TRANSCO PRODUCTS INC.

TRANSCO TEST REPORT NO. TR-161

FIRE AND HOSE STREAM TESTS OF TCO-001 CEMENT, TCO-002 MEDIUM DENSITY SILICONE, AND TCO-007 SILICONE ADHESIVE USED IN ELECTRICAL CONDUIT AND BLOCKOUT PENETRATIONS

By: T. Hoff
Test Date: 11/20/84

REVISON LOG

A.) As revised 2/13/85:

1.) Page 6 of 23, third paragraph, second and third line, delete "anything", and insert "any seal surface,".

2.) Page 9 of 23, first paragraph, fourth line, delete "inside".

3.) Page 9 of 23, third paragraph, second line, delete "pressure".

4.) Page 10 of 23, second line, delete "penetrate the seals" and insert "project from the unexposed surface of the seals".

5.) Page 10 of 23, seventh line, delete "are" insert "were".

6.) Page 10 of 23, item "c.)", delete the first "hose".

7.) Page 10 of 23, second to the last line, delete "exposed" and insert "unexposed".

A.) SYNOPSIS:

This report describes a three-hour fire and subsequent hose stream tests (in a floor assembly) of Transco #TCO-001 Cement (US Gypsum Firecode CT Gypsum Cement), #TCO-002 Medium Density Silicone, and #TCO-007 Silicone Adhesive (Dow Corning 96-081) installed in simulated electrical openings. The test was performed in accordance with the ASTM E-119 time/temperature curve for three hours along with provisions set forth in the ANI, NML, and IEEE-634 standards for conducting qualification tests for penetration seals. The purpose of this test was to demonstrate the fire resistant qualities of the overall seals when tested to the parameters of these standards. The test was conducted on November 20, 1984 at Portland Cement Association/Construction Technology Laboratories Fire Research Laboratory (Skokie, Illinois).

The specimen consisted of 6-5" diameter (I.D.) conduits cast in concrete into a 21" x 30" section of the 48" x 48" x 12" thick concrete slab. A 9" x 30" x 12" deep rectangular opening remained in the 48" x 48" x 12" thick slab which was divided into 2 equal sections of 9" x 14½" x 12" deep each using a 1" thick Carborundum Ceramic Hot Board. 2-2" diameter (I.D.) conduits with bends on both ends were inserted into the 2-9" x 14½" x 12" deep rectangular openings (1 in each). All conduits contained varying amounts of electrical cable (the 2 rectangular openings had no cable), and all penetrations were sealed using CT Gypsum, Medium Density Silicone, or Silicone Adhesive, and US Gypsum CT Thermafiber damming.

B.) TEST SLAB:

The test slab measured 48" x 48" x 12" thick. The following are the specifics for each penetration:

PENE. A & B

Consisted of 4-7/8" (I.D.) flex-type conduit with PVC coating which extended 9" on the fire side and 20" on the cold side.

PENE. C & D

Consisted of 4-7/8" (I.D.), 12" long flex-type conduit with PVC coating attached to 5" (I.D.) continuous solid conduit at 15" above the cold side of the slab. The continuous solid conduit extended 9" on the fire side.

PENE. E

Consisted of 5" (I.D.) continuous solid conduit which extended 9" on the fire side and 15" on the cold side.

PENE: F

Consisted of a 4-7/8" (I.D.), 12" long flex-type conduit with PVC coating attached to 5" (I.D.) continuous solid conduit at 15" above the cold side. The continuous rigid conduit extended 9" on the fire side.

PENE. G & H

Consisted of 9" x 14½" x 12" deep rectangular opening (each) with 1-2" (I.D.) solid continuous conduit (each) which extended through the opening and turned 90° on both the top (to 20" above slab) and bottom (to 9" below slab) of the slab.

C.) SPECIMEN CONFIGURATION:

Each conduit contained IEEE-383 rated electrical cable with Hypalon jacket as described as follows:

Penetrations A thru F (Cable loading for each conduit)

2 pcs.	3/C - 1/0 Power Cable (Okonite) (@ 1.6231 in.^{2} ea.)	3.2462 in.^{2}
4 pcs.	12/C-#14 Control Cable (Okonite) (@ .6013 in.^{2} ea.)	2.4052 in.^{2}
45 pcs.	1PR #16TW Instrumentation Cable (Samuel Moore)(@ .0621 in.^{2}ea.)	2.7945 in.^{2}
	Total Loading....	8.4459 in.^{2}

Based on 5" diameter (I.D.) solid conduit (Pene. E) @ 19.64 in.^{2}, total loading equals 43%
Based on $4\frac{7}{8}$" diameter (I.D.) flex conduit (Pene. A,B,C,D,F) @ 18.67 in.^{2}, total loading equals 45.24%

Penetrations G and H (Cable Loading for each Conduit)

1 pc. of	12/C - #14 Control Cable (Okonite) (@ .6013 in.^{2} ea.)	.6013 in.
13 pcs. of	1PR - #16 TW Instrumentation Cable (Samuel Moore)(@ .0621 in.^{2}ea.)	.8073 in.
	Total Loading.....	1.4086 in.

Based on 2" diameter (I.D.) conduit @ 3.142 in.^{2}, total loading equals 44.83%

All cables penetrated through the conduit sleeves 1' on the exposed side of slab, 1' through the sleeves, and 3' on the unexposed side of slab, for a total length of 5'. Cables weresecured on the unexposed side of slab only using a steel frame and steel wire. The conduits in Pene. G and H were welded in place @ the unexposed side of slab. The cables and conduit were not secured on the exposed side of slab. All cable ends on the unexposed side of slab were sealed with caulking compound in compliance with IEEE-634.

One conduit (Pene. E) contained a P-Line (pull rope used for cable pulls) which passed continuously through the conduit out of both the fire and cold side ends of the conduit. The outer surface of the flex conduits in Penetrations B and C were taped with 3M #27 Tape to seal off most of the PVC coating on the flex conduits. This was done on the unexposed side of these penetrations only.

D.) SEAL INSTALLATION:

U.S. Gypsum CT Thermafiber was the only damming material used for this test, and was used and left-in-place in all penetrations. 4" of CT Thermafiber was used in Penetration F and the 2" conduit in Penetration H; 6" of CT Thermafiber was used in Penetration A,B,C,D,E; 5" of CT Thermafiber was used in Penetrations G and H; and 2" CT Thermafiber was used in the 2" conduit in Penetration G. The CT Thermafiber was premeasured to these dimensions and then stuffed into the penetration and between the cables back far enough to allow the installation of the seal material so that the seal material, when installed, would end up flush with the top of the penetration. Damming measurements made for the 2" conduit penetrations (in Penetrations G and H) were made from the opening of the conduit along the back of the conduit (the long radius of the conduit). Also, these 2" conduits did not have any straight section where the seals were installed.

The dry #TCO-001 Cement was mixed with water in a large plastic bucket using a small electric drill motor equipped with a paddle mixer. Material was installed by hand and using a cartridgeless caulking gun. The #TCO-002 Medium Density Silicone was hand mixed (1:1 mixing ratio by weight) in a small plastic bucket using an electric drill motor equipped with a paddle mixer, and was installed by hand. The #TCO-007 Silicone Adhesive, supplied in tubes, was installed using a caulking gun. When installing the seal material between cables, the cables were moved by hand to allow the material to flow between the cables. The CT Gypsum was mixed to between a 3-1/2" and 6-1/2" slump. CT Gypsum was installed to a fill depth of 2" in Penetrations A thru E, and Penetrations G,H, and the conduit in Penetration H had a 5" fill depth.

