

Plan for Hemyc (1-Hour) and M.T. (3-Hour) Electrical Raceway Fire Barrier Systems Performance Testing

Revision M
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1 PURPOSE AND SCOPE

Section 50.48, “Fire Protection,” of 10 CFR Part 50 requires that each operating nuclear power plant have a fire protection plan that satisfies General Design Criterion 3 of Appendix A to 10 CFR Part 50. Criterion 3 requires that structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components. Section 50.48 also requires that all plants with operating licenses issued prior to January 1, 1979, satisfy the requirements of Sections III.G, III.J, and III.O of Appendix R to 10 CFR Part 50. (Post 1979 plants (per 10 CFR Part 50.48) have to comply with the provisions of their licenses.)

Section III.G of Appendix R, which addresses fire protection of safe shutdown capability, requires that fire protection features be provided such that one train of systems necessary to achieve hot shutdown conditions remains free of fire damage. One acceptable means of satisfying this requirement is to separate cables and equipment and associated non-safety circuits of redundant systems necessary to achieve and maintain hot shutdown conditions located in the same fire area by a fire barrier having a 3-hour fire rating (Section III.G.2.a). Another means is to enclose cables and equipment and associated

non-safety circuits of one redundant train in a fire barrier having a 1-hour fire rating and install fire detectors and an automatic fire suppression system in the fire area (Section III.G.2.c).

The scope of this document is to describe the overall plan for investigating the fire resistance rating of Hemyc (1-hour) and M.T. (3-hour) electrical raceway fire barrier systems (ERFBS). The primary approach will be to perform a series of ASTM E 119 furnace tests on a number of cable raceway types that are protected by either the Hemyc (with and without air gaps) or M.T. fire barrier material. The Hemyc tests will be performed for a period of 60-minutes each, followed by a hose stream test and post-test visual inspection of the ERFBS. The M.T. test will be performed in a similar manner with the principal difference being that it will be conducted for a period of 3-hours. Descriptions of these tests and of the overall approach are provided below.

2 OBJECTIVE

The objective of this program is to assess the fire resistance rating of Hemyc and M.T. ERFBS by subjecting various test specimens (conduit, cable trays, cable drops, and junction boxes) to standard temperature-time conditions as specified in ASTM E 119 and criterion stipulated in GL 86-10, Supplement 1. The types and characteristics of the ERFBS enclosing the test specimens are intended to simulate as-installed configurations.

These tests will also provide additional data in that redundant conduits loaded to their maximum capacities with cables will be included in two of the test runs. Also, a few support structure analogs partially enclosed in the ERFBS will be exposed to the one- and three-hour test conditions.

3 APPROACH

The following sections describe the test specimens and the test conditions to be employed for the performance assessments of the Hemyc and M.T. electrical raceway fire barrier systems.

3.1 Test Specimens

The principal test specimens will include a variety of cable raceway types protected by either the Hemyc 1-hour rated ERFBS or M.T. 3-hour rated ERFBS. In one test, the test specimens will be protected with Hemyc fire barrier material directly attached to the raceway (i.e., without air gaps). The test specimens in the second test will include a mix of test specimen enclosure methods: some protected by Hemyc ERFBS framed with structural supports to provide a 5-cm (2 in) air gap between the ERFBS and the raceway and others protected with Hemyc by direct attachment. For the third test, the test specimens (of the same types included in the first test) will be protected with the M.T. ERFBS (directly attached to the raceways) and subjected to a 3-hour ASTM E 119 furnace exposure.

The types of test specimens and the configurations of the ERFBS selected for these tests are based principally on the application usage information provided to the NRC/NRR by industry (Letter: Emerson, NEI, to Frumkin, NRC/NRR, "Promatec Hemyc 1-Hour and M.T. 3-Hour Fire Barrier Systems," December 28, 2001 and via letter: Marion, NEI, to Hannon, NRC/NRR, "Comments on NRC Hemyc Test Plan," December 6, 2002). Additional correspondence addressing specific details about industry practices in Hemyc applications were also taken into account and, where practical, incorporated into the test plan (e.g., Email: Emerson, NEI, to Salley, NRC/RES, "Hemyc – Predominant Industry Practices," January 18, 2005 [a copy of this message is provided in Appendix B]).

