
Annular Space Protection
of Openings Created by Penetrations
of Tubular Steel Conduit - A Review
of UL Special Services Investigation
File NC546 Project 90NK11650

Prepared by the
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ANNULAR SPACE PROTECTION OF OPENINGS CREATED BY PENETRATIONS OF TUBULAR STEEL CONDUIT A REVIEW OF UL SPECIAL SERVICES INVESTIGATION FILE NC546 PROJECT 90NK11650

PREFACE BY NEMA's STEEL CONDUIT MANUFACTURERS:

It has long been known that penetration by different materials requires different types of protection. A main consideration is the ability of the penetrating item to withstand the fire conditions without melting or burning. Steel conduit is unique in that its melting point is well above the 1850° F maximum temperature of the E 119 time-temperature curve for a 2-hour fire test; as well as the 2000° F maximum for a 4-hour test. It is not just “noncombustible.” With regard to the size of the penetrating item, the maximum electrical conduit trade size produced is 6” and only a very small percentage of conduit used is larger than 4” trade size. One-half inch and 3/4” are by far the most prevalent. Maximum penetration size is predetermined when considering electrical conduit and tubing; specifically, galvanized rigid conduit (GRC), intermediate metal conduit (IMC), and electrical metallic tubing (EMT).

There are, without doubt, many excellent “through-penetration” sealing systems on the market which are covered by other sections of the building codes. A number of these certainly can be used with steel conduit. The testing that the NEMA group sponsored at UL was to support the code recognized option of annular space filler protection and provide inspectors with confirmation of what they intuitively knew. This helps to promote full code compliance and leaves no excuse for unsealed penetrations which would compromise safety. Both types of sealing methods, annular space filler and through-penetration systems, do the job with steel conduit and tubing. The UL Special Investigation reviewed in this document covered annular space filler materials.

These tests were performed as generically as possible, using materials purchased by UL from local supply houses. Construction was representative of ordinary field practice using good workmanship as expected by the codes. These are original results with no retesting to secure a passing result.

A review of the Special Services Investigation (File NC546 Project 90NK 11650) made by Underwriters Laboratories Inc. (UL) follows:

The subject of the fire test investigation was various annular space protection materials installed in a concrete block wall, concrete floor assemblies, gypsum wallboard/wood joist/plywood deck floor-ceiling assemblies, and two variations of gypsum wallboard/steel stud wall assemblies. The purpose of the investigation was to determine if commonly available construction materials could be used as annular space protection materials in conjunction with tubular steel conduit products. The NEMA Rigid Steel Conduit and EMT Section sponsored this testing for the purpose of verifying that these combinations of products will meet the requirements contained in the following Model Building Code Sections:

- 1) BOCA National Building Code, Sec. 915.7 of the 1989 Supplement to the 1987 Code.
- 2) ICBO Uniform Building Code, Sec. 4304 (e) and (f), and Sec. 4305 (c) of the 1990 Supplement to the 1988 Code.
- 3) SBCCI Standard Building Code, Sec. 1001.3.5 of the 1989/90 Supplement to the 1988 Code.

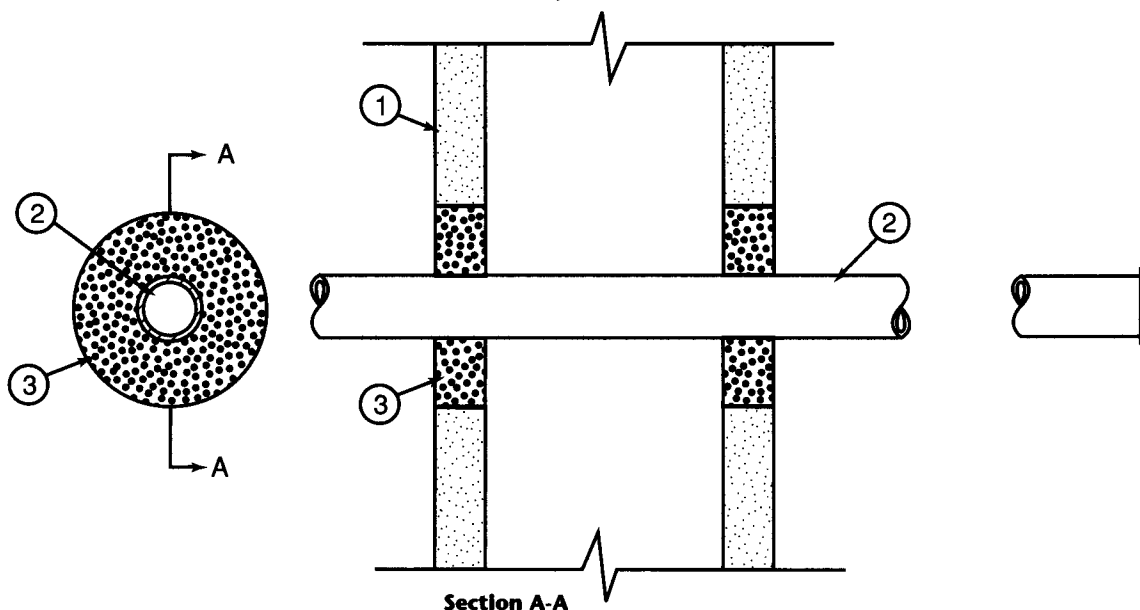
These sections of the Model Building Codes require that the annular space between a noncombustible penetrating item and the periphery of the opening in a fire resistance rated assembly be filled with a material which will prevent the passage of flames and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions of ASTM E 119 under a minimum positive pressure of 0.01 in. of water column at the location of the penetration for a time period equivalent to the required fire resistance rating of the assembly penetrated.

