinity's IBM 370 computer. The data is then further analyzed, plotted, and compared with other known test data. All test results from Trinity University's computer section are sent back to Southwest Research Institute in two modes:

1. Via a data phone set to a Tektronix CRT (Model 4015), for analysis and review of the data and graphs.

2. Via plots and graphs hand-carried to SwRI from Trinity.

A block diagram of the data system is shown in Figure V-1 and Figure V-2 shows the minicomputer system used.

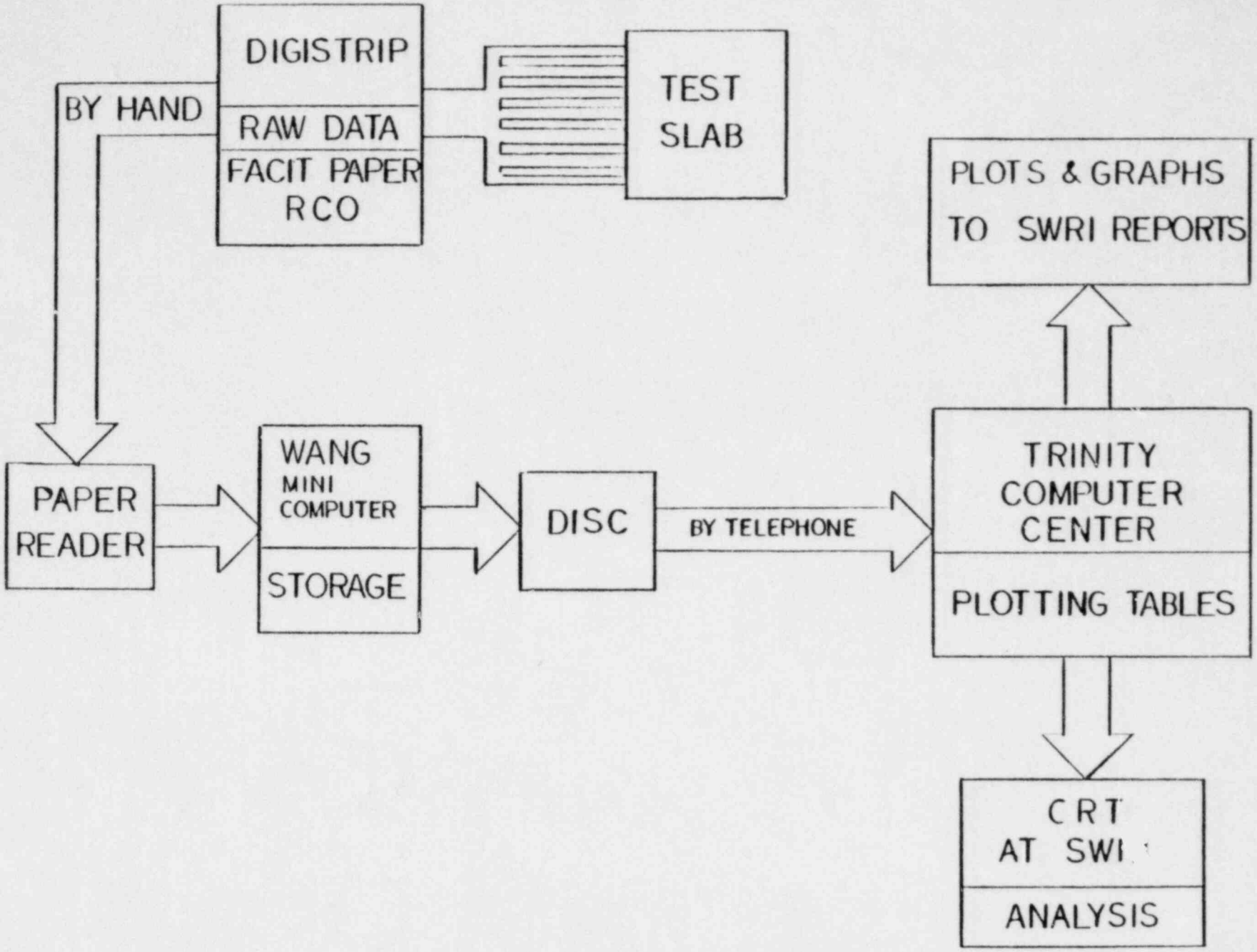
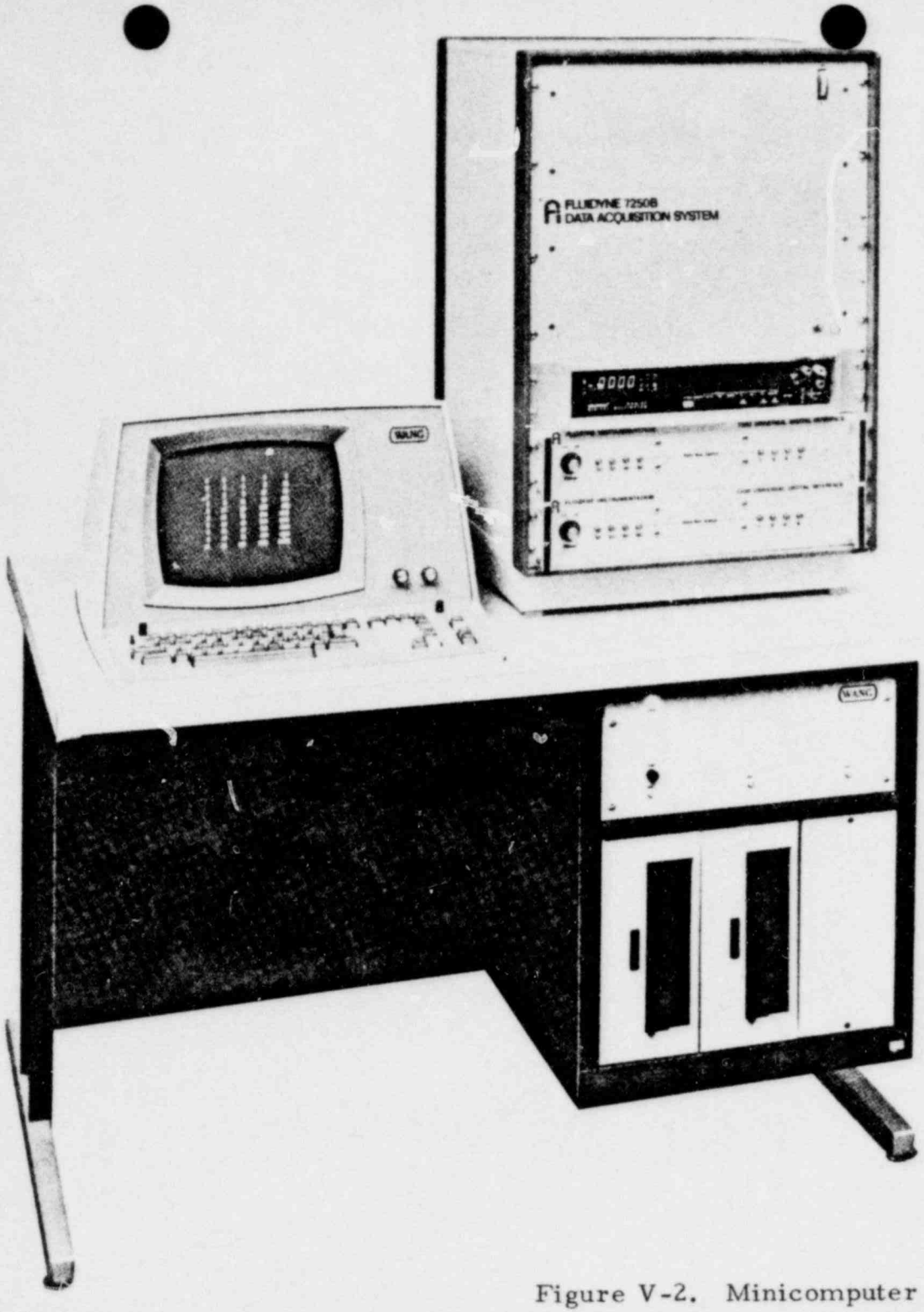
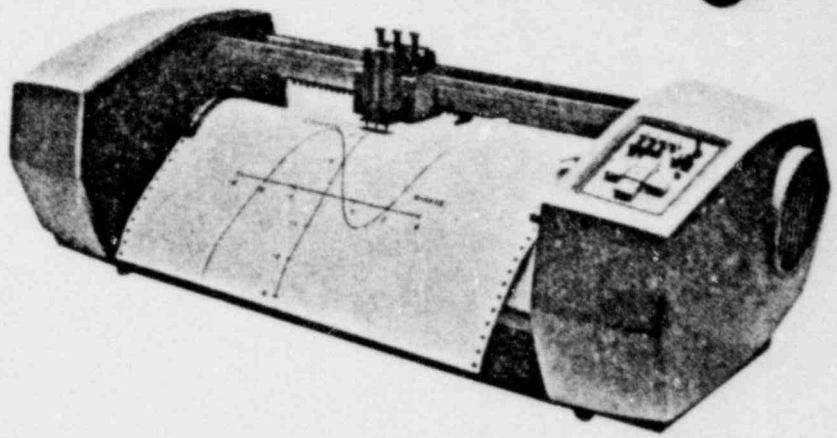