The test protocols presented here are intended to provide bounding states of the protective material performance under standard test conditions. Also, this method is per NRC guidance, as stated in Generic Letter 86-10, Supplement 1, and represents current staff positions on bounding test approaches. Additionally, it is also required that the assembly and installation of the Hemyc and M.T. ERFBS shall be done in accordance with the vendor's specifications and meet all required vendor quality standards.

The test specimens will include the following items:

- 27-mm (1 in) Steel rigid metal conduit (RMC) arranged in a modified “U” configuration such that one vertical leg and one end of the horizontal span of the conduit intersect at a condolet LB access fitting, forming a right angle, while the other end of the horizontal span transitions to the second vertical leg via a conduit radius bend or elbow. Tests will be conducted on both “empty” and “loaded”¹ conduit configurations.
- 63-mm (2½ in) Steel rigid metal conduit (RMC) arranged in a modified “U” configuration such that one vertical leg and one end of the horizontal span of the conduit intersect at a condolet LB access fitting, forming a right angle, while the other end of the horizontal span will transition to the second vertical leg by means of a conduit radius bend or elbow. Both “empty” and “loaded” conduit configurations will be tested.
- 103-mm (4 in) Steel rigid metal conduit (RMC) arranged in a modified “U” configuration such that one vertical leg and one end of the horizontal span of the conduit intersect at a condolet LB access fitting, forming a right angle, while the other end of the horizontal span will transition to the second vertical leg through a conduit radius bend or elbow. Again, “empty” and “loaded” conduit configurations will be tested.
- A 305-mm (12 in) wide 16-gage galvanized steel ladder-back cable tray with 10 cm (4 in) high side rails and 23 cm (9 in) rung spacing. The cable tray will be constructed in a modified “U” configuration such that one vertical leg and one end of the horizontal span of the conduit intersect at a right angle, while the other end of the horizontal span will transition to the second vertical leg by means of a tray vertical curve. Only empty cable trays will undergo testing.
- A 914-mm (36 in) wide 16-gage galvanized steel ladder-back cable tray with 10 cm (4 in) high side rails and 23 cm (9 in) rung spacing. The cable tray will be constructed in a modified “U” configuration such that one vertical leg and one end of the horizontal span of the conduit intersect at a right angle, while the other end of the horizontal span will transition to the second vertical leg by means of a tray vertical curve. The cable trays will be tested without cables.
- Short cable drops consisting of a small bundle of No. 8 AWG bare copper wire suspended from the top of the furnace in a “U” loop configuration to simulate air drops.
- 46 cm x 61 cm x 20 cm (18" x 24" x 8") Steel junction boxes. The junction boxes will be suspended using supports protected by the ERFBS through direct attachment.
- Four separate support structure test elements consisting of two different cross sections (Unistrut® and square steel tube) formed into a right angle (“L”)

¹ “Loaded” refers to approximately 30% of cross sectional area fill using bare #8 copper wires.

configuration and partially covered by the ERFBS. These structures are being included in the test program to evaluate the magnitude of heat transmission along their wrapped length and the possible thermal coupling effect on any supported assemblies or intervening items.

A bare #8 stranded copper wire, instrumented with thermocouples along its length, will be routed through each of the conduit test specimens and placed along the horizontal center of the cable tray test specimens and attached to the bottom of the rungs. The thermocouples will be mechanically attached to the bare copper conductor at 150-mm (6 in) spacing intervals. Additional thermocouples will be mechanically attached to the outer surfaces of the conduit test specimens and along the length of both side rails of the cable tray test specimens at 150-mm (6 in) intervals. The ends of the test specimens will be insulated with fiber filler inside and around their perimeters at the furnace-ceiling interface in accordance with the vendor's requirements.