ALL MATERIALS TESTED PASSED AND MAINTAINED THE FIRE RESISTANCE RATING FOR THE TIME PERIOD SPECIFIED FOR THE ASSEMBLY - including joint compound used as annular space filler in a 2-hour gypsum wallboard/steel stud wall assembly.

This is excellent news and should confirm the real importance of primarily assuring an opening is closed.

Additionally, although not specifically required by the Model Building Codes, the test assemblies were subjected to the hose stream test, as specified in the Standard, "Fire Tests of Through-Penetration Firestops", ANSI/UL 1479 (ASTM E 814).

EXAMPLE OF PENETRATION OF 4 HR. CONCRETE BLOCK WALL
TEST ASSEMBLY NO. 1/TEST CONFIGURATION NO. 4



Item no.	Description
1	Nom. 8" thick Concrete Block Wall.
2	Nom. 1/2" Rigid Conduit centered in Nom. 4" opening. Conduit extended 12" & 36" beyond the exposed & unexposed surfaces, respectively. Nom. 1/8" thick steel plate welded to exposed end of conduit.
3	Nom. 2 1/8" Thickness of type M mortar installed within the annular space of both faces of block, flush with each surface of wall.

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TEST ASSEMBLY #1—4 HOUR FIRE EXPOSURE PERIOD
CONCRETE BLOCK WALL

Test Configuration No.	Opening Size	Penetrating Item(s)	Annular Space Protection Material(s)	Fire Exposure Results
1	Nominal 8 in. diameter	Nominal 4 in. diameter EMT	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
2	Nominal 8 in. diameter	Nominal 4 in. diameter rigid conduit	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
3	Nominal 6 in. diameter	Nominal 2 in. diameter EMT	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
4	Nominal 4 in. diameter	Nominal 1/2 in. diameter rigid conduit	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
5	Nominal 4 in. diameter	Nominal 1/2 in. diameter EMT	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
6	Nominal 6 in. high by 10-1/2 in. wide	Nominal 1/2, 3/4, 1-1/2, 2 and 4 in. diameter EMT, spaced 3/4 in. apart	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass
7	Nominal 6-1/2 in. high by 11 in. wide	Nominal 1/2, 3/4, 1-1/4, 2 and 4 in. diameter rigid conduit, spaced 3/4 in. apart	Nominal 2-1/8 in. thickness of Type M mortar on each side of wall.	Pass

TEST ASSEMBLIES:

4 HOUR RATED CONCRETE BLOCK WALL ASSEMBLY

The concrete block wall consisted of a 54 in. wide by 66 in. high wall constructed with nominal 8 in. thick concrete blocks having a 4 hour fire endurance rating when tested in accordance with the Standard "Fire Tests of Building Construction and Materials", ANSI/UL 263 (ASTM E119). The blocks were assembled using Type M mortar.

3 HOUR RATED CONCRETE FLOOR ASSEMBLY

The concrete floor assembly consisted of a 48 in. by 48 in. by 4-1/2 in. thick lightweight concrete slab having a 3 hour fire endurance rating.