Figure V-1. Data System





A complete data acquisition/data processing system is dedicated solely for use by Fire Technology. The system provides the capability to input and read 224 signals per second. The data acquisition system is addressed by a keyboard through a central processing unit. By this means, the channels to be scanned and the rate of scan may be selected. The input signals are digitized and stored on magnetic disks for subsequent processing. The system output may be in either printed form, using the 112-character impact line printer, or graphic form, using the 16-in. digital drum plotter.

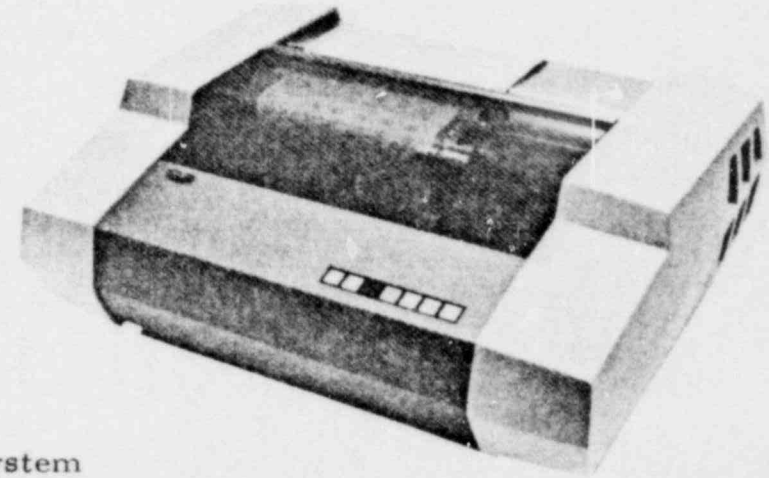


Figure V-2. Minicomputer System

APPENDIX VI

CABLE PENETRATION FIRE STOP

QUALIFICATION TEST

IEEE 634-1978

IEEE STANDARD CABLE PENETRATION

FIRE STOP QUALIFICATION TEST

Foreword

(This Foreword is not a part of IEEE Std C34-1978, Cable Penetration Fire Stop Qualification Test.)