D.) SEAL INSTALLATION (cont'd):

The #TCO-002 Medium Density Silicone was installed to a fill depth of 7" in the conduit in Penetration G. The #TCO-007 Silicone Adhesive was installed to a fill depth of 1" in Penetration F. All seal material was installed flush with the top of the penetration except in Penetration H where the CT Gypsum (5" thick) was installed flush with the bottom of the penetration. All conduit ends were sealed on both the exposed and unexposed sides of the slab.

Penetration G and H were tested to provide test data on cracks in CT Gypsum. The CT Gypsum in each penetration was cracked 1/4" wide x 14½" wide long x full depth of CT Gypsum (approximately 5" thick) to demonstrate that a 1/4" wide straight through crack (straight through to CT Thermafiber damming) could pass the 3 hour fire test and subsequent hose stream tests. Because the 5" CT Gypsum/4" CT Thermafiber seal configuration is used in wall penetrations as well as floor penetrations, this seal configuration was tested in both directions to demonstrate a symmetrical seal (CT Gypsum flush with top of slab in Penetration G, and CT Gypsum flush with bottom of slab in Penetration H).

E.) THERMOCOUPLES:

Thermocouples were mounted to the test specimen to gather temperature data throughout the test at 5 minute intervals for the first 2 hours and at 10 minute intervals for the remaining hour (per IEEE-634). Temperatures were recorded for the seal surface and seal/sleeve interface on the unexposed side of the slab for each penetration. Thermocouples were also placed at the point the continuous conduits penetrated the unexposed side of the slab (Penes. A thru F) and where the continuous conduits penetrated the unexposed side of the seal surface (Penes. G&H).

All unexposed side seal surface thermocouples were pushed slightly into the seal surface to prevent contact with ambient air temperatures. Thermocouples used for monitoring cable temperatures on the unexposed side were mounted so that their tips were also positioned slightly below the seal surface.

A thermocouple was also placed over the ¼" wide crack in the CT Gypsum surface in Penetration G (@ unexposed side). This thermocouple was not in contact with any seal surface, but was positioned over the ¼" crack area at slightly below the surrounding CT Gypsum surface level, to monitor the air temperature coming through the crack area. Another thermocouple was placed on the CT Thermafiber damming material over the area where the ¼" wide crack in the CT Gypsum existed in Penetration H (@ unexposed side).

The thermocouples used in this test along with final temperature readings are as follows (temperature data for the entire test can be found in Section "H" of this report):

KEY: (a) = 3/C-1/0 Power Cable (Okonite)
(b) = 12/C-#14 Control Cable (Okonite)
(c) = 1PR #16 TW Instrumentation Cable (Samuel Moore)

T/C#	Description (all unexposed side thermocouples)	Final Temperature (^{o}F)
1	Pene. H Seal Surface Over Crack Area	84^{o} (143^{o} high)
2	Pene. H Seal Surface	96^{o} (129^{o} high)
3	Pene. H Conduit/Seal Exit Interface	272^{o}
4	Pene. H Seal Interface	120^{o}
5	Pene. G Seal Surface	81^{o}
6	Pene. G Seal Surface	118^{o}
7	Pene. G ¼" Wide CT Gypsum Crack	80^{o}
8	Pene. G Conduit/Seal Exit Interface	205^{o}
9	Pene. G Seal Interface	101^{o}
10	Pene. E Seal Surface	129^{o}
11	Pene. E Power Cable (a)	159^{o}
12	Pene. E Control Cable (b)	133^{o}
13	Pene. E Instrument Cable (c)	120^{o}
14	Pene. E Seal Interface	135^{o}
15	Pene. E Conduit/Slab Exit Interface	227^{o}
16	Pene. F Seal Surface	88^{o}
17	Pene. F Power Cable (a)	92^{o}
18	Pene. F Control Cable (b)	88^{o}
19	Pene. F Instrument Cable (c)	88^{o}
20	Pene. F Seal Interface	79^{o}
21	Pene. F Conduit/Slab Exit Interface	230^{o}
22	Pene. C Seal Surface	93^{o}
23	Pene. C Power Cable (a)	94^{o}
24	Pene. C Control Cable (b)	88^{o}
25	Pene. C Instrument Cable (c)	93^{o}
26	Pene. C Seal Interface	89^{o}
27	Pene. C Conduit/Slab Exit Interface	234^{o}
28	Pene. D Seal Surface	89^{o}
29	Pene. D Power Cable (a)	101^{o}
30	Pene. D Control Cable (b)	92^{o}
31	Pene. D Instrument Cable (c)	88^{o}
32	Pene. D Seal Interface	86^{o}
33	Pene. D Conduit/Slab Exit Interface	241^{o}
34	Pene. B Seal Surface	102^{o}
35	Pene. B Power Cable (a)	120^{o}
36	Pene. B Control Cable (b)	104^{o}
37	Pene. B Instrument Cable (c)	104^{o}
38	Pene. B Seal Interface	102^{o}
39	Pene. B Conduit/Slab Exit Interface	166^{o} (169^{o} high)
40	Pene. A Seal Surface	107^{o}

T/C#	Description (all unexposed side thermocouples)	Final Temperature (^{o}F)
41	Pene. A Power Cable (a)	125^{o}
42	Pene. A Control Cable (b)	103^{o}
43	Pene. A Instrument Cable (c)	106^{o}
44	Pene. A Seal Surface	106^{o}
45	Pene. A Conduit/Slab Exit Interface	230^{o}
46	Pene. H (Conduit) Seal Surface	89^{o}
47	Pene. H (Conduit) Control Cable (b)	91^{o}
48	Pene. H (Conduit) Instrument Cable (c)	93^{o}
49	Pene. H (Conduit) Seal Interface	92^{o}
50	Pene. G (Conduit) Seal Surface	91^{o}
51	Pene. G (Conduit) Control Cable (b)	85^{o}
52	Pene. G (Conduit) Instrument Cable (c)	91^{o}
53	Pene. G (Conduit) Seal Interface	87^{o}

F.) FURNACE:

The furnace used for this test measures approximately 4' X 4' at its support points. The furnace atmosphere is controlled by 4 self-igniting burners which burn natural gas and operate in unison. The burners are automatically controlled from the control room. As the furnace atmosphere temperatures are monitored in the control room, automatic adjustments can be made to account for varying amounts of fuel contribution throughout the test.

The furnace atmosphere temperatures are monitored by three thermocouples located 12" below the test slab. These temperatures are individually printed on a strip chart and automatically averaged and compared to the ASTM E119 time/temperature curve by computer.

The furnace draft was controlled during the test to an average pressure of approximately negative .08" water throughout the test. Due to adjustments of fuel and draft during the test (in order to follow the ASTM E119 time/temperature curve), brief periods of positive pressure were introduced into the furnace.

G.) TEST RECORD:

The fire test was conducted for 3 hours in accordance with the ASTM E119 time/temperature curve. Throughout the test, an even blanket of flame covered the plan area of the furnace. All combustible materials located on the exposed surface of the slab (ie, cable jacketing material) quickly ignited and continued to char for the duration of the test.

Three (3) separate hose stream tests were conducted on the specimen upon conclusion of the 3 hour fire test. Water did not project from the unexposed surface of the seals during any of the 24 second long exposures, except on Penetration G, where water did pass through the premade 1/4" through crack in the CT Gypsum during the third and final hose stream test (ASTM E119 Solid Hose Stream). Penetration G did pass the first two hose stream tests (IEEE-634 and ANI). The hose stream tests conducted were as follows:

a.) IEEE-634: 75 psi hose stream delivered through a 1-1/2" hose equipped with a fog nozzle set at a discharge angle of 30° from a distance of 10 feet.

b.) ANI: Same as above except that the nozzle was set at a discharge angle of 15°.

c.) ASTM E119: 30 psi solid stream delivered through a 2-1/2" hose equipped with a 1-1/8" tip set on a playpipe from a distance of 20 feet.