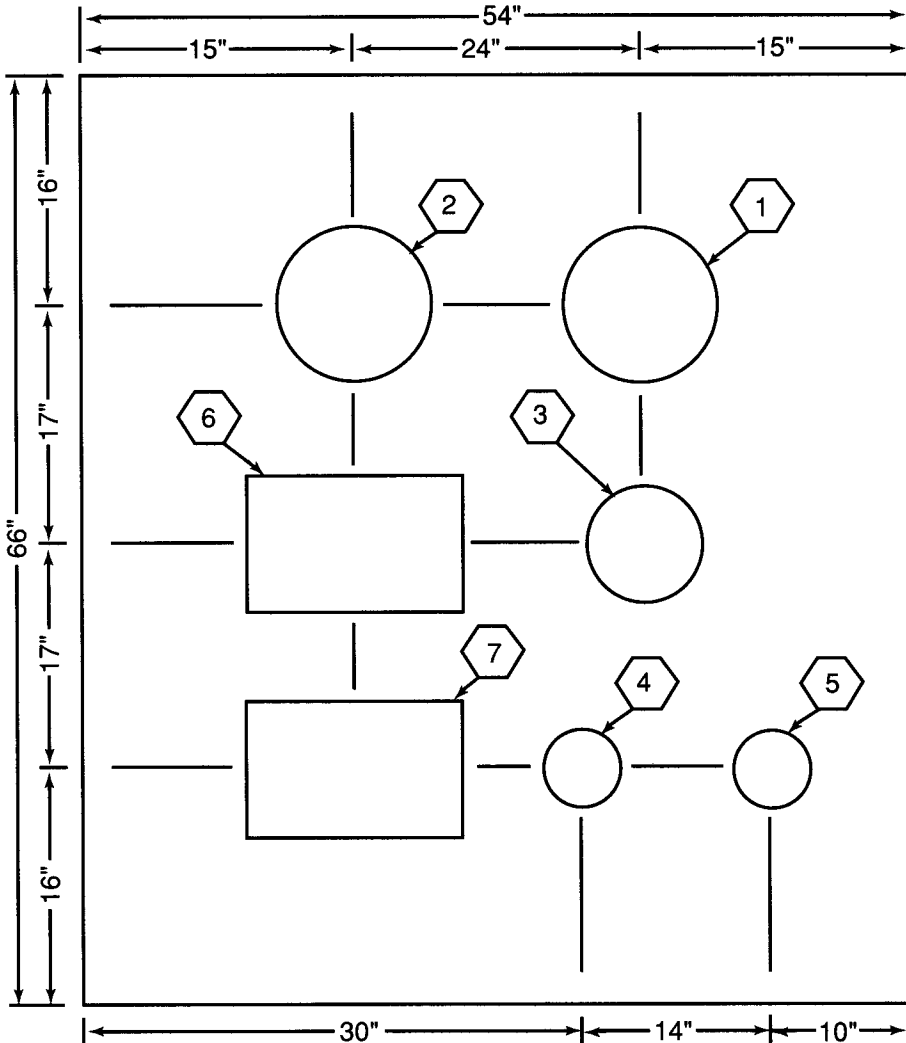
2 HOUR RATED WOOD JOIST FLOOR CEILING ASSEMBLY

The wood joist floor-ceiling assembly consisted of a 48 in. by 48 in. by 12 in. thick assembly constructed with nominal 2 in. x 10 in. wood joists protected on the ceiling side with two layers of 5/8 in. thick gypsum wallboard separated by 5/8 in. thick resilient channel and on the floor side with 3/4 in. thick plywood. The floor-ceiling assembly constructed in this manner has a 2 hour fire endurance rating.

2 HOUR RATED GYPSUM WALLBOARD/STEEL STUD WALL ASSEMBLY

The first gypsum wallboard/steel stud wall assembly consisted of nominal 52 in. wide by 62 in. high wall constructed with nominal 3-1/2 in. wide No. 25 MSG steel studs spaced 24 in. OC. The steel studs were faced with two layers of 5/8 in. thick gypsum wallboard on each side. The wall assembly constructed in this manner has a 2 hour fire endurance rating.

EXAMPLE OF A TEST ASSEMBLY CONTAINING BOTH SINGULAR AND MULTIPLE PENETRATIONS
TEST ASSEMBLY NO. 1/ CONCRETE BLOCK WALL



Test Configuration No.	Opening Size, in.	Size & type of penetrating item(s)
1	8	Nom. 4" EMT
2	8	Nom. 4" Rigid Conduit
3	4	Nom. 2" EMT
4	4	Nom. 1/2" Rigid Conduit
5	4	Nom. 1/2" EMT
6	6 x 10 1/2	Nom. 1/2", 3/4", 1 1/4", 2" + 4" EMT's
7	6 1/2 x 11	Nom. 1/2", 3/4", 1 1/4", 2" + 4" Rigid Conduits

Note: Penetrating items not shown, see individual construction drawings

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1 HOUR RATED GYPSUM WALLBOARD STEEL STUD WALL ASSEMBLY

The second gypsum wallboard/steel stud wall assembly consisted of 52 in. wide by 62 in. high wall constructed with nominal

3-1/2 in. wide No. 25 MSG steel studs spaced 24 in. OC. The steel studs were faced with one layer of 5/8 in. thick gypsum wallboard on each side. The wall assembly constructed in this manner has a 1 hour fire endurance rating.

These assemblies were then penetrated by various sizes and types of tubular steel electrical conduit and tubing.

GENERAL TEST INFORMATION

UL has determined through previous test programs that for through-penetration firestop systems subjected to tests in accordance with the Standards, ANSI/UL 1479 (ASTM E 814), the larger diameter, thinner wall steel penetrating items provide the most critical performance. Therefore, the selection of penetrating items was based upon the concept that the results achieved for each test configuration would be applicable for any equal or smaller diameter conduit and any equal or heavier wall thickness conduit. Hence, tests conducted on Electrical Metallic Tubing (EMT) would also be applicable for Intermediate Ferrous Metal Conduit (IMC) and Rigid Steel Conduit.

SUPPORT OF PENETRATING ITEMS

The penetrating items (EMT and Rigid Steel Conduits) were suspended in the through openings from steel support racks with attachment points located 12 in. and 30 in. from the unexposed surface of the floor or wall assembly. No support provisions for the penetrating items were present on the exposed side of the test assembly.

It has been demonstrated that under fire conditions a wall assembly will bow toward the fire. Since items penetrating actual wall constructions are continuous and rigidly supported on both sides of the wall, the items are restrained against movement during a fire. In order to determine whether the inward bowing of the wall assemblies in conjunction with the restrained penetrating items would cause distress or failure of the test configurations, the steel support racks to which each penetrating item was secured were attached to the test frames and were completely independent of the wall assemblies.