This standard provides qualification test procedures for type testing cable penetration fire stops when mounted in rated fire barriers.

In the course of construction of all types of buildings, cables in raceways penetrate barriers such as walls, floors, or floor-ceiling assemblies of that building. If these barriers are rated as fire resistive barriers, the penetrations should be as resistant to fire as required of the barriers. Thus, in order to test the penetration and rate it, the penetration should be mounted in a rated wall, floor, or floor ceiling assembly as it would be used in practice and the combination exposed to the same standard fire as used for the wall, floor, or floor-ceiling assembly.

Rating of a Fire Resistive Barrier, with No Penetrations

This rating is expressed in hours and represents the ability of that barrier to withstand, without failure, exposure to a standard fire for that length of time. A fire rating for a barrier may be arrived at by testing it according to the procedure outlined in ANSI A2.1-1972, Methods of Fire Tests of Building Construction and Materials (ASTM E119-1971) (ISO 834).

A barrier achieves its rating if, during the specified time, it contains the fire, and its surface unexposed to the fire does not heat up sufficiently to ignite cotton waste or the temperature does not exceed 250°F above ambient. In addition, following the fire, the barrier is required to withstand a specified standard fire hose test on the hot face.

Caution Re: ANSI A2.1-1972, Limitations

ANSI A2.1-1972 cautions that its results give only a *relative* measure of fire performance of comparable barriers (see 2.2), that it does not measure degree of control or limitation of smoke or products of combustion through the assembly (see 2.4.3), and does not consider the effect of conventional openings, that is, electrical receptacle outlets or plumbing pipe, etc (see 2.4.6).

Standard Fire in ANSI A2.1-1972

The standard fire is defined by a time-temperature relationship which must be produced by the test furnace. The seven defined points on this curve are given as follows:

1000°F (538°C) at 5 min
1300°F (704°C) at 10 min
1550°F (843°C) at 30 min
1700°F (927°C) at 1 hr
1850°F (1,010°C) at 2 hr
2000°F (1,093°C) at 4 hr
2300°F (1,260°C) at 8 hr or more

A more detailed description is given in ANSI A2.1-1972, Appendix A1 which lists intervening points and tabulates the integrated area under the time-temperature curve as a function of time.

The same standard fire is used on the cable penetration fire stop qualification test.

Fundamental Difference Between a Fire Test on a Barrier Alone and a Penetration-Barrier Combination

The fire resistive barrier described above has a relatively low thermal conductivity so that it can maintain a 1300-1600°F temperature difference between the face exposed to the fire and the opposite face. A cable penetration has a metallic electrical conductor which has a very high thermal conductance. It may have many large copper conductors and steel trays or conduits or metal parts of the penetration, all of which pass through the barrier. On the cool side of the barrier, these metal parts are necessarily at a higher temperature than the wall adjacent to the penetration. The stop material filling the interstices between cables or between cables and the barrier should give comparable thermal conductance to the barrier itself, in addition to resisting the fire.

Thus the higher temperature rise of the metallic parts of the penetration presents a new and different problem and may make it impossible to use the same pass-fail criteria as for the barriers. An obvious failure occurs when sufficient heat is transmitted so that the insulation of the cable on the cold side bursts into flame. This is discussed further in 2.3.

Maximum Allowable Cable Penetration Fire Stop Face Temperature

If one examines the temperatures across the unexposed face of the cable penetration fire stop near the end of a 3 h test, the temperatures will vary widely depending on the distance from a cable or a raceway. The temperature of the unexposed face of the cable penetration fire stop material at a point away from the cable or the raceway will also depend on the thermal conductivity of the cable penetration fire stop material. The *maximum* temperature on that face is the important one. If this temperature is at the interface between the cable jacket and the cable penetration fire stop material, and if this temperature rises to the self-ignition temperature of the cable jacket or the stop material, a fire may result.

Thus, the test procedure finds the maximum temperature on the unexposed cable penetration fire stop face and compares it with a maximum allowable temperature. The maximum allowable temperature is defined as one at which the insulation systems expected to be used should not ignite.

The maximum allowable temperature is arrived at by an examination of the known ignition temperatures of insulating materials. Ignition temperature is measured by a procedure in ANSI K65.111-1971, Method of Test for the Ignition Properties of Plastics (ASTM D129-1968). This is described as a hot-air ignition furnace. The values obtained represent the lowest ambient air temperature that will cause ignition of the material under the conditions of test. Measured properties are "flash-ignition temperature" where an igniting source is present (small gas flame) and "self-ignition temperature," where ignition occurs spontaneously.

For ignition, there must be adequate temperature; the combustible gases released from the hot insulation must be mixed with the correct proportion of air.

The required temperature to cause ignition would be much higher than the ASTM value because the hot gases released are swept away by air drafts, and a higher temperature is needed to produce a higher rate of release of gases so that an ignitable gas-air ratio can be attained. Thus, there is a good factor of safety in the assigned maximum allowable temperature.

Typical values of the ignition temperatures as determined in ANSI K65.111-1971 are given below in degrees Fahrenheit:

Material	Flash-Ignition	Self-Ignition
Cotton	446-511	490
Newspaper	445	445
Pine shavings	406-507	500
Wool	401	—
Polyethylene	645	660
Polyvinyl chloride	735	850
Polytetrafluroethylene	—	986
Polyvinyl chloride-acetate	608-644	815-1035
Polystyrene	635-680	910-925
Nylon 66	750-790	788-806

The maximum allowable temperature selected for a cable penetration fire stop should be based on 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 cable penetration fire stops the self-ignition temperatures of the outer cable covering and fire stop materials are generally above 700° F.