The Hemyc ERFBS consists of blankets constructed of 38-mm (1.5 in) or 50-mm (2 in) thick, 128 kg/m³ (8 lb/cu ft), JM Cerablanket/B&W Kaowool blanket covered with Refrasil fabric mesh on all surfaces exposed to the fire². The materials are sewn together with "Astroquartz" thread. The cable tray and cable drop test specimens framed to support a 50-mm (2 in) air gap will use the 38-mm thick Hemyc covers and all direct attachment configurations will use the 50-mm thick wraps. All installation shall be in accordance with the vendor's requirements.

The M.T. three-hour ERFBS is virtually identical in concept and uses the same basic materials in construction as Hemyc, but the M.T. also has an internal layer of a heat-activated compound.

PCI Promatec, Inc. has been contracted to fabricate and install the Hemyc and M.T. materials on all of the test specimens.

² Previous versions of this test plan called for the use of Siltemp 84CH and 84SR fabric, however the manufacturer of Siltemp is no longer in business and Siltemp is no longer manufactured. Refrasil is an approved material for the fabrication of Promatec protective wrap components and will thus be used as the outer fabric for the Hemyc barriers for these tests.

Table 1 presents the test conditions to be investigated in terms of ERFBS type and configuration for each of the test specimens during the three tests. Conduits will not be tested in the air gap framed configuration and no cable trays will be tested with M.T.

Detailed construction drawings of each of the test specimens are provided in the appendix to this plan. The drawings define the specific details of the design and assembly of each test specimen. Promatec will provide separate drawings detailing the installation of the designated ERFBS. Drawings and descriptions of the dimensions and setup configurations in the furnace and instrumentation details are provided. The fabrication and installation of the ERFBS will be performed in accordance with vendor procedures. Provisions will be made to verify that all material/installation quality requirements are met.

Table 1: Test Matrix

	Test #1	Test #2	Test #3
	Hemyc (1-Hour, Direct Attachment)	Hemyc (1-Hour, Framed for Air Gap and Direct Attachment)	M.T. (3-Hour, Direct Attachment)
27-mm (1-in) Conduit ¹	X	(Not included)	X
63-mm (2½-in) Conduit ¹	X	(Not included)	X
103-mm (4-in) Conduit ¹	X	(Not included)	X
305-mm (12-in) Tray	(Not included)	X	(Not included)
914-mm (36-in) Tray	(Not included)	X	(Not included)
Junction Box ²	X	X	X
Cable Drop	(Not included)	X	X
Unistrut Support	X	(Not included)	X
Tube Steel Support	X	(Not included)	X

¹ Conduit test specimens will be tested under both “empty” and “loaded-with-cable” conditions.

² Only a single junction box will be included in Test #2 that will be enclosed in Hemyc by Direct Attachment secured with metal bands.

Sandia National Laboratories will procure the required materials for the test specimens. The type of material and equipment obtained will include raceways (conduit, trays,

condolets, and junction boxes), metal to fabricate the support structure specimens, and miscellaneous hardware (nuts, bolts, screws, etc.) plus spare parts. Promatec will be responsible for QA of the Hemyc and M.T. materials and ERFBS installation.

The test laboratory will construct the test specimens in accordance with the detailed construction drawings. The process will include the positive mechanical fastening of the thermocouples to the outer surfaces of the test specimens and checkout for proper operation prior to the installation of the ERFBS. The test laboratory will also be responsible for installation of the instrumented bare #8 copper wire and the additional conductors within the raceways. Table 2 indicates the number of bare #8 conductors to be installed in the “loaded” conduit test specimens. The individual weights of the assembled, but empty, test specimens will be recorded prior to attachment to the test deck. Similarly, the weights of the bare #8 copper wire bundles will also be recorded prior to installation in the selected conduits. The resulting mass per unit length will be used as a first-order basis for determining the influence of cable loading on thermal response of the raceways. The test laboratory will be responsible for QA of the furnace temperatures and test operations. The laboratory will provide logs and record instrument data during the tests.

Table 2: Number of No. 8 Bare Conductors Routed in Loaded Conduit.