TEST ASSEMBLY #2—3 HOUR FIRE EXPOSURE PERIOD
CONCRETE FLOOR ASSEMBLY

Test Configuration No.	Opening Size	Penetrating Item(s)	Annular Space Protection Material(s)	Fire Exposure Results
1	6 in. diameter	Nominal 4 in. diameter EMT	Nominal 4-1/2 in. thickness of mineral wool	Pass
2	6 in. diameter	Nominal 4 in. diameter EMT	Nominal 4-1/2 in. thickness of caulk*	Pass
3	6 in. diameter	Nominal 4 in. diameter EMT	Nominal 4-1/2 in. thickness of mortar	Pass
4	6 in. diameter	Nominal 4 in. diameter EMT	Nominal 4-1/2 in. thickness of hydraulic cement	Pass
5	6 in. diameter	Nominal 4 in. diameter EMT	Nominal 3-1/2 in. thickness of mineral wool, flush with exposed surface, topped with nominal 1 in. thickness of grout, flush with unexposed surface	Pass

* — Upon removal of the cardboard dam used to retain the caulk while in its wet state, it was noted that the lower portion of the annular space was not entirely filled with caulk. The height of the void ranged from approximately 0 to 2-1/2 in., with the average being approximately 1-1/2 in. In order to avoid a delay in the test program while additional material cured, it was decided to fill the voids with mineral wool. The mineral wool was hand-packed into the void, such that it was flush with the exposed surface of the floor assembly.

ANNULAR SPACE FILLERS

The annular space between the penetrating item and the periphery of the opening in the wall and floor assemblies was filled with an annular space protection material. The annular space protection materials evaluated were selected so as to represent materials which are readily available to the construction industry. The materials selected include mineral wool, latex paint, silicone caulk, joint compound materials, Type M mortar, grout and hydraulic cement. The materials selected were all readily obtainable in the Northbrook, IL area.

For purposes of this report, the annular space protection material in conjunction with the penetrating item comprise the test configuration.

After the appropriate curing of the annular space protection materials, one side of each wall assembly and the lower surface of each floor, or floor-ceiling

assembly, was subjected to a fire exposure in accordance with the Standard Time-Temperature Fire Conditions of ASTM E 119. During the fire exposure test, observations were made relative to the ability of the annular space protection materials to prevent the passage of flames and hot gases sufficient to ignite cotton waste. As stipulated by the building code sections, a minimum positive pressure of 0.01 in. of water column was maintained in the furnace during the fire exposure test.

INFORMATION ON CHARACTERISTICS OF THE CONSTRUCTION MATERIALS:

Concrete Block

The concrete blocks were composed of Type I Portland cement and fly ash aggregate. The two core hole blocks measured 7-5/8 in. thick by 15-9/16 in. wide by 7-1/2 in. high. The blocks had an equivalent thickness of 5.57 in., which provides a 4 hour fire endurance rating.

Mortar

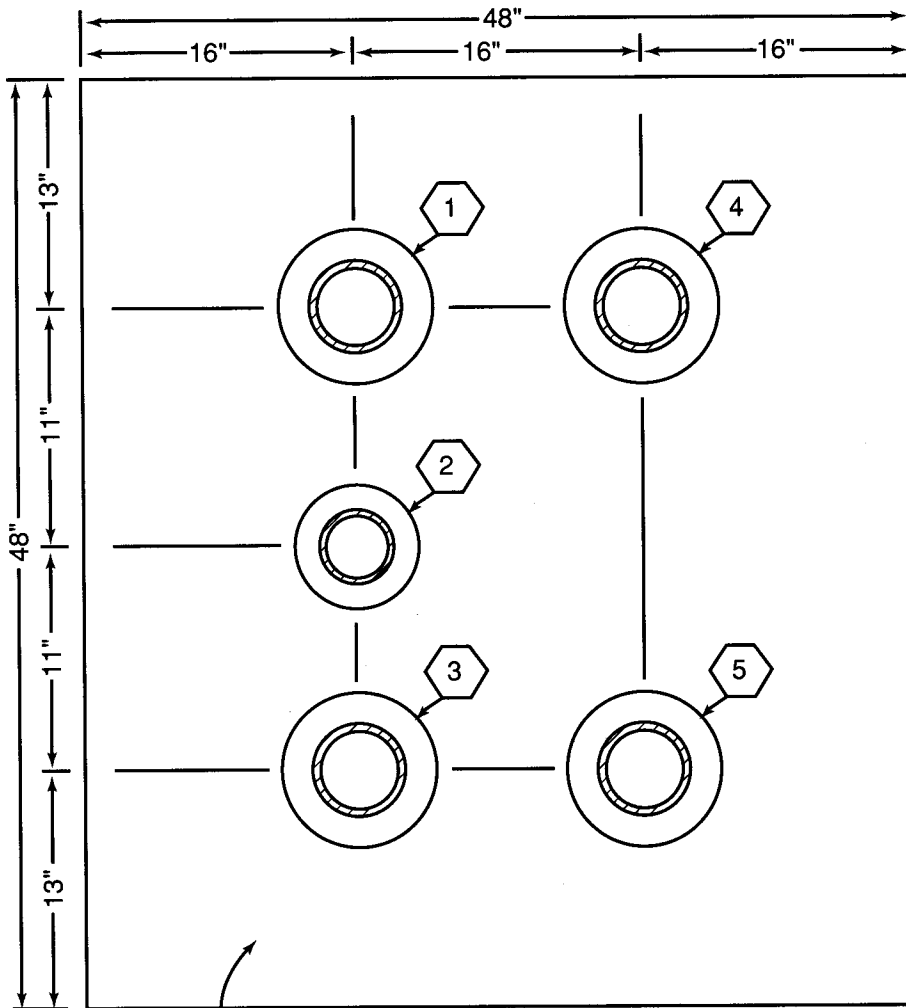
The mortar mix used to assemble the concrete block wall was a Type "M" mortar, as defined in Table 24-A of the 1988 Edition of the U.B.C.. The mortar was composed of 1 part Type I Portland cement, 1/4 part hydrated lime, 2-1/2 parts No. 4 mason's sand, by bulk volume, mixed with water as needed to achieve a workable mixture.