The maximum allowable temperature is the actual measured temperature on the unexposed side and *not* temperature rise. This is because the ignition of a given material occurs at a specific temperature of degrees Fahrenheit.

What This Standard Does Not Do, and Problems Yet to Be Covered

Pressure Seals

A penetration fire stop and the fire barrier itself should, in some locations, function as a seal to maintain any existing pressure difference and should not pass through hot gases or smoke. It should maintain that ability for the duration of the rating test. While this problem is recognized, the present standard does not address it, nor does the ANSI A2.1-1972 test. This should be a future task.

If it is desired by the user of this standard, he can specify an added test, outside the scope of this standard and supplementing the information it provides, which would require a check of the ability of the penetration to maintain a differential pressure before, during, and after the fire test. There has been no standard method yet proposed and accepted for checking this seal during a fire test.

Ampacity Derating Due to Penetration Stops

It is recognized that the thermal insulating characteristics of a penetration fire stop may have an effect on the ampacity of the cables passing through the penetration. Design of the fire stop should address this effect. However, ampacity considerations are not a part of the qualification test and, consequently, are not within the scope of this standard.

Adequacy of Test Furnace

Furnaces used in these rating tests are sometimes operated at lower than atmospheric pressure, and thus hot gases or smoke would not tend to leak outward, but cold air would tend to flow inward toward the fire. This test may not represent a typical situation in a real fire and should be the subject of future investigations.

Test Limitation and Cautions

Just as in the case of the fire barrier in ANSI A2.1-1972, this test is run with a specific standard fire. This fire may or may not be as severe as fires actually experienced and hence may not predict the performance of the cable penetration fire stop barrier combination in actual service. It is the judgment of those experienced in the field that *relative* performance is accurately portrayed, and the relative values may be used as a basis for engineering judgment in a particular design situation.

The test, as already pointed out, gives no information on the necessity, if any, for ampacity derating of cables within the cable penetration, nor does it give any indication of the capability of the stop to maintain a pressure differential between the opposing faces of the barrier before, during, or after a fire test.

Furthermore, the user must consider the higher temperature of those components emerging from the face of the barrier not exposed to fire, for example, the conductors and metallic elements, such as the tray, conduit, or structural parts of the penetration. These higher temperatures must be considered by the designer who will perform a hazards analysis and will take steps necessary to counter these hazards if any are found.

Electric Penetration Assemblies in Containment Structures

Electric penetration assemblies in containment structures are not covered in this standard. For guidance in this area, refer to IEEE Std 317-1976, Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

Seismic, Radiation, Aging, and LOCA

Although it is recognized that seismic, radiation, aging, and LOCA conditions may be required to be considered and evaluated for nuclear power plants, these effects are not within the scope of this standard. For guidance in these areas, refer to IEEE Std 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, and IEEE Std 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

This standard was prepared by Task Force 12-40 of the Insulated Conductors Committee and at the time of approval had the following membership:

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Contents

IEEE Standard Cable Penetration Fire Stop Qualification Test

1. Scope

This standard provides direction for establishing type tests for qualifying the performance of cable penetration fire stops when mounted in rated fire barriers.

2. Purpose

The purpose of this standard is to establish type tests to assure that cable penetration fire stops meet the required fire rating.

2.1 General. The requirements presented include the principles and procedures for testing. These test requirements, when met, will confirm the adequacy of the cable penetration fire stop design under fire conditions tested.

2.2 Applicability. Cable penetration fire stops that meet the requirements outlined herein are intended for use in power-generating stations including nuclear-generating stations, as well as other applicable commercial and industrial installations. Among the categories of cables covered, but not limited to, are those used for power, control, and instrumentation services.

2.3 Method of Approach. When a cable penetration is used in a rated fire-resistive barrier, the fire stop should remain intact and prevent the spread of fire and restrict the passage of hot gases through that barrier for the required rated time. A fire barrier meeting the requirements of ANSI A2.1-1972, Methods of Fire Tests of Building Construction and Materials (ASTM E119-1971)[1] (ISO 834), must limit the flow of heat or gases through from the fire side as indicated by a relatively cool surface, one whose temperature will not ignite gases, cotton waste, or National Fire Prevention Association Class A materials which require a temperature of approximately 400°F (in ANSI A2.1-1972 this is expressed as 250°F above ambient). With a fire stop, however, there are always metallic conductors and perhaps structural portions of the penetration which present good thermal conduction paths through the fire stop and whose temperatures at the point of exit may exceed markedly the approximately 400°F expected of the unpenetrated wall. The temperature can be such that the insulation and jacket on the cable may ignite, indicating a failure of the stop. These higher temperatures of the metallic through-portions of the penetration must be considered and evaluated by the user/designer.