H.) TEMPERATURE DATA:

The following sheets identify both complete furnace atmosphere and unexposed surface temperatures throughout the 3 hour fire test.

CR5549 - TRANSCO TR-161 - 11/20/84

TEST COMMENTS

0:10:00 LIGHT SMOKE NOTED FROM BOTTOM COUPLING IN PIPE PEN B.
0:10:00 LIGHT SMOKE NOTED FROM PIPE IN PEN G.
0:10:00 LIGHT SMOKE NOTED FROM PIPE IN PEN H.
0:10:00 BUBBLING LIQUID NOTED AT COUPLING IN PIPE IN PEN G.
0:15:00 LIGHT SMOKE NOTED FROM TOP OF PIPE IN PEN F.
0:15:00 LIGHT SMOKE NOTED FROM 2 ND COUPLING IN PEN B.
0:20:00 LIGHT SMOKE NOTED IN GAP IN PEN G.
0:22:00 LIGHT SMOKE NOTED FROM BOTTOM COUPLING IN PEN B.
0:50:00 SMOKE NO LONGER NOTED FROM TEST PENS.
1:05:00 WATER NOTED ALONG OUTER SIDES OF THE 30 X 30 OPENING

HOSE STREAM TESTS:
NO WATER PROJECTED BEYOND THE UNEXPOSED SURFACE DURING IEEE-634 HOSE STREAM TEST FOR 24 SEC. IN ALL PEN.
NO WATER PROJECTED BEYOND THE UNEXPOSED SURFACE DURING ANI HOSE STREAM TEST FOR 24 SEC. IN ALL PEN.
NO WATER PROJECTED BEYOND THE UNEXPOSED SURFACE DURING ASTM E-119 HOSE STREAM TEST FOR 24 SEC IN ALL PEN. EXCEPT IN PEN. G WHERE WATER DID PROJECT BEYOND THE UNEXPOSED SURFACE THROUGH THE PREMADE GAP.

NOTES:
DRAFT RUN AT .08 NEG.

CR5549 - TRANSCO TR-161 - 11/20/84

FURNACE ATMOSPHERE TEMPERATURE (DEG. F)

TEST TIME, Hr:Min	FURNACE TEMP. F	ASTM E119 TEMP. F	VARIATION FROM ASTM TEMP. F
0:00	76	68	8
0:05	1003	1000	3
0:10	1333	1300	33
0:15	1385	1399	-14
0:20	1460	1462	-2
0:25	1504	1510	-6
0:30	1547	1550	-3
0:35	1576	1584	-8
0:40	1604	1613	-9
0:45	1640	1638	2
0:50	1669	1661	8
0:55	1683	1681	2
1:00	1683	1700	-17
1:05	1807	1718	89
1:10	1728	1735	-7
1:15	1735	1750	-15
1:20	1772	1765	7
1:25	1782	1779	3
1:30	1936	1792	144
1:35	1799	1804	-5
1:40	1812	1815	-3
1:45	1824	1826	-2
1:50	1835	1835	0
1:55	1842	1843	-1
2:00	1848	1850	-2
2:10	1860	1862	-2
2:20	1874	1875	-1
2:30	1874	1888	-14
2:40	1890	1900	-10
2:50	1911	1912	-1
3:00	1914	1925	-11

AREA UNDER CURVE= 295275 DEG. F-MINUTES
AREA UNDER ASTM E119 CURVE= 294600 DEG. F-MINUTES
VARIATION FROM ASTM CURVE= 00.2291 %

CR5549 - TRANSCO TR-161 - 11/20/84
THERMOCOUPLE REFERENCE CHART

FRAME NO.	PRINT NO.	THERMOCOUPLE NO.	THERMOCOUPLE LOCATION
9	1	1	PEN H Seal Surface Over Crack Area
9	2	2	PEN H Seal Surface
9	3	3	PEN H Conduit/Seal Exit Interface
9	5	4	PEN H Seal Interface
9	6	5	PEN G Seal Surface
9	7	6	PEN G Seal Surface
9	8	7	PEN G ½" Wide CT Gypsum Crack
9	9	8	PEN G Conduit/Seal Exit Interface
9	10	9	PEN G Seal Interface
11	1	10	PEN E Seal Surface
11	2	11	PEN E Power Cable (a)
11	3	12	PEN E Control Cable (b)
11	4	13	PEN E Instrument Cable (c)
11	5	14	PEN E Seal Interface
11	6	15	PEN E Conduit/Slab Exit Interface
11	7	16	PEN F Seal Surface
11	8	17	PEN F Power Cable (a)
11	9	18	PEN F Control Cable (b)
11	10	19	PEN F Instrument Cable (c)
11	11	20	PEN F Seal Interface
11	12	21	PEN F Conduit/Slab Exit Interface
12	1	22	PEN C Seal Surface
12	2	23	PEN C Power Cable (a)
12	3	24	PEN C Control Cable (b)
12	4	25	PEN C Instrument Cable (c)
12	5	26	PEN C Seal Interface
12	6	27	PEN C Conduit/Slab Exit Interface
12	7	28	PEN D Seal Surface
12	8	29	PEN D Power Cable (a)
12	9	30	PEN D Control Cable (b)
12	10	31	PEN D Instrument Cable (c)
12	11	32	PEN D Seal Interface
12	12	33	PEN D Conduit/Slab Exit Interface
13	1	34	PEN B Seal Surface
13	2	35	PEN B Power Cable (a)
13	3	36	PEN B Control Cable (b)
13	4	37	PEN B Instrument Cable (c)
13	5	38	PEN B Seal Interface
13	6	39	PEN B Conduit/Slab Exit Interface
13	7	40	PEN A Seal Surface
13	8	41	PEN A Power Cable (a)
13	9	42	PEN A Control Cable (b)

13	10	43	PEN A Instrument Cable (c)
13	11	44	PEN A Seal Interface
13	12	45	PEN A Conduit/Slab Exit Interface
14	1	46	PEN H (Conduit) Seal Surface
14	2	47	PEN H (Conduit) Control Cable (b)
14	3	48	PEN H (Conduit) Instrument Cable (c)
14	4	49	PEN H (Conduit) Seal Interface
14	5	50	PEN G (Conduit) Seal Surface
14	6	51	PEN G (Conduit) Control Cable (b)
14	7	52	PEN G (Conduit) Instrument Cable (c)
14	8	53	PEN G (Conduit) Seal Interface

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	1	2	3	4	5	6
0:00	74	74	75	78	70	71
0:05	74	74	99	78	70	71
0:10	75	74	204	79	70	71
0:15	125	100	210	98	70	71
0:20	140	122	211	106	70	71
0:25	143	129	202	112	70	71
0:30	108	91	195	86	70	71
0:35	98	83	194	83	70	71
0:40	91	79	194	80	70	71
0:45	88	77	196	80	70	71
0:50	88	76	200	80	70	71
0:55	100	78	204	82	70	71
1:00	91	78	207	81	70	72
1:05	122	85	209	89	70	72
1:10	110	95	209	91	70	73
1:15	99	82	209	88	70	74
1:20	96	81	209	93	70	74
1:25	97	82	210	95	71	75
1:30	89	79	211	96	71	77
1:35	85	76	212	97	71	78
1:40	82	79	214	97	71	79
1:45	81	77	214	100	72	81
1:50	80	77	217	101	72	83
1:55	80	77	218	101	72	85
2:00	79	77	219	102	73	88
2:10	79	82	224	107	74	93
2:20	80	87	230	110	75	99
2:30	81	90	236	113	76	104
2:40	82	92	248	116	78	109
2:50	83	94	259	118	79	114
3:00	84	96	272	120	81	118