Loaded Test Specimens	No. bare #8 stranded wires	Approximate mass per unit length of wire
103-mm (4") Conduit	291	21.72 kg/m (14.58 lb/ft)
63-mm (2½") Conduit	113	8.45 kg/m (5.68 lb/ft)
27-mm (1") Conduit	18	1.38 kg/m (0.95 lb/ft)
Cable Drops	7	0.70 kg/m (0.50 lb/ft)

Photographs and documented written logs of the test specimens, both during and after assembly, shall be prepared by the testing laboratory prior to testing and included as part of the test QA documentation for the final test report.

PCI Promatec, Inc., through a contract with Sandia National Laboratories, will be responsible for fabricating and installing the ERFBS materials on the test specimens following construction, instrumentation and mounting on the test deck.

3.2 Assessment Criteria

The test specimens will be subjected to the ASTM E 119 temperature-time profile in the test furnace. An assessment of the ERFBS performance will be based on two principal factors, as stated in Generic Letter 86-10, Supplement 1:

- 1. The time at which the average unexposed side temperature of the fire barrier system, as measured on the exterior surface of the raceway or component, exceeds 139 C (250 F) above its initial temperature. Or the time at which a single temperature reading of a test specimen exceeds 30% of the maximum allowable temperature rise (i.e., 181 C [325 F]) above its initial temperature.*
- 2. The fire barrier system remains intact during the fire exposure and water hose stream test without developing any openings through which the cable raceway is visible.*

3.3 Test Facilities

The furnace tests will be conducted at Omega Point Laboratories (OPL), located in Elmendorf, Texas. OPL has a full-scale horizontal furnace that fully satisfies the requirements of this test plan. It is 3.7 m (12 ft) wide by 5.5 m (18 ft) long and 2.1 m (7 ft) deep equipped with twelve propane burners. The furnace has been demonstrated to produce the ASTM E 119 standard time-temperature profile.

The test furnace is located in a 18 m (60 ft) by 61 m (200 ft) by 9 m (30 ft) high building. This building has ample room for test specimen assembly and fire barrier installation activities prior to placement inside the furnace.

3.4 Primary Tests

Three separate test runs will be conducted as part of the primary test series. Two of the tests will test the performance of 1-hour rated Hemyc ERFBS and the third test will assess the performance of 3-hour rated M.T. ERFBS. All of the primary tests will be conducted using the ASTM E 119 standard time-temperature curve (Figure 1). The furnace calibration shall be within ASTM E 119 requirements and the calibration documentation included in the final test report. All thermocouples used in the testing (furnace and test specimens) shall be within ASTM E 119 requirements and the calibration documentation included in the final report.

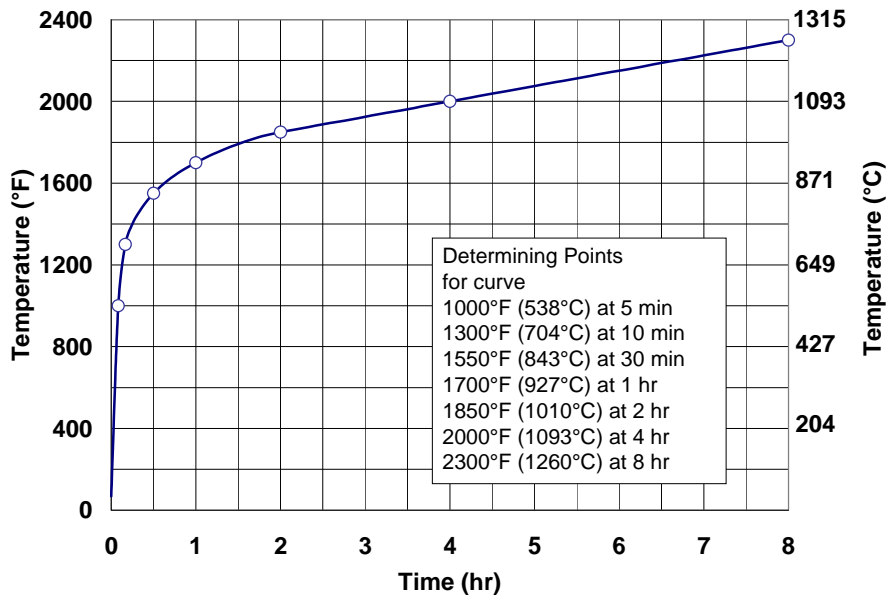


Figure 1. The Standard Time-Temperature Curve (based on data provided in ASTM E 119 – 00a).