3. Definitions

These definitions establish the meanings of words in the context of their use in this standard.

cable penetration. An assembly or group of assemblies for electrical conductors to enter and continue through a fire-rated structural wall, floor, or floor-ceiling assembly.

cable penetration fire stop. Material, devices, or an assembly of parts providing cable penetrations through fire-rated walls, floors, or floor-ceiling assemblies, and maintaining their required fire rating.

fire rating. The term applied to cable penetration fire stops to indicate the endurance in time (hours and minutes) to the standard time-

[1] ANSI documents are available from American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

temperature curve in ANSI/ASTM E119-76, while satisfying the acceptance criteria specified in this standard.

fire resistive barrier. A wall, floor, or floor-ceiling assembly erected to prevent the spread of fire. (To be effective, fire barriers must have sufficient fire resistance to withstand the effects of the most severe fire that may be expected to occur in the area adjacent to the fire barrier and must provide a complete barrier to the spread of fire.)

fire resistive barrier rating. This is expressed in time (hours and minutes) and indicates that the wall, floor, or floor-ceiling assembly can withstand, without failure, exposure to a standard fire for that period of time. The test fire procedure and acceptance criteria are defined in American National Standard A2.1-1972.

module. An opening in a fire resistive barrier so located and spaced from adjacent modules (openings) that its respective cable penetration fire stop's performance will not affect the performance of cable penetration fire stops in any adjacent module. A module may take on any shape to permit the passage of cables from one or any number of raceways.

raceway. Any channel that is designed and used expressly for supporting or enclosing wires, cable, or bus bars. Raceways consist primarily of, but are not restricted to, cable trays and conduits.

unexposed side. The side of a fire-rated wall, floor-ceiling assembly, or floor which is opposite to the fire side. Also referred to as cold side.

4. References

The following standards were used as references in preparing this guide and may be useful in interpretation of its meaning:

[1] ANSI A2.1-1972, Methods of Fire Tests of Building Construction and Materials (ASTM E119-1971) (ISO 834).

[2] ASTM E84-1976a, Test for Surface Burning Characteristics of Building Materials.

[3] ASTM D2863-1976, Measuring of Test for Flammability of Plastics Using Oxygen Index Method.

[4] IEEE Std 317-1976, Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

[5] ANSI K65.111-1971, Methods of Test for the Ignition Properties of Plastics (ASTM D 1929-1968).

5. Test Description

5.1 General. This section describes the methods for testing cable penetration fire stops around cables penetrating a fire resistive barrier.

5.1.1 *Applicability.* These methods shall be applicable to assemblies or groups of cables and materials or components which comprise the fire stop that will be installed in a fire resistive barrier wall, floor, or floor-ceiling assembly. It is not the intent of this standard to test the wall, floor, floor-ceiling assembly or other structural members of the fire resistive barrier. Therefore, no simulated structural loading is required.

5.1.2 *Penetration Fire Stop Components – Excluding Cable.* Individual components of the fire stop system shall have a flame spread rating of 25 or less in accordance with Ref [2]. Components to which the test in Ref [2] are not applicable shall be tested in accordance with Ref [3] and shall have a minimum limiting oxygen index of 25.

5.1.3 *Method of Testing.* Qualification shall be by type testing of an actual full-sized cable penetration fire stop or module indicative of installed conditions.

5.1.4 *Test Experience.* Cable penetration fire stops or modules or both that have successfully functioned under test can be considered qualified for equal or less severe fire rating. Testing in the floor-ceiling position qualifies the cable penetration fire stops for either floor or wall penetration provided the cable penetration fire stop under test is constructed symmetrically so as to provide equal resistance to fire from either side. For unsymmetrical design, refer to 5.3.5.

5.2 Test Specimens

5.2.1 *General.* The type tests specified shall be for power, control, and instrumentation

(including signal and communications) cables. The cable penetration fire stops shall be installed in modules or openings through fire-rated barriers, which may be lined with metallic components. Cables may penetrate these openings either directly without a raceway or within a metallic raceway depending on the intended installed configuration.

5.2.2 *Cable Selection and Raceway Fill.* The selection of the sizes, construction, and materials of the cables and cable penetration opening fill to be used in the test shall be representative of the cables used in the fire stop under actual installed conditions.

The cable sizes and cable penetration fire stop fill listed in Table 1 may be used. If these sizes, constructions, or fills are not indicative of the actual installed conditions, more suitable selections shall be used. It is not the intent that different construction types, that is, instrumentation and medium voltage power cable, be installed in the same test cable penetration unless this is indicative of actual conditions.

In order to assess the design of cable penetration fire stops by type testing, similar designs with maximum and minimum, or zero, percent cable fills shall be tested.

When large modules in the fire resistive barrier are used to permit several cable systems to pass through, intermediate percent fills as well as minimum and maximum should be tested in the openings. If these designs are successfully tested, then all designs within these extremities of fill also are qualified. For further guidance, refer to Appendix A2.

5.2.3 *Cable Penetration Fire Stop Opening Dimensions and Type.* The opening dimensions and type of cable penetration fire stops to be tested shall be representative of the type to be used. In order to facilitate the selection of test specimens where several variations of the same type penetration are used, the sizes and type of cable penetration fire stop openings listed in Table 2 may be used as a basis for selection.

If these sizes or types are not indicative of the actual installed condition, more suitable selections shall be used.

In order to assess the design of the cable penetration fire stop by type testing, the largest module or opening or both shall be tested and the cable selected in accordance with 5.2.2.

If the largest cross-sectional module design is successfully tested, then all designs of the same type and size module or smaller modules are also qualified. Likewise, arrays of openings or modules which are successfully tested shall qualify similar arrays with the same or larger spacing.

The user of cable penetration fire stops and modules qualified by themselves shall demonstrate that the influence of adjacent cable penetration fire stops or modules or both does not compromise their qualification. For further guidance, refer to Appendix A2.

5.3 Fire Test Facility and Procedure

5.3.1 *Test Room.* The fire test shall be conducted in a suitable room or area as defined in American National Standard A2.1-1972, 10.1.

5.3.2 *System Test.* The cable penetration fire stop shall be tested as a complete system. The raceway mounting and anchoring to the fire stop assembly, the cable arrangement, including attachment to raceway and the raceway fill, shall be representative of the actual installed conditions.