Concrete

The ready-mixed concrete, obtained from a local source, was composed of 1 part Type I Portland cement, 1.71 parts sand, and 3.1 parts Gravelite aggregate (expanded shale by rotary-kiln method), by bulk volume, mixed with approximately 7.8 gal of water and 3 oz of air entraining agent per bag of cement. The strength and density of the concrete at 28 days, as determined from standard 6 by 12 in. cylinders, averaged 4430 psi and 114.3 lb/ft respectively. The range of the strength was from 4120 to 4770 psi and the density range was from 113.89 to 115.1 lb/ft.

FLOOR/CEILING ASSEMBLY CONTAINING SINGLE PENETRATIONS

TEST ASSEMBLY NO. 3



Nom. 48" x 48" x 12" thick gypsum wallboard/
wood joist/plywood deck floor/ceiling assembly

Opening No.	Diameter of Opening, in.	Size & Type of Penetrating item
1	6	Nom. 4" EMT
2	4	Nom. 2" EMT
3	6	Nom. 4" Rigid Conduit
4	6	Nom. 4" EMT
5	6	Nom. 4" EMT

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Steel Reinforcement

The steel reinforcement for the concrete floor slabs was a 6 by 6 in. welded wire mesh of No. 10 SWG uncoated steel wire (6x6 - W1.4xW1.4).

Wood Joists

The wood joists were nominal 2 by 10 in. Douglas Fir-Larch lumber supplied in 12 ft. lengths.

Plywood Deck

The plywood deck was nominal 3/4 in. thick standard interior grade plywood conforming with PSI-66.

Gypsum Wallboard

The 5/8 in. thick "Type C" and "Type X" UL Classified gypsum wallboard was supplied in 4 by 8 ft. sheets weighing approximately 2.3 psf. and was manufactured by the United States Gypsum Co., Chicago, IL.

Joint Compound

The joint compound was a premixed ready-to-use compound manufactured specifically for use as a gypsum wallboard joint treatment material.

Resilient Channels

The resilient channels were fabricated from 0.021 in. thick (No. 25 gauge) galvanized steel and measured 1-1/2 in. wide by 5/8 in. deep and were supplied in 10 ft. lengths.

Fasteners

Fasteners for the floor assembly were 16d and 8d common nails and 1 in. long Type S self-drilling, self-tapping bugle-head steel screws. Fasteners for the wall assemblies were 1/4 in. 20 hex-head steel bolts with nuts into strut channels, 1/2 in. long Type S-12 self-drilling, self-tapping pan head steel screws and 1 in. and 1-5/8 in. long Type S self-drilling, self-tapping bugle head steel screws.

Floor and Ceiling Runners

The channel-shaped runners were fabricated from 0.022 in. thick (No. 25 gauge) electrogalvanized steel and measured 3-5/8 in. wide by 1-3/8 in. deep and were supplied in 10 ft. lengths.

Steel Studs

The steel studs were fabricated from 0.024 in. thick (No. 25 gauge) electrogalvanized steel and measured 3-1/2 in. wide by 1-1/4 in. deep with 5/16 in. folded back return flange legs. The studs were supplied in 10 ft. lengths.

Joint Tape

The 2 in. wide joint tape was made of a porous 0.010 in. thick paper with numerous pin-hole perforations throughout.

Conduit and Tubing

The galvanized steel conduit and tubing ranged from 1/2" trade size EMT and GRC to 4" trade size EMT and GRC. All conduits and tubing were sealed on the fire-exposed end with a 1/8 in. thick steel plate welded to the end.