As indicated above, these tests will be governed by the conditions provided in this test plan. The test specimens will consist of those items described in Section 3.1. The specific setup and configuration for each test is discussed below.

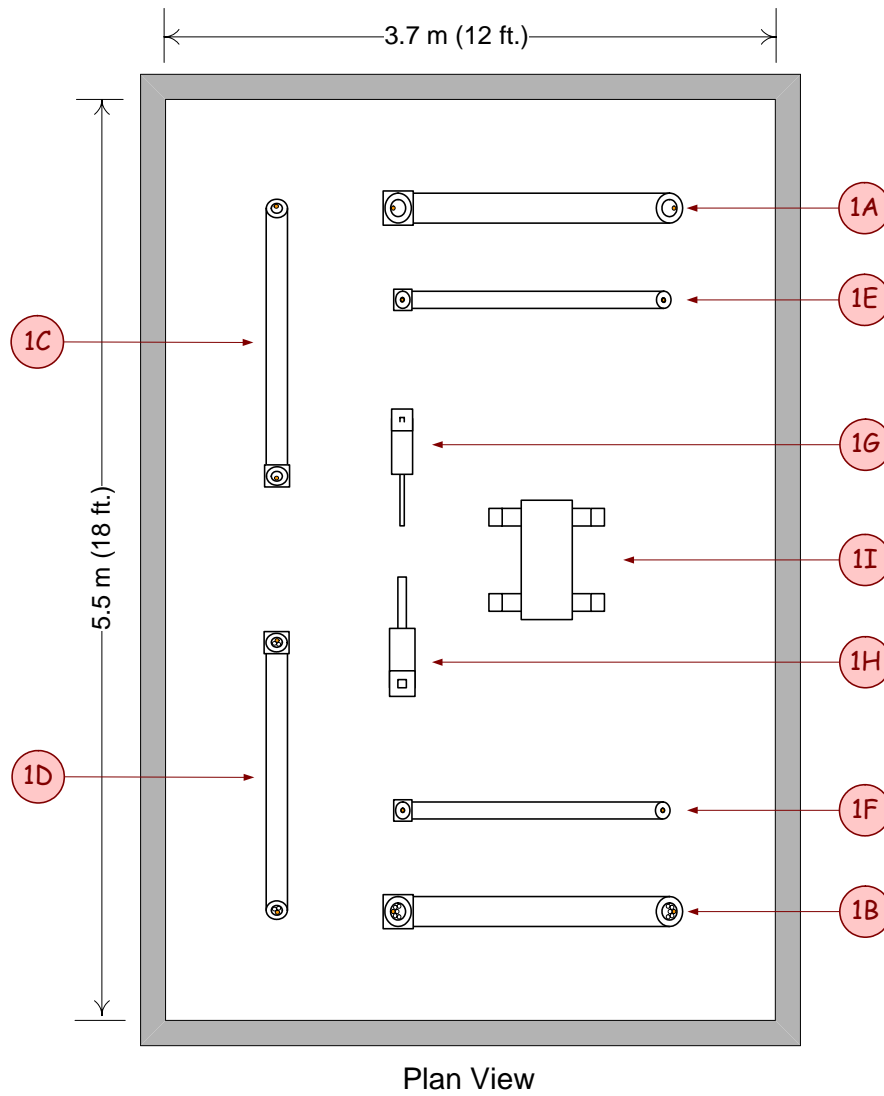
The Hemyc material will use Refrasil fabric on both the internal and external covering. Stainless steel bands will be used for attachment (i.e., no finger straps will be used). The spacing of the bands will be per Promatec's maximum spacing requirements. Standard 96 – 128 kg/m³ (6 – 8 lb/ft³) density ceramic fiber material will be used to construct the Hemyc wraps. The 27-mm (1-in) empty conduit, 63-mm (2½-in) loaded conduit and the 103-mm (4-in) conduit (empty and loaded) will all employ butt joints with 150-mm (6 in) wide collar over wraps. The 27-mm (1-in) loaded conduit and the 63-mm (2½-in) empty conduit will employ 50-mm (2-in) overlap joints. All cable trays will use the overlap joint method. In addition, the cable drop with the 50-mm (2-in) air gap will use the overlap method for sealing the material joints while the cable drop without the air gap will use collars to cover the butt joints.