5.3.3 *Cable Installation.* The cable within the penetration shall protrude 3 ft to 5 ft on the unexposed side and the ends capped. The cable on the side to which the flame is to be applied shall protrude a minimum of 1 ft. Vertical cables in floor penetration tests shall be supported on the unexposed side to simulate continuous cables in an actual installation.

5.3.4 *Raceway Installation.* If the penetration under test is to simulate an actual penetration in which the raceway passes through the fire barrier, the test raceway shall protrude 3 ft to 5 ft on the unexposed side and a minimum of 1 ft on the exposed side.

5.3.5 *Orientation.* Testing in the floor-ceiling position qualifies the cable penetration fire stop for either a floor or wall penetration. Cable penetration fire stops that are symmetrical with respect to design and location in the wall-floor need only be fire tested on one side. Cable penetration fire stop designs which are unsymmetrical in design or location may require testing on both sides for qualification. For example of unsymmetrical designs and location, refer to Appendix A2.

5.3.6 *Time-Temperature Curve.* The test penetration module shall be subjected to the standard time-temperature curve in ANSI A2.1-1972 (reproduced in Appendix A1) for the time necessary to obtain the required fire rating.

Table 1
Suggested Representative Cables and Cable Penetration Fire Stop Opening Fill for Type Tests

Cable Fire Stop Penetration Type Cable	Size Cable and Construction	Fraction of Total* Fill for Each Penetration Type
Medium voltage power (2-15 kV)	3/C No 6 AWG	1/3
	3/C No 2/0	1/3
	3/C No 4/0	1/3
Low voltage power	3/C No 6 AWG	1/3
	3/C No 2/0	1/3
	3/C No 4/0	1/3
Control and instrumentation	7/C No 12	1/2
	1 pr No 16 AWG shielded	1/2

*Total fill is the total quantity of cable to be installed in the test penetration. For example, this could be 40 percent of the cross-sectional area of the raceway penetration or raceway.

Table 2
Suggested Representative Penetration Opening Dimensions

Cable Fire Stop Penetration Type — Structural	Cross-Sectional Dimensions (Inches)	Slab Thickness (Inches)
Round — No metal sleeve; cables pass through without raceway	6 (diameter)	12 or 6
Round — No metal sleeve; cables pass through in metal raceway	6 (diameter)	12 or 6
Round — Metal sleeve; cables pass through without raceway	6 (diameter)	12 or 6
Round — Metal sleeve; cables pass through in raceway	6 (diameter)	12 or 6
Rectangular — No metal sleeve; cables pass through without raceway	8 x 42 or 48	12 or 6
Rectangular — No metal sleeve; cables pass through in metal raceway	8 x 42 or 48	12 or 6
Rectangular — Metal sleeve; cables pass through without raceway	8 x 42 or 48	12 or 6
Rectangular — Metal sleeve; cables pass through in raceway	8 x 42 or 48	12 or 6

5.3.7 *Exposed Side Test Instrumentation.* The temperature fixed by the curve shall be deemed to be the average temperature obtained from the readings of not less than three thermocouples symmetrically disposed and distributed to show the temperature for each cable penetration fire stop. Additional thermocouples shall be used, as necessary, for larger test specimens. The thermocouples shall be enclosed in sealed porcelain tubes ¾ in (19 mm) in outside diameter and ⅛ in (3 mm) in wall thickness, or, as an alternative in the case of base metal thermocouples, enclosed in sealed, standardweight, ½ in (13 mm), black wrought steel or black wrought iron pipe. The exposed length of the pyrometer tube and thermocouple in the flame area shall be not less than 12 in (305 mm). Other types of protecting tubes or pyrometers may be used that, under test conditions, give the same indications as the above standard. For cable penetrations through floors or floor-ceiling assemblies, the junction of the thermocouples shall be placed 12 in away from the exposed face of the test penetration at the beginning of the test and, during the test, shall not touch the sample as a result of its deflection. In the case of cable penetration through walls, the thermocouples shall be placed 6 in (152 mm) away from the exposed face of the test penetration at the beginning of the test and shall not touch the test penetration during the test, in the event of deflection.

5.3.8 *Exposed Side Temperature Reading Intervals.* The temperatures shall be read at intervals not exceeding 5 min during the first 2 h, and thereafter the intervals may be increased to not more than 10 min.

5.3.9 *Flame Source Accuracy.* The accuracy of the flame source control shall be such that the area under the time-temperature curve, obtained by averaging the results from the pyrometer readings, is within the following tolerances, or exceeds the corresponding area under the standard time-temperature curve in Appendix A1.

Fire Test Duration	Tolerance (%)
1 h or less	10
Over 1 h to 2 h	7.5
Over 2 h	5

5.3.10 *Unexposed Side Temperature.* Temperatures on the penetration cold side surfaces shall be measured with thermocouples. A minimum of three thermocouples shall be located on the surface of each fire stop under test. The maximum temperature on the face of the cable penetration fire stop shall be measured. As a minimum, temperature shall be measured at the cable jacket, cable penetration fire stop interface, the interface between the fire stop, and through metallic components, other than the insulated cable conductor, and on the surface of the fire stop material.

5.3.11 *Unexposed Side Temperature Reading Intervals.* Temperature readings shall be taken at intervals not exceeding 15 min until a reading exceeding 212°F (100°C) has been obtained at any one point. Thereafter, the readings may be taken more frequently at the discretion of the tester, but the intervals need not be less than 5 min.

5.3.12 *Hose Stream Test.* A hose stream test shall be conducted immediately following the end of the fire endurance test and removal, if necessary, of the test slab.