TEST ASSEMBLY #3—2 HOUR FIRE EXPOSURE PERIOD
PLYWOOD/WOOD JOISTS/GYPSUM WALLBOARD FLOOR—CEILING ASSEMBLY
(DESIGN NOS. L505, L511, OR L536)

Test Configuration No.	Opening Size	Penetrating Item(s)	Annular Space Protection Material(s)	Fire Exposure Results
1	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Upper level: nominal 3/4 in. thickness of caulk Lower level: nominal 5/8 in. thickness of caulk, flush with exposed surface, topped with nominal 2 in. thickness of mineral wool	Pass
2	Nominal 4 in. diameter	Nominal 2 in. diameter EMT	Upper level: nominal 3/4 in. thickness of caulk Lower level: nominal 5/8 in. thickness of caulk, flush with exposed surface, topped with nominal 2 in. thickness of mineral wool	Pass
3	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Upper level: nominal 3/4 in. thickness of caulk Lower level: nominal 1-7/8 in. thickness of caulk	Pass
4	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Upper level: nominal 3/4 in. thickness of mineral wool, covered with 30 mil thickness of paint Lower level: nominal 2 in. thickness of mineral wool, covered with 30 mil thickness of paint	Pass
5	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Upper level: nominal 3/4 in. thickness of joint compound Lower level: nominal 1-7/8 in. thickness of joint compound	Pass

ANNULAR SPACE FILLER DESCRIPTIONS

Mineral Wool - The mineral wool insulation used in the test configurations was manufactured by Partek Insulations, Inc., Phoenix City, AL. The mineral wool was supplied in nominal 24 by 48 by 2 in. thick batts having a nominal density of 4 pcf. The actual density of the batts was 4.4 pcf.

Caulk - The one part RTV silicone caulk material used in the test configurations was manufactured by Dow Corning Corp., Midland, MI and was designated "Silastic 732 RTV Adhesive/Sealant".

Mortar - The mortar used in the test configurations was a Type "M" mortar, as defined in Table 24-A of the 1988 Edition of the U.B.C.. The mortar was composed of 1 part Type I Portland cement, 1/4 part

hydrated lime, 2-1/2 parts No. 4 mason's sand, by bulk volume, mixed with water as needed to achieve a workable mixture.

Hydraulic Cement - The hydraulic cement used in the test configurations was a prepared dry mixture manufactured by Thoro System Products, Miami, FL and was designated "Thorite". The dry mixture was mixed with water as needed to achieve a workable mixture.

TEST ASSEMBLY #4—2 HOUR FIRE EXPOSURE PERIOD
GYPSUM WALLBOARD/STEEL STUD WALL ASSEMBLY (DESIGN NO. U465)

Test Configuration No.	Opening Size	Penetrating Item(s)	Annular Space Protection Material(s)	Fire Exposure Results
1	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 1-1/4 in. thickness of joint compound on each side of wall	Pass
2	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 1-1/4 in. thickness of caulk on each side of wall	Pass
3	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 2 in. thickness of mineral wool, covered with 30 mils thickness of paint, on each side of wall	Pass
4	Nominal 6 in. diameter	Nominal 4 in. diameter rigid conduit	Nominal 1-1/4 in. thickness of caulk on each side of wall	Pass
5	Nominal 10-1/2 in. high by 6 in. wide	Nominal 1/2, 3/4, 1-1/4, 2 and 3 in. diameter EMT, spaced 3/4 in. apart	Nominal 4-3/4 in. thickness of mineral wool centered in wall and packed between and around penetrating items, covered with nominal 5/8 in. thickness of joint compound, flush with each surface of wall	Pass

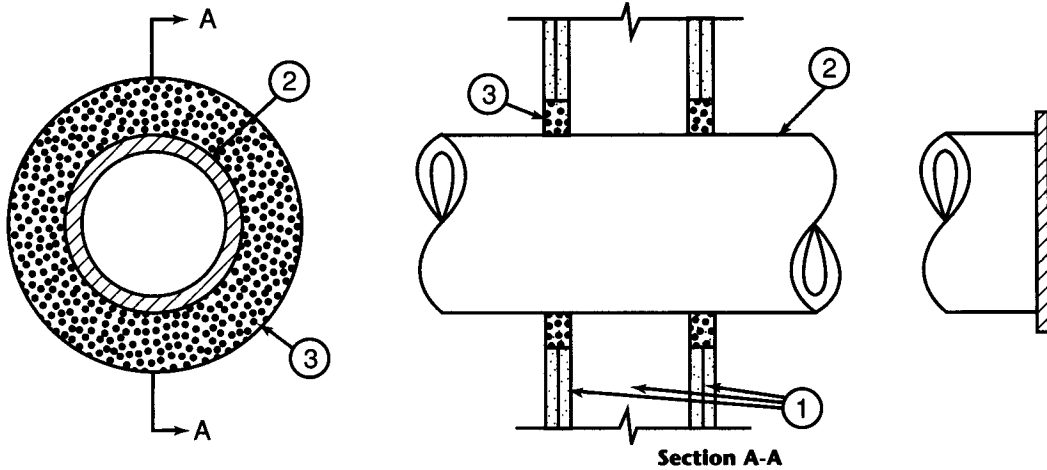
Grout - The grout used in the test configurations was a prepared dry mixture manufactured by U. S. Grout Corp., Fairfield, CT and designated "5 Star Grout". The dry mixture was mixed with water as needed to achieve a workable mixture.