3.4.1 Test #1

The first test of the series will be conducted on nine test specimens with Hemyc ERFBS directly attached to the raceways (i.e., without framework to provide air gaps between the fire barrier material and raceways). The nominal thickness of the Hemyc will be 50 mm (2 in).

Figure 2 shows one possible configuration of the test specimens inside the furnace. As indicated in the figure, the test specimens include:

- A 103-mm (4 in) conduit without additional cables,
- A 103-mm (4 in) conduit loaded with the maximum (30% of conduit's cross-sectional area) fill of cables,
- A 27-mm (1 in) conduit and condolet LB assembly without cables,
- A 27-mm (1 in) conduit and condolet LB assembly with additional cables (30% fill),
- A 63-mm (2½ in) conduit and condolet LB assembly with no cables,
- A 63-mm (2½ in) conduit and condolet LB assembly with cables (30% fill),
- A 46 cm X 61 cm X 20 cm (18" x 24" x 8") junction box,
- A partially protected Unistrut® support assembly, and
- A partially protected 5 cm x 5 cm (2" x 2") square steel tube support assembly



Test #1 Configuration Layout
Test Specimens Direct Attachment with Hemyc

1A - 103 mm (4") Conduit (0% Fill)	1F - 27 mm (1") Conduit (30% Fill)
1B - 103 mm (4") Conduit (30% Fill)	1G - Unistrut Support
1C - 63 mm (2½") Conduit (0% Fill)	1H - 5 cm X 5 cm (2" X 2") Tube Steel Support
1D - 63 mm (2½") Conduit (30% Fill)	1I - 46 cm X 61 cm X 20 cm (18" X 24" X 8") Junction Box
1E - 27 mm (1") Conduit (0% Fill)	

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Figure 2. Example of Test Specimen Layout during Test #1 (Hemyc, Direct Attachment Configurations).

This arrangement of the test specimens is intended to maximize thermal exposures and minimize the potential for one specimen to influence the response of another specimen to the thermal environment (i.e., minimize shadowing).

The conduit will be supported from the furnace ceiling in a modified “U” configuration. The metal test deck will be adequately insulated to prevent interaction with the portion of the test specimens located outside the furnace and to protect the metal deck from structural failure during the 1-hour test. Each conduit will include one sharp 90-degree transition from the horizontal span to one of the vertical legs; a condolet fitting will be employed to provide the right angle transition from horizontal to vertical. At the other transition point a radius bend will be used. The two vertical runs of these test articles will be approximately 0.9 m (36 in) along each leg and the horizontal span will be approximately 1.5 m (60 in) (See Figures A1, A2, and A3 in Appendix A). The ERFBS will completely cover the test specimens within the furnace and extend through the test deck for a distance of 15 to 30 cm (6 – 12 in) above the test deck (See Figure A19 in Appendix A). All raceway supports shall be outside the furnace and shall not interfere with the ERFBS during testing.

A Hemyc ERFBS will be directly attached to the support structure analogs such that 30 cm (12 in) of their horizontal sections are exposed to the furnace environment. The junction box will be suspended from the test deck by Unistrut support members and protected with Hemyc through direct attachment (See figure A6 in Appendix A).

The vertical run of the Unistrut will be approximately 0.9 m (36 in) inside the furnace and the horizontal run will be 0.6 m (24 in) (See figure A8 in Appendix A).