For power-generating stations including nuclear-generating stations, a 1½ in hose discharging through a nozzle approved, for use on fires in electrical equipment producing a long-range-narrow-angle (30-90° set at 30° included angle) high velocity spray only shall be used. The hose stream shall be applied to the exposed side. The water pressure shall be 75 p/in², calculated, at the base of the nozzle and minimum flow of 75 gal/min with a duration of application of 2½ min per 100 ft² of test slab. The nozzle distance shall be 10 ft from the center of the exposed surface of the test specimen.

For other applicable industrial and commercial establishments, the hose stream shall be applied to the exposed surface for a period calculated on a basis of 2½ min per 100 ft² of test slab. The stream shall be delivered through a 2½ in national standard playpipe equipped with 1⅛ in tip, nozzle pressure of 30 p/in² calculated, located 20 ft from the exposed face.

6. Evaluation of Test Results

Cable penetration fire stops which allow cables or fire stop materials on the unexposed side to ignite, or allow thermocouples on the unexposed side to exceed the temperature limits specified, or any visible flame on the unexposed side, within the specified fire rating time, or

the hose stream to cause through-openings, fail the test.

6.1 Acceptance. The test can be considered acceptable and the cable penetration fire stop suitable for use in accordance with the fire rating, provided the following is met:

6.1.1 The cable penetration fire stop shall have withstood the fire endurance test as specified without passage of flame or gases hot enough to ignite the cable or other fire stop material on the unexposed side for a period equal to the required fire rating.

6.1.2 Transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self-ignition temperature as determined in ANSI K65.111-1971 of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable penetration fire stop, when measured in accordance with 5.3.10 and 5.3.11. For power generating station, the maximum temperature is 700° F.

6.1.3 The fire stop shall have withstood the hose stream test without the hose stream causing an opening through the test specimen.

7. Documentation of Testing

Following the procedures outlined in this standard, provide data necessary to document satisfactory compliance. Type test data derived from tests shall be organized to present the results in an orderly manner so as to be easily understood and located.

Specifically, the following data shall be recorded:

(1) Manufacturer of cable

(2) Manufacturer's designation for cable and generic name of materials used

(3) Temperature, current, and voltage rating of cable

(4) Physical dimensions including conductor size insulation and jacket thickness

(5) Miscellaneous construction details including type of raceway, etc

(6) Manufacturer of fire stop materials or devices

(7) Manufacturer of fire stop designation and generic name of materials or devices or both

(8) Environmental conditions, such as air ambient, air currents

(9) Details of hose stream test

(10) Complete description of materials surrounding the fire stop, including test results of 5.1.2

(11) The temperature and time readings taken

The test equipment shall be described in detail, supplemented with record of fuel supply, photographs, dimensioned drawings, and written specifications with not less data than that necessary to reproduce accurately the same test.

The results, pass or fail, shall be recorded and supplemented with photographs and a statement of the conclusions drawn made by those conducting the test.

Engineering data and references to other publications which were used to make the test and select the equipment shall be included in the documentation.

Installation methods shall be described including any Quality Assurance data applicable to the specific materials and installation methods used.

Appendix

A1. Standard Time-Temperature Curve for Control of Fire Tests

Time (h:min)	Temperature (°F)	Area Above 68° F Base (°F-min)	(°F-h)	Temperature (°C)	Area Above 20° C Base (°C-min)	(°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