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	7	8	9	10	11	12
0:00	66	74	74	73	75	74
0:05	66	75	75	73	75	74
0:10	65	87	75	73	75	74
0:15	66	140	75	73	75	74
0:20	67	149	75	73	75	74
0:25	67	149	75	73	76	75
0:30	66	154	74	73	76	74
0:35	66	168	74	74	77	75
0:40	67	169	74	74	78	75
0:45	67	171	74	74	79	76
0:50	67	173	74	75	81	77
0:55	67	175	75	76	83	77
1:00	67	176	75	77	86	79
1:05	67	178	75	79	89	80
1:10	68	179	76	80	91	81
1:15	68	179	76	82	94	83
1:20	68	177	77	84	97	85
1:25	69	178	77	86	100	88
1:30	69	178	78	88	104	90
1:35	69	180	79	91	107	92
1:40	69	181	80	94	111	95
1:45	70	183	81	97	113	99
1:50	71	184	82	100	117	102
1:55	70	186	83	103	121	104
2:00	71	187	84	105	124	106
2:10	73	191	87	110	131	112
2:20	74	194	89	115	138	117
2:30	75	199	92	119	145	121
2:40	76	201	95	123	150	126
2:50	78	203	98	126	155	129
3:00	80	205	101	129	159	133

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	13	14	15	16	17	18
0:00	74	74	78	74	74	74
0:05	74	75	78	74	74	74
0:10	74	75	80	74	74	74
0:15	75	75	84	74	74	74
0:20	75	75	87	74	74	74
0:25	75	75	92	74	74	74
0:30	75	76	97	74	74	74
0:35	76	76	103	74	74	74
0:40	76	77	110	75	74	74
0:45	77	78	118	74	74	74
0:50	77	79	126	75	75	74
0:55	78	80	132	75	75	75
1:00	79	82	136	75	75	75
1:05	81	84	140	75	75	75
1:10	82	86	144	75	75	75
1:15	83	88	146	75	76	75
1:20	85	90	149	75	76	75
1:25	87	93	155	76	77	76
1:30	89	96	158	76	77	76
1:35	90	97	162	76	77	76
1:40	93	100	169	77	78	77
1:45	96	104	175	77	79	77
1:50	99	108	180	78	80	78
1:55	100	111	183	78	80	78
2:00	102	112	185	78	80	79
2:10	107	120	194	80	82	80
2:20	110	123	203	81	84	82
2:30	113	126	208	82	86	83
2:40	117	130	217	84	88	85
2:50	117	132	218	86	89	86
3:00	120	135	227	88	92	88

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	19	20	21	22	23	24
0:00	74	73	77	72	72	72
0:05	74	73	78	72	72	72
0:10	74	74	79	72	72	72
0:15	74	74	83	72	72	72
0:20	74	74	84	72	72	72
0:25	74	75	87	72	72	72
0:30	74	75	91	72	72	72
0:35	74	76	100	73	72	72
0:40	74	76	111	73	72	72
0:45	74	76	120	73	73	72
0:50	74	76	125	73	73	73
0:55	75	77	130	73	73	73
1:00	75	77	134	74	73	73
1:05	75	77	139	74	74	73
1:10	75	78	144	74	74	73
1:15	75	78	147	75	74	74
1:20	76	78	154	75	74	74
1:25	76	79	161	76	75	74
1:30	77	79	166	76	76	75
1:35	77	79	168	77	76	75
1:40	77	78	173	78	77	75
1:45	78	78	177	78	77	76
1:50	79	77	180	79	78	77
1:55	79	78	185	80	79	77
2:00	79	76	188	80	79	77
2:10	81	76	196	82	81	79
2:20	82	77	202	84	83	80
2:30	84	77	207	86	86	82
2:40	85	78	213	89	89	84
2:50	86	78	223	91	92	87
3:00	88	79	230	93	94	88

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	25	26	27	28	29	30
0:00	73	72	77	73	73	73
0:05	73	72	79	73	73	73
0:10	73	72	84	73	73	73
0:15	73	72	85	73	73	73
0:20	73	72	88	73	73	73
0:25	73	72	89	73	73	73
0:30	73	73	91	73	73	73
0:35	74	73	96	74	73	73
0:40	74	73	102	74	73	73
0:45	74	73	110	73	73	73
0:50	74	73	118	74	73	73
0:55	74	73	126	73	74	73
1:00	74	74	131	76	74	73
1:05	74	74	135	74	74	73
1:10	74	74	140	75	75	73
1:15	75	75	146	75	75	74
1:20	75	75	149	76	76	74
1:25	75	75	154	76	76	74
1:30	76	76	160	76	77	75
1:35	76	76	165	76	77	75
1:40	77	77	171	80	78	76
1:45	78	77	176	84	80	76
1:50	79	78	180	82	81	77
1:55	79	78	185	81	82	78
2:00	79	78	189	80	83	78
2:10	81	80	192	86	85	80
2:20	84	82	200	88	88	82
2:30	86	83	211	86	91	84
2:40	88	85	215	87	95	87
2:50	90	87	225	87	98	89
3:00	93	89	234	89	101	92

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	31	32	33	34	35	36
0:00	72	71	78	71	73	72
0:05	72	72	78	72	73	72
0:10	72	72	79	72	73	72
0:15	72	72	83	71	73	72
0:20	72	72	90	71	73	72
0:25	72	72	97	71	73	72
0:30	72	72	104	71	73	72
0:35	72	71	111	72	73	72
0:40	72	72	123	72	74	73
0:45	72	71	133	72	74	73
0:50	72	72	145	72	74	73
0:55	72	72	152	73	75	74
1:00	72	72	157	74	77	75
1:05	72	72	161	74	78	75
1:10	72	72	164	76	80	77
1:15	72	72	166	77	82	78
1:20	73	72	168	79	85	79
1:25	73	73	170	80	87	81
1:30	73	73	173	82	89	83
1:35	73	73	179	83	91	84
1:40	74	74	184	84	93	85
1:45	75	75	190	85	95	86
1:50	75	75	192	87	97	88
1:55	76	75	193	87	99	89
2:00	76	75	196	88	101	90
2:10	78	77	202	90	104	92
2:20	80	79	208	93	108	95
2:30	82	81	216	96	112	98
2:40	84	83	225	98	115	100
2:50	86	84	234	100	118	102
3:00	88	86	241	102	120	104

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	37	38	39	40	41	42
0:00	72	72	78	73	74	73
0:05	73	72	78	73	74	73
0:10	73	72	78	73	74	73
0:15	73	72	80	73	74	73
0:20	73	72	94	73	74	73
0:25	73	72	101	73	74	73
0:30	73	72	104	73	74	73
0:35	73	73	106	73	74	73
0:40	74	73	116	74	75	74
0:45	74	73	128	74	75	73
0:50	74	73	129	75	76	74
0:55	75	74	135	75	77	74
1:00	76	75	140	76	78	74
1:05	77	75	142	76	79	75
1:10	78	77	144	77	80	75
1:15	79	78	143	78	82	76
1:20	81	80	148	79	83	76
1:25	82	81	147	80	85	77
1:30	84	83	149	81	86	78
1:35	85	84	151	82	88	78
1:40	87	86	152	83	89	80
1:45	88	87	144	85	91	81
1:50	89	88	156	87	94	82
1:55	91	88	154	87	97	83
2:00	92	90	159	90	99	85
2:10	95	92	150	93	104	89
2:20	98	94	151	97	109	93
2:30	100	97	164	100	113	95
2:40	101	99	169	104	117	98
2:50	102	101	165	105	121	101
3:00	104	102	166	107	125	103