Paint - The paint used in the test configurations was manufactured by The O'Brien Corp., South San Francisco, CA and was designated "Fuller O'Brien Professional Finishes Double AA Acrylic Semi-Gloss Latex Enamels".

Joint Compound - The joint compound used in the test configurations was a premixed ready-to-use compound manufactured by The United States Gypsum Co., Chicago, IL and designated "Sheetrock All Purpose Joint Compound Ready Mix."

Fire Exposure results are shown in Tables for each test assembly.

EXAMPLE OF ANNULAR SPACE FILLER DETAIL IN A WALL ASSEMBLY
TEST ASSEMBLY NO. 4/TEST CONFIGURATION NO. 1



Item no.

Description

- 1 Nom. 6" thick Gypsum Wallboard Wall.
- 2 Nom. 4" EMT centered in Nom. 6" opening. EMT extended 12" & 36" beyond the exposed & unexposed surfaces, respectively. Nom. 1/8" thick steel plate welded to exposed end of EMT.
- 3 Nom. 1 1/4" Thickness of joint compound installed within the annular space of both surfaces of wall, flush with each surface wall.

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TEST ASSEMBLY #5—1 HOUR FIRE EXPOSURE PERIOD
 GYPSUM WALLBOARD/STEEL STUD WALL ASSEMBLY (DESIGN NO. U411)

<u>Test Configuration No.</u>	<u>Opening Size</u>	<u>Penetrating Item(s)</u>	<u>Annular Space Protection Material(s)</u>	<u>Fire Exposure Results</u>
1	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 5/8 in. thickness of joint compound on each side of wall	Pass
2	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 5/8 in. thickness of caulk on each side of wall	Pass
3	Nominal 6 in. diameter	Nominal 4 in. diameter EMT	Nominal 1 in. thickness of mineral wool, covered with 30 mils thickness of paint, on each side of wall	Pass
4	Nominal 6 in. diameter	Nominal 4 in. diameter rigid conduit	Nominal 5/8 in. thickness of caulk on each side of wall	Pass
5	Nominal 10-1/2 in. high by 6 in. wide	Nominal 1/2, 3/4, 1-1/4, 2 and 3 in. diameter EMT, spaced 3/4 in. apart	Nominal 3-1/2 in. thickness of mineral wool centered in wall and packed between and around penetrating items, covered with nominal 5/8 in. thickness of joint compound, flush with each surface of wall	Pass

HOSE STREAM TEST INFORMATION:

Although not required where annular space protection materials are permitted by the referenced Code Sections, the conduit producers requested the hose stream test be conducted. This supplemental information on the hose stream performance of the test configurations responds to the concerns of those who attach importance to this test.

All hose stream tests were conducted in accordance with Section 5 of the Standard ANSI/UL 1479 (ASTM E 814). Paragraph 5.1 of this standard provides for use of a duplicate test assembly for hose stream testing. The duplicate assembly is subjected to a fire exposure of one half the original rating period, but not more than 60 min. For some test configurations, this duplicate test assembly was not utilized because the original assembly, after fire exposure for the full rating period, passed the hose stream test, thus far exceeding the requirements. As an example, concrete block, with mortar as the annular space protection, passed after being subjected to four times the required fire exposure.

The duplicate test for hose stream was performed only for those test configurations which did not pass after fire exposure for the full rating period.

Construction was identical to the original test assemblies. Slight changes were made in annular space filler as shown in notes (1), (2) and (3) in Table HI.

The configurations which passed the hose stream test after being subjected to the full rating fire exposure period are contained in column (a) of Table HI.

Results of the duplicate assembly testing are contained in column (b) of Table HI.

The hose stream test is intended as a measure of structural stability, and not as an indicator of resistance to fire

extinguishing activity. It is significant to note that when original testing of assembly No. 4 (2 hr. rated Gypsum Wallboard/Steel Stud Assembly) was initiated, an explosion occurred in the furnace. Examination of the exposed side of the wall assembly revealed the following:

The top edge of the wall assembly had moved outwards approximately 1/16 in. with respect to the test frame. In Penetration Nos. 1, 2, 4 and 5, the wall assembly was pushed out between 1/32 and 1/4 in. with respect to the test configurations. A small crack existed in the gypsum wallboard emanating from the lower edge of Penetration No.1. In Penetration No. 5, a crack existed in the joint compound from the 1/2 in. EMT to the adjacent corner.

The decision was made to continue with the test. Even after this physical insult
**ALL TEST CONFIGURATIONS
MAINTAINED THE RATING OF THE
ASSEMBLY AND PREVENTED THE
IGNITION OF COTTON WASTE.**

SUMMARY OF PERFORMANCE RELATIVE TO THE REFERENCED BUILDING CODE SECTIONS:

All test configurations prevented the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the ASTM E 119 time-temperature fire conditions under a minimum positive pressure differential of 0.01 in. of water at the location of the penetration for the time period equivalent to the fire endurance rating of the assembly penetrated.