A2. Cable Penetration Type Tests

A2.1 Typical Cross Sections

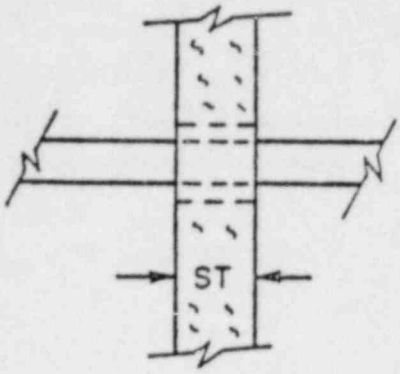

Fig A1
Raceway Passes
Through Fire
Resistive Barrier

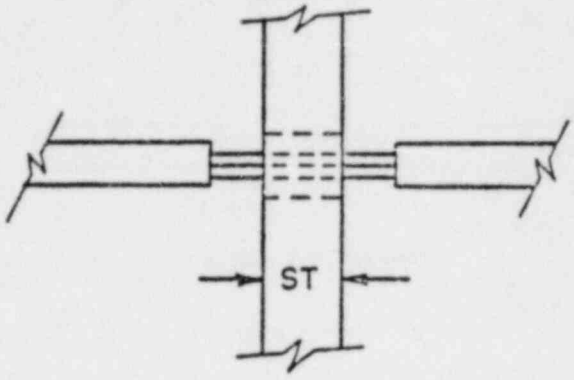

Fig A2
Raceway Does Not
Pass Through Fire
Resistive Barrier

A2.2 Example of Single Type Test

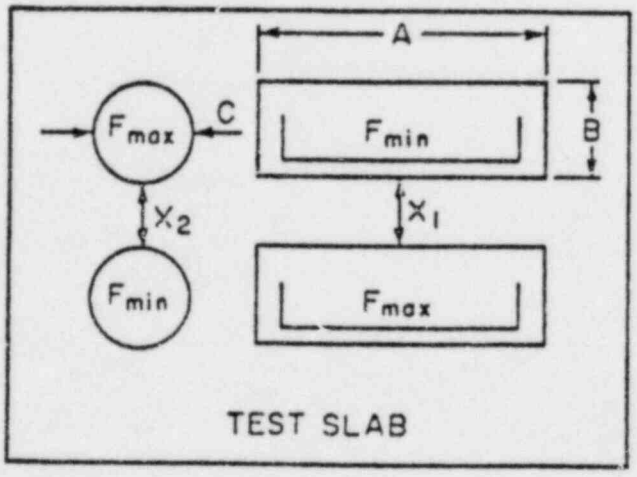

Fig A3
Four Individual Modules Each
with One Opening

A2.3 Multiopening Single Module Type Test Example

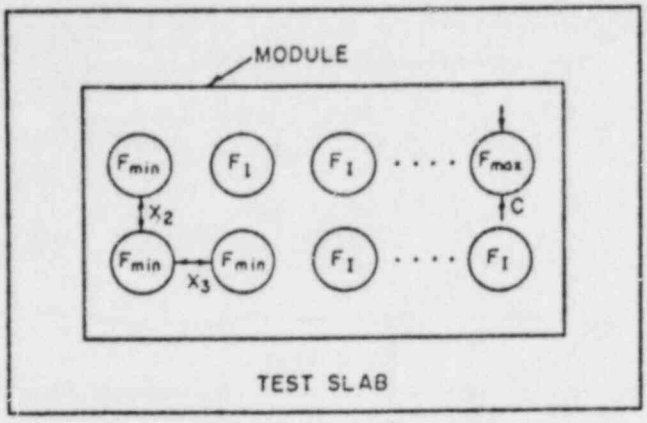

Fig A4
Typical Conduit or Sleeve Penetration

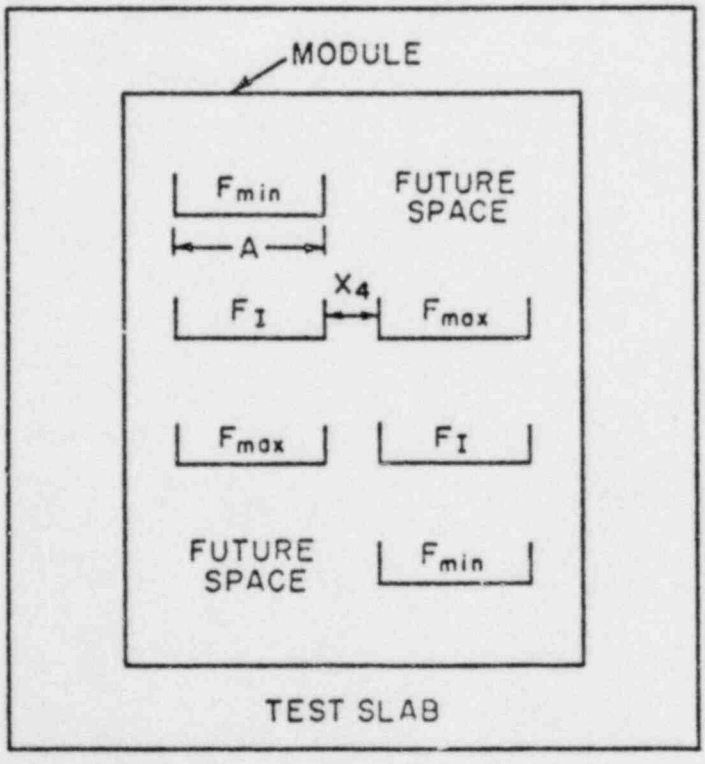

Fig A5
Typical Tray Opening Penetration

NOTE: If test facility will permit, both multiopening single modules shown above could be tested simultaneously.

A2.4 Example of Modules with Nonsymmetrical Fire Stops

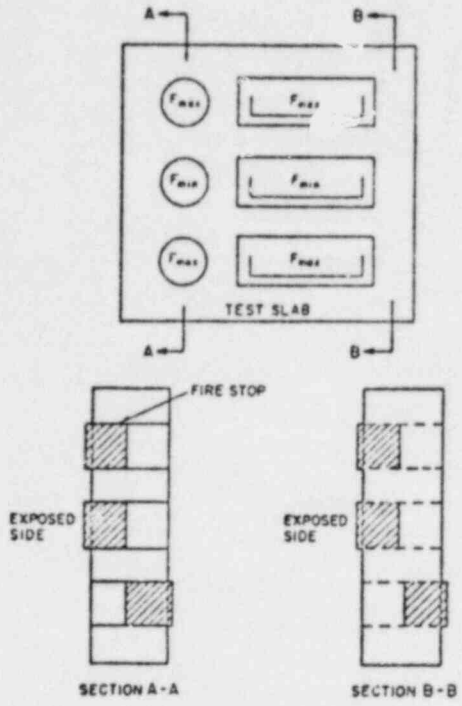

Fig A6
Fire Stop Non-Symmetrical
with Respect to Location

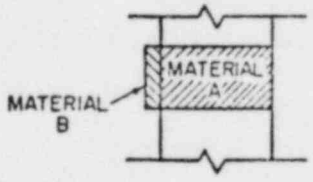

Fig A7
Fire Stop Non-Symmetrical
with Respect to Materials

A2.5 Symbol Definitions

ST	Slab thickness. If minimum slab thickness is qualified, all larger thicknesses of similar design are also qualified.
A, B, C	Largest dimensions of opening to be qualified. If largest A, B, C dimension is qualified, all smaller A, B, C of similar design are also qualified.
X_1, X_2, X_3	Minimum separation to be qualified. If X_1, X_2, X_3 is qualified, all larger X_1, X_2, X_3 are also qualified.
F_{max}	Maximum percent cable fill to be qualified.
F_{min}	Minimum percent cable fill used. If design is to be qualified for spares, then $F_{min} = 0$ percent.
FI	Intermediate percent cable fill, usually taken as $(F_{max} + F_{min})/2$.