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.					
	43	44	45	46	47	48
0:00	73	71	79	72	72	73
0:05	73	73	79	72	72	73
0:10	73	73	80	72	72	73
0:15	73	73	83	72	72	73
0:20	73	74	88	73	73	74
0:25	73	74	95	73	73	75
0:30	73	74	102	73	74	76
0:35	73	74	108	74	75	77
0:40	74	75	120	75	76	78
0:45	74	75	127	74	76	79
0:50	74	75	137	76	77	79
0:55	75	76	145	76	78	80
1:00	75	76	150	76	78	80
1:05	76	77	151	76	78	81
1:10	76	77	152	76	78	81
1:15	77	78	156	79	79	81
1:20	78	78	158	78	79	82
1:25	79	79	160	77	80	82
1:30	79	80	164	78	80	83
1:35	80	80	169	79	81	83
1:40	82	81	172	80	82	84
1:45	84	83	178	83	83	85
1:50	86	85	180	82	84	86
1:55	88	86	182	80	84	87
2:00	89	87	188	82	84	87
2:10	93	90	194	83	86	88
2:20	96	94	199	87	87	90
2:30	99	98	207	87	88	91
2:40	101	101	215	89	90	92
2:50	103	103	222	88	90	92
3:00	106	106	230	89	91	93

CR5549 - TRANSCO TR-161 - 11/20/84

TEST SPECIMEN THERMOCOUPLE READINGS (DEG. F)

TEST TIME, Hr:Min	T/C NO.				
	49	50	51	52	53
0:00	72	73	76	73	73
0:05	73	74	76	73	73
0:10	73	74	76	74	73
0:15	73	74	76	74	73
0:20	73	74	76	74	73
0:25	74	74	76	74	74
0:30	75	74	76	74	73
0:35	76	74	76	74	74
0:40	77	75	76	75	74
0:45	78	75	77	75	74
0:50	79	76	77	76	75
0:55	79	77	77	77	75
1:00	80	77	78	78	76
1:05	80	78	78	79	76
1:10	80	79	79	80	77
1:15	81	80	79	81	78
1:20	81	81	80	81	79
1:25	81	82	80	82	79
1:30	82	82	81	83	79
1:35	82	83	81	83	79
1:40	83	83	81	84	81
1:45	84	84	81	85	82
1:50	85	85	82	86	83
1:55	86	86	82	86	82
2:00	86	86	82	86	82
2:10	87	86	82	87	83
2:20	88	87	83	88	85
2:30	90	88	83	89	86
2:40	91	89	84	89	86
2:50	91	90	84	90	87
3:00	92	91	85	91	87

TRANSCO INC.
55 East Jackson
Chicago, IL 60604

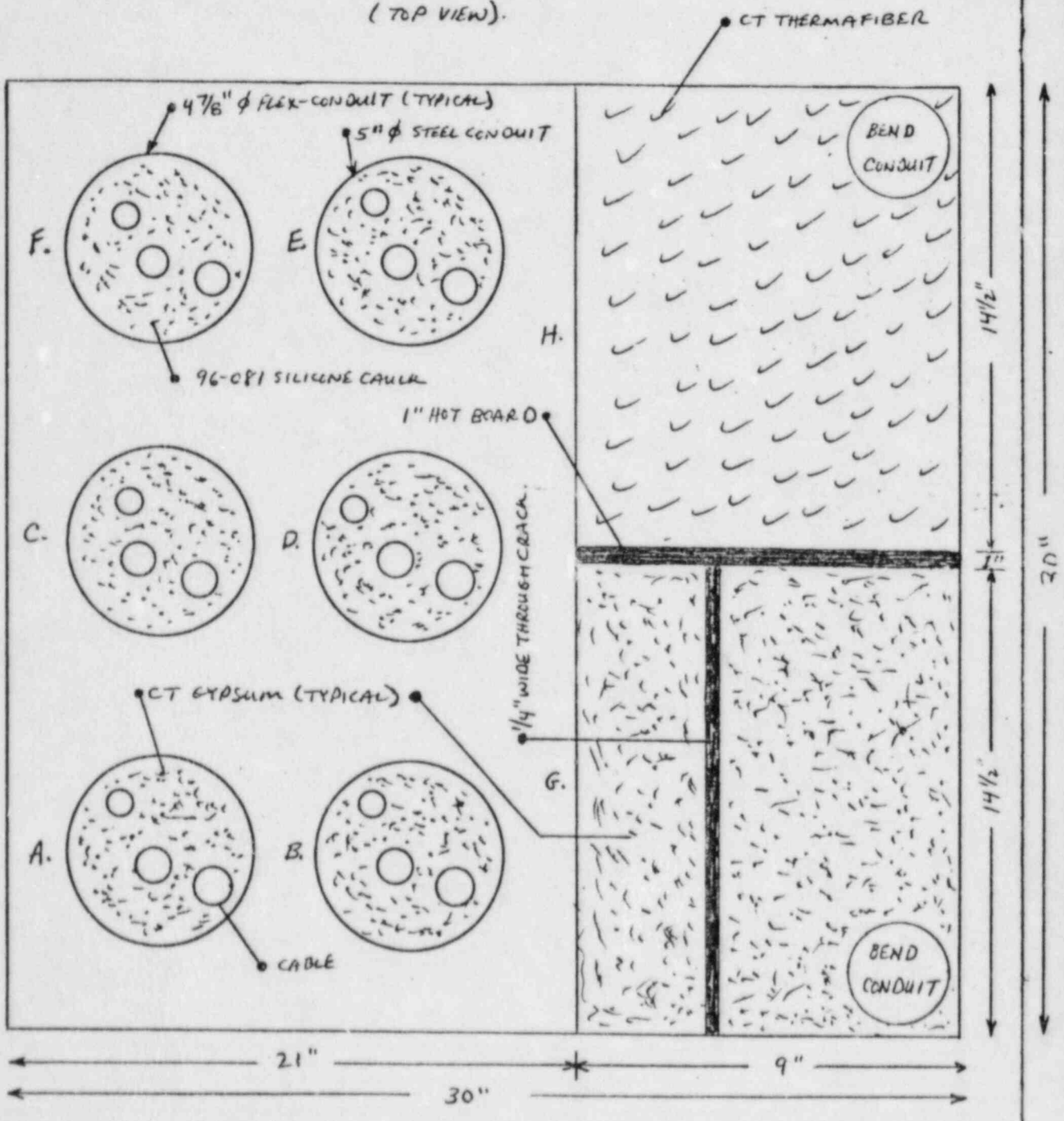
DEPT. _____ JOB NO. _____ SHEET 1 OF APPX.

BID NO. _____ DATE _____

SUBJECT: FLOOR FIRE TEST, TR-161 BY _____

CHKD _____

FLOOR SLAB
(TOP VIEW).