HOSE STREAM TEST RESULTS

Table H-1

<u>Test Assembly No.</u>	<u>Penetration No.</u>	<u>Penetrating Item(s)</u>	<u>Annular Space Protection Material(s)</u>	<u>Fire Exposure Test</u>	<u>(a) Passed Hose Stream (Full Rating Period)</u>	<u>(b) Passed Hose Stream (Duplicate Assembly)</u>
<u>4 Hr. Asmbly.</u>						
1	1	4 in. EMT	Mortar	Pass	Yes	
1	2	4 in. Rigid	Mortar	Pass	Yes	
1	3	2 in. EMT	Mortar	Pass	Yes	
1	4	1/2 in. Rigid	Mortar	Pass	Yes	
1	5	1/2 in. EMT	Mortar	Pass	Yes	
1	6	Mult. EMT	Mortar	Pass	Yes	
1	7	Mult. Rigid	Mortar	Pass	Yes	
<u>3 Hr. Asmbly.</u>						
2	1	4 in. EMT	Mineral wool	Pass	See (b)	(1)
9	1	4 in. EMT	(2) 1 in. caulk over mineral wool	Pass		Yes
2	2	4 in. EMT	Caulk	Pass	See 9 (b)	
9	2	4 in. EMT	Caulk	Pass		Yes
2	3	4 in. EMT	Mortar	Pass	Yes	
9	3	4 in. EMT	(2) 1-1/2 in. caulk over mineral wool	Pass		Yes
2	4	4 in. EMT	Hydraulic cement	Pass	Yes	
9	4	4 in. EMT	(2) 2-1/2 in. caulk over mineral wool	Pass		Yes
2	5	4 in. EMT	Grout over mineral wool	Pass	See 9 (b)	
9	5	4 in. EMT	Grout over mineral wool	Pass		Yes
<u>2 Hr. Asmbly.</u>						
3	1	4 in. EMT	Caulk and mineral wool	Pass	See 8 (b)	
8	1	4 in. EMT	Caulk and mineral wool	Pass		Yes
3	2	2 in. EMT	Caulk and mineral wool	Pass	See 8 (b)	
8	2	2 in. EMT	Caulk and mineral wool	Pass		Yes
3	3	4 in. EMT	Caulk	Pass	See 8 (b)	
8	3	4 in. EMT	Caulk	Pass		Yes
3	4	4 in. EMT	Paint over mineral wool	Pass	See 8 (b)	
8	4	4 in. EMT	Paint over mineral wool	Pass		Yes
3	5	4 in. EMT	Joint compound	Pass	See 8 (b)	
8	5	4 in. EMT	(3) Joint compound	Pass		Yes
<u>2 Hr. Asmbly.</u>						
4	1	4 in. EMT	Joint compound	Pass	See 6 (b)	
6	1	4 in. EMT	Joint compound	Pass		No
4	2	4 in. EMT	Caulk	Pass	See 6 (b)	
6	2	4 in. EMT	Caulk	Pass		Yes
4	3	4 in. EMT	Paint over mineral wool	Pass	See 6 (b)	
6	3	4 in. EMT	Paint over mineral wool	Pass		No
4	4	4 in. Rigid	Caulk	Pass	See 6 (b)	
6	4	4 in. Rigid	Caulk	Pass		Yes
4	5	Mult. EMT	Joint compound over mineral wool	Pass	See 6 (b)	
6	5	Mult. EMT	Joint compound over mineral wool	Pass		Yes

TABLE H-1 continued

Test Assembly No.	Penetration No.	Penetrating Item(s)	Annular Space Protection Material(s)	Fire Exposure Test	(a) Passed Hose Stream (Full Rating Period)	(b) Passed Hose Stream (Duplicate Assembly)
<u>1 Hr. Asmbly.</u>						
5	1	4 in. EMT	Joint compound	Pass	See 7 (b)	
7	1	4 in. EMT	Paint over joint compound	Pass		No
5	2	4 in. EMT	Caulk	Pass	See 7 (b)	
7	2	4 in. EMT	Caulk	Pass		Yes
5	3	4 in. EMT	Paint over mineral wool	Pass	See 7 (b)	
7	3	4 in. EMT	Paint over mineral wool	Pass		No (4)
5	4	4 in. Rigid	Caulk	Pass	See 7 (b)	
7	4	4 in. Rigid	Caulk	Pass		Yes
5	5	Mult. EMT	Joint compound over mineral wool	Pass	See 7 (b)	
7	5	Mult. EMT	Joint compound over mineral wool	Pass		No

(1) At the request of the submitter, duplicate testing was omitted.

(2) At the request of the submitter, this new test configuration was incorporated in the assembly. It was obvious from the original test that mineral wool would require some other filler to hold it in place during the hose stream application. Three different thicknesses of caulk were tested for this purpose.

(3) At the request of the submitter, the joint compound was domed approximately 1-1/4 in. above surface of plywood deck. This represents an alternate configuration from that evaluated in Test Assembly No. 3, Penetration No. 5.

(4) In Test Configuration No. 3, the painted mineral wool was still adhered to the gypsum wallboard. However, the paint had separated from the penetrating item, creating a hairline crack. Based upon the flexible nature of the painted mineral wool, it was judged that this separation would allow a through projection of water.

SPECIAL NOTES:

We repeat here, verbatim, the standard UL caveat:

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