TRANSCO INC.
55 East Jackson
Chicago, IL 60604

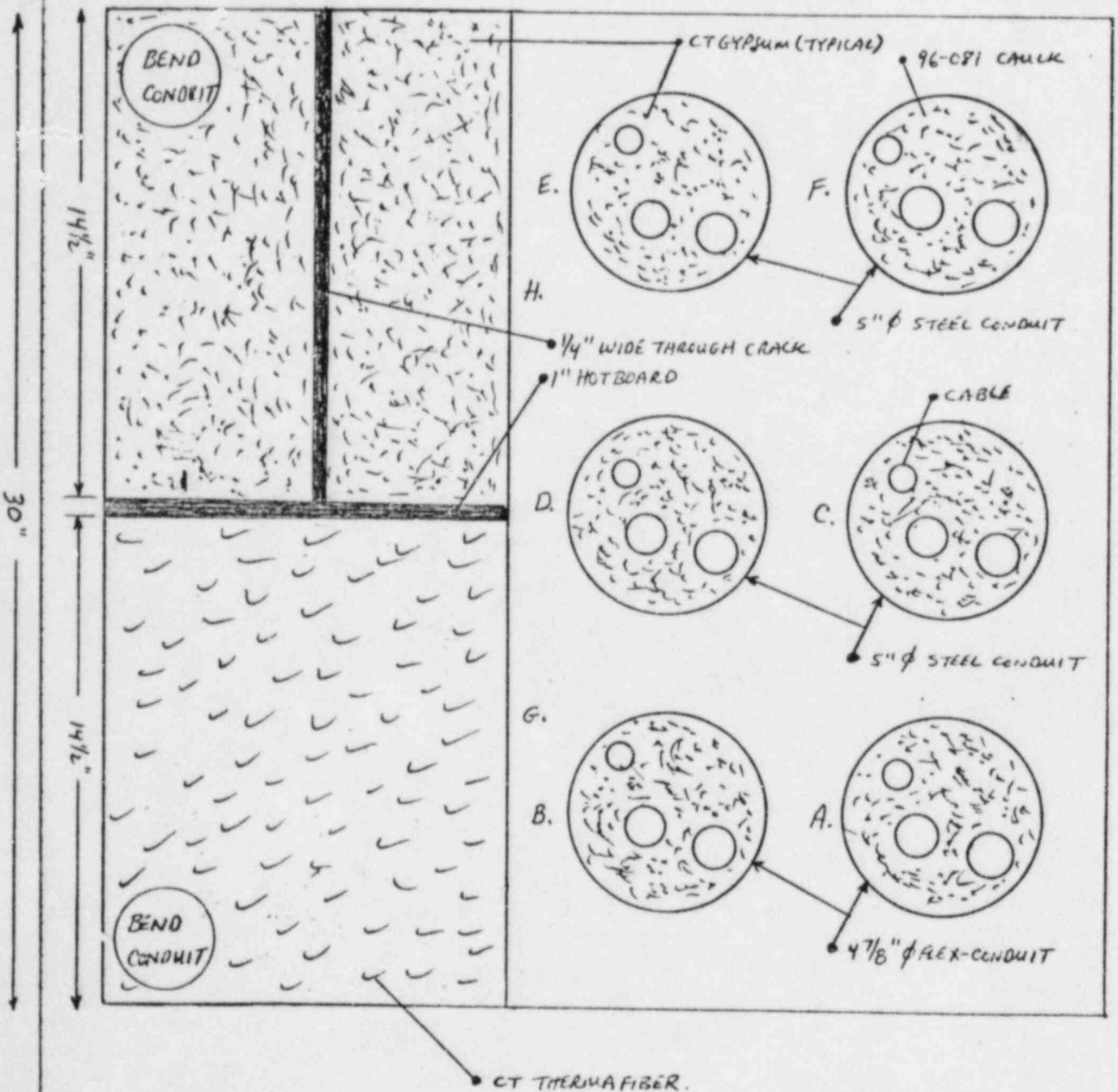
DEPT. _____ JOB NO. _____ SHEET 2 OF APPX.

BID NO. _____ DATE _____

SUBJECT: FLOOR FIRE TEST, TR-161 BY tgl

CHKD _____

FLOOR SLAB.
(BOTTOM VIEW)



TRANSCO PRODUCTS INC.
55 East Jackson
Chicago, IL 60604

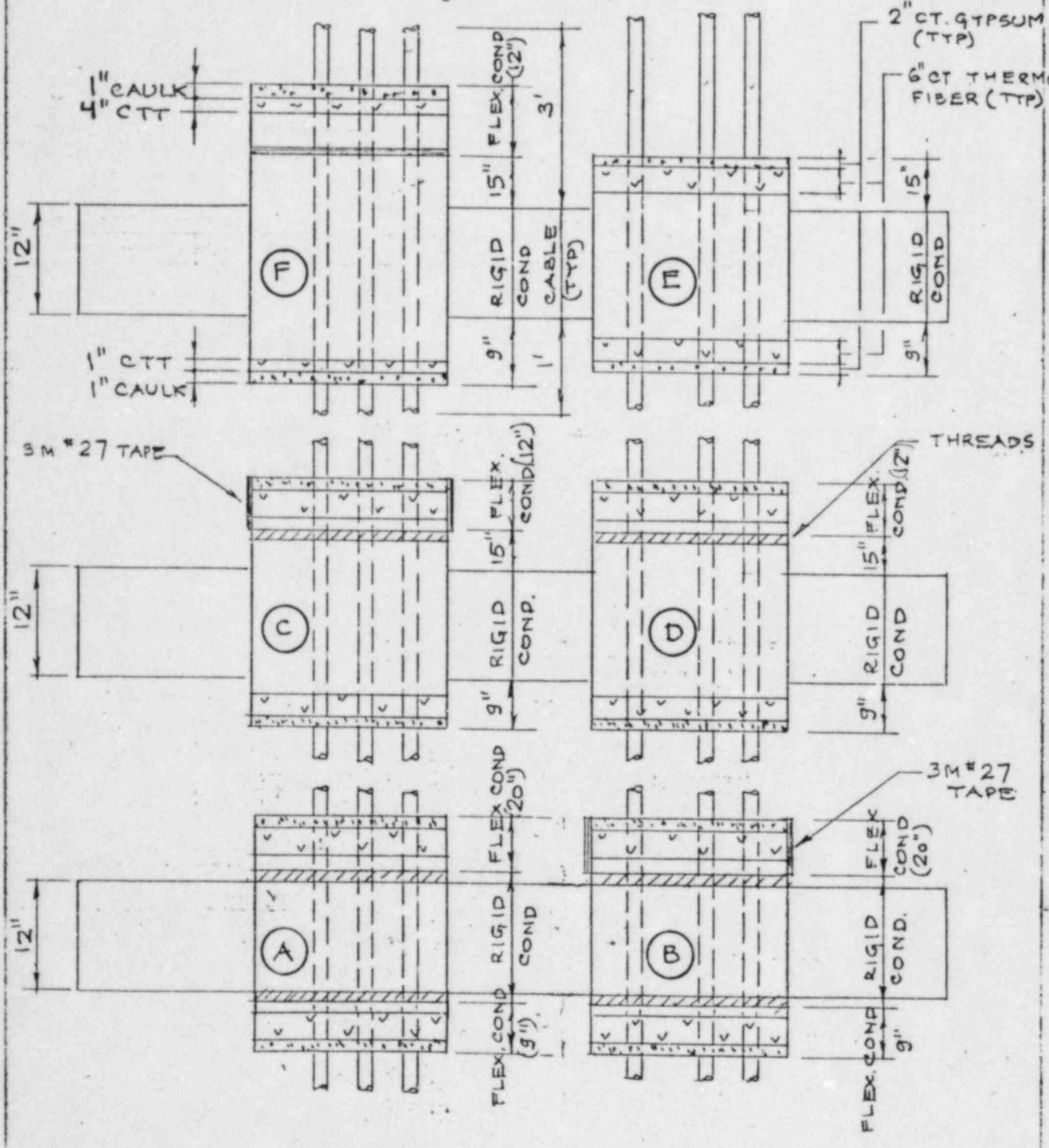
DEPT. _____ JOB NO. _____ SHEET 3 OF APPX.

BID NO. _____ DATE _____

SUBJECT: FLOOR FIRE TEST, TR-161 BY M.G

CHKD _____

FLOOR SLAB
(SECTION)



TRANSCO INC.
55 East Jackson
Chicago, IL 60604

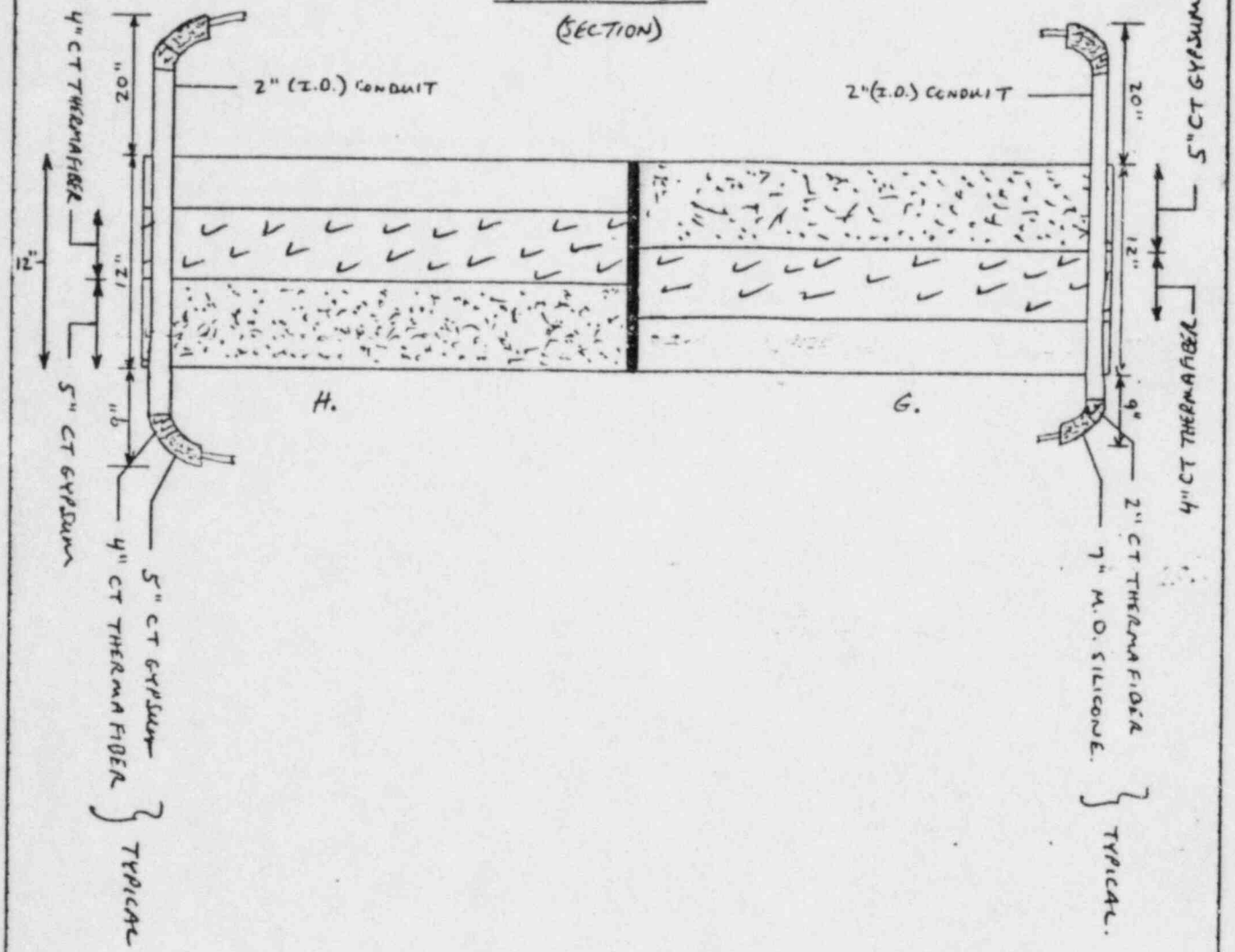
DEPT. _____ JOB NO. _____ SHEET 4 OF APPX.

BID NO. _____ DATE _____

SUBJECT: FLOOR FIRE TEST, TR-161 BY tyl

CHKD _____

FLOOR SLAB
(SECTION)



M&M Protection Consultants

A Technical Service of Marsh & McLennan

December 10, 1984

Mr. D. Elias
Commonwealth Edison Company
P. O. Box 767
Chicago, IL 60690

Re: TRANSCO PRODUCTS, INC.
FIRE TEST REPORTS
NOS. TR-159 AND TR-161

Dear Mr. Elias:

A fire test was conducted on November 14, 1984 on simulated electrical openings in a wall assembly, and on November 20, 1984 on simulated electrical openings in a floor assembly. The tests were conducted for the purposes of qualifying the fire barrier penetration seals in accordance with the IEEE-634 Standard. The fire tests were witnessed by M&MPC representatives and preliminary copies of the captioned reports were reviewed in accordance with IEEE-634 Standard acceptance criteria. We find the fire tests satisfactorily meet the IEEE-634 test acceptance criteria, except as indicated below. A final review and comment on the certified test reports will be provided when the reports are submitted.

TEST REPORT TR-159

This test report describes a three hour fire and subsequent hose stream test for a wall assembly using Transco No. TCO-001 Cement (US Gypsum fire code CT Gypsum cement). The test slab measured 48"x 48"x12" thick. A total of nine, 5" diameter steel conduits were installed within the test slab. As a result of our review of this test and test report we find that penetrations A, C, E, G, H and I satisfactorily meet the acceptance criteria. Penetrations B, F and D meet the acceptance criteria to the extent that the penetration seals did not allow the passage of hot gases or flames through the barrier or the burning of cable installations on the unexposed side. Penetrations B, F and D, did not satisfactorily pass the temperature criteria for conductor temperatures on the unexposed surface.

The IEEE-634 hose stream test, ANI hose stream test and solid hose test was conducted on all penetrations with satisfactory results.

In summary, the test results show that the installation of 2" of CT gypsum with 6" CT thermafibre is not an acceptable installation where the seal is applied at the wall. The test does show that the fire penetration seal configuration of 2" of gypsum and 6" of CT thermafibre is acceptable for conduit end seals, where both ends of the conduit are sealed with the same configuration.

TEST REPORT NO. TR-161

We find penetrations A through F acceptable throughout the Byron plant in both 3-hour floor assemblies as well as 3-hour fire walls. These penetrations performed in an acceptable manner in the configurations tested.

Penetrations G and H have passed the temperature criteria on the unexposed side as well as the IEEE-634 hose stream test and the ANI hose stream test. However, when the solid stream test was performed on these seals, penetration G did project water on the unexposed side and penetration H experienced a slight bulging of the seal. It should not be used in an area (such as: Fuel Handling Building) where solid stream hose nozzles are present.

Penetrations G and H both contained a 2" conduit. Conduit end seals were provided in each penetration. Penetration G contained 7" of silicone foam and 2" of CT thermafibre. Conduit H contained 5" of gypsum and 4" of CT thermafibre. Both penetration conduits contained a bend with no straight sections. The seals within the conduit were placed within the bend area.

We would not recommend that penetration assemblies utilized in the plant be of any other configuration that would be larger or with less sealant material than tested within these fire tests. In areas of the plant where the configuration using 2" of gypsum and 6" of CT thermafibre is applied at the wall, we would recommend the necessary repairs as tested be implemented. Acceptable repairs would be to install either an additional 4 inches of thermafibre or apply the acceptable floor penetration seal configuration consisting of 5" of CT gypsum and 4 inches of CT thermafibre.

Should you have any further questions regarding our comments, please let me know.

Very truly yours,

R. J. Smith Jr. /lw.

R. J. Smith, Jr.
Fire Protection Consultant

RJS/lw

cc: K. A. Ainger
R. C. Ward
C. Diaz
S. J. Chingo
N. F. Malicki
J. Mahavolich
J. D. Deress

M&M Protection Consultants
Technical Service of Marsh & McLennan

December 13, 1984

Mr. D. Elias
Station Nuclear Engineering Department
Commonwealth Edison Company
P. O. Box 767
Chicago, IL 60690

Re: CONSTRUCTION TECHNICAL LABORATORIES
CERTIFIED TEST REPORTS FOR
TRANSCO PRODUCTS INC.
FIRE TESTS NOS. TR159 AND TR161

Dear Mr. Elias:

This is to confirm our review and receipt of the Construction Technical Laroratories certification of the fire tests conducted for Transco Products Inc., report numbers TR159 and TR161 conducted on November 14, 1984 and November 20, 1984 respectively. Based upon our review, we conclude that the fire tests were conducted in accordance with the IEEE-634 Standard and satisfactorily meet the IEEE-634 Standard acceptance criteria as detailed in my letter of December 10, 1984.

Should you have any further questions regarding the fire tests or our review, please let me know.

Very truly yours,

R. J. Smith, Jr. /lw

R. J. Smith, Jr
Fire Protection Consultant

RJS/lw

cc: K. A. Ainger
R. C. Ward
C. J. Diaz
S. J. Chingo
N. F. Malicki
J. Mihovilovich
J. D. Deress

222 South Riverside Plaza, Chicago, Illinois 60606, Telephone 312 648-6000

M&M Protection Consultants
A Technical Service of Marsh & McLennan

April 30, 1985

Mr. D. Elias
Project Engineer
Commonwealth Edison Company
P. O. Box 767
Chicago, Illinois 60690

Re: Transco Fire Tests TR159 & TR161
"Crack Criteria"

Dear Mr. Elias:

As a result of our witnessing and review of the above referenced fire tests and corresponding fire test report, we recommend the existing inspection "crack criteria" for the Transco Products, Inc. fire penetration seal configurations consisting of combination CT gypsum and CT thermafiber as tested, may be expanded as follows:

Crack Dimensions	Action To Be Taken
Initial Acceptance Inspection*	
1. Cracks less than three thirty-seconds of an inch (3/32") in width.	No further action necessary.
2. Cracks three thirty-seconds of an inch (3/32") or greater in width.	Seal not acceptable for initial acceptance - Repair per Transco Products, Inc. fire penetration seal repair procedures.
Seal Surveillance Criteria**	
1. Cracks less than five thirty-seconds of an inch (5/32") in width.	No immediate repairs required. Seal is considered operable.*** Seal should be placed on the surveillances or monitoring of crack to ensure crack is periodically surveyed and measured for expansion.

* "Initial Acceptance Inspection" refers to the contractors' final inspection of the penetration seal prior to turnover to Station (CECo).

** Seal Surveillance Criteria refers to station's regular seal inspection program per station procedure requirements.

*** Reference to "Operable Seal" indicates seal integrity has not been jeopardized and remains a functioning rated fire penetration seal as tested in the Qualification Fire test.

Crack Dimensions	Action To Be Taken
2. Cracks greater than or equal to five thirty-seconds of an inch (5/32") and less than one-quarter of an inch (1/4") in width.	Seal is considered operable, however, placed on a repair schedule to be repaired per the Transco Product, Inc. seal repair procedures.
3. Cracks greater than or equal to one-quarter of an inch in width.	Seal considered inoperable.* Necessary repairs should be made and normal station procedures should dictate necessary action for inoperable seals.

On March 29, 1985 a meeting was held at the Braidwood Station construction site to discuss the crack criteria as previously described. In addition to the aforementioned criteria recommended by M&MPC to the attendees, the following briefly summarizes the meeting events.

1. A summary of the purpose of the meeting and brief history regarding the subject of cracks within the CT gypsum material was provided by T. Thornley (S&L), and T. Hoff (Transco Products, Inc.). Mr. H. Massin (CECo-SNED) also provided input with respect to some of the history to the crack subject regarding the discussions for the LaSalle County Station with the NRC.

2. It was agreed to that within the Transco procedures and CECo procedures there will be no attempt to differentiate between the previously identified types of "cracks" such as hairline cracks, surface cracks, or through cracks. The procedures will address "cracks" to apply to all situations.

3. A discussion regarding the applicability of applying an acceptance criteria limiting the length of the crack and possibly the overall surface area of the crack based upon the ratio between the crack tested compared to the seal configuration dimensions was discussed. It was concluded at this time this criteria was not be applied to the acceptance or surveillance of the penetration seals.

4. The aforementioned acceptance criteria recommended by M&MPC would be applied to the Braidwood site only at the present time. No immediate action would be taken at the LaSalle County Station and

* Reference to "inoperable" seal indicates that seal no longer remains a functioning fire penetration seal as tested and requires appropriate repairs or replacement.

Byron Station Unit 2, with respect to the contractors' final inspections. It was felt that Byron Station personnel did not want to change the acceptance criteria from that which was previously applied to the Unit 1 and common areas fire penetration seals. A decision regarding the Byron Station 18-month surveillance procedure criteria will be determined at a later date.

5. CECo-SNED will determine whether this "crack criteria" presented, with supporting fire tests, will be submitted to the NRC for their concurrence.

6. During the meeting, Transco confirmed that with the exception of conduit end-seals, all seal configurations at the three sites will use a fire penetration seal configuration consisting of a minimum five inches (5") of CT gypsum with four inches (4") of CT thermafiber.

7. Based upon M&MPC's review of the fire tests conducted and test results which successfully tested a seal configuration with a crack (Test Report 161) the recommended crack criteria is applicable to all areas of the plants, except where solid stream hose nozzles are provided (i.e., refuel floor) with the seal installed in a configuration such that the CT thermafiber is installed in a direction exposed to the area in which the solid stream hose nozzles are provided. With the exception of this situation, the "crack criteria" proposed can be applied to the referenced fire penetration seal configuration in all other areas.

This concludes the summary of items discussed during this meeting. By copy of this letter, meeting attendees are requested to advise this writer if the information provided does not accurately reflect and summarize the discussions. Should you have any further questions, please do not hesitate to contact me.

Very truly yours,

Robert J. Smith Jr.

R. J. Smith, Jr.
Fire Protection Consultant

RJS/pf

cc: J. Deress
C. Gray
S. Chingo
P. Hart
T. Meyer
E. McVey
H. Massin
P. Hoffman
J. Phelan
A. Nies
D. Contorno
T. Huff
C. Diaz
M. Pietraszewski
M. Smith
D. Thornley
R. Ward
M. Teras