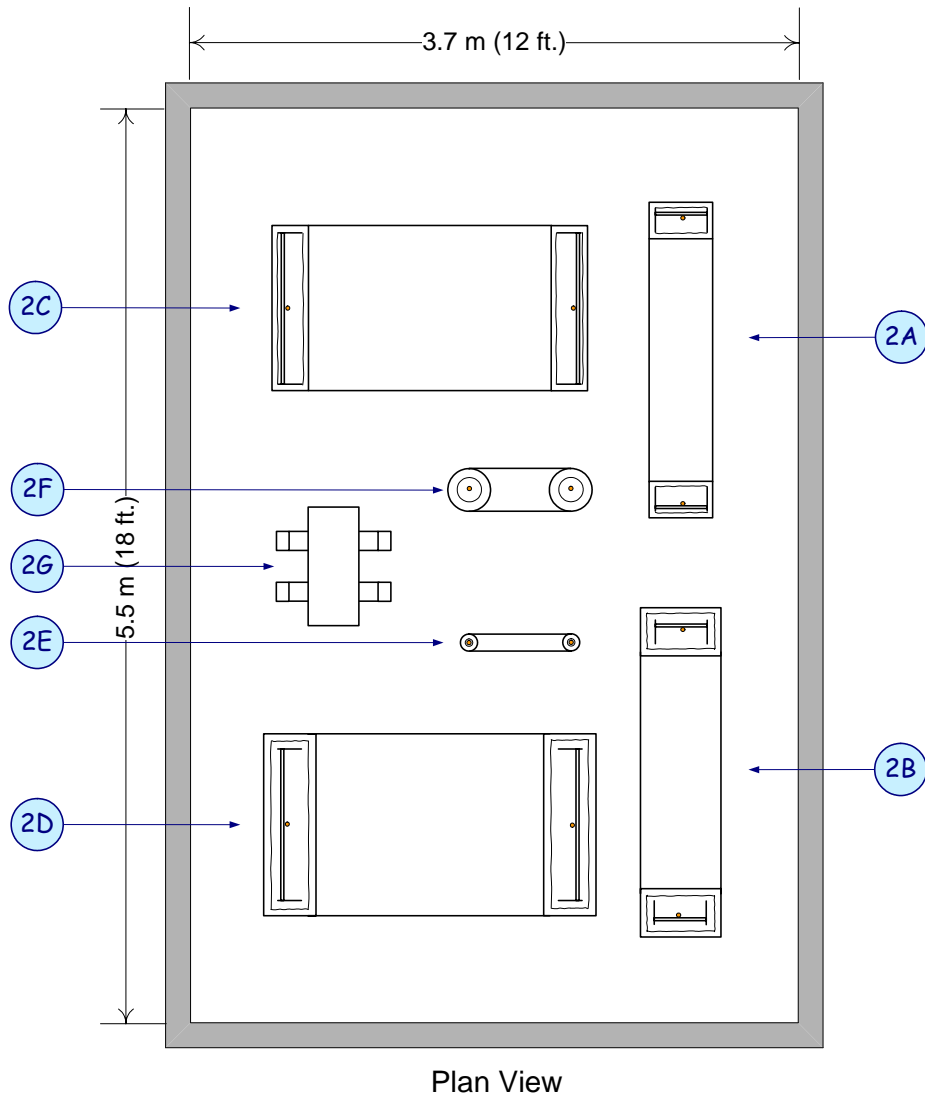
The vertical run of the 5 cm x 5 cm (2 in. x 2 in) tube steel will be approximately 0.9 m (36 in) below the test deck and the horizontal run will be 0.6 m (24 in) (See figure A7 in Appendix A).

3.4.2 Test #2

The second test will be conducted on seven test specimens, which will be protected with Hemyc ERFBS. Two of the cable trays and one cable drop will incorporate the necessary framework to provide a minimum of 50-mm (2 in) air gaps between the ERFBS and item. The nominal thickness of the Hemyc ERFBS enclosing the framed components will be 38 mm (1½ in). The remaining two cable trays, cable drop and junction box will be protected with directly attached (i.e., without air gap framework) Hemyc with a nominal wrap thickness of 50-mm (2 in).

One possible arrangement of the test specimens in the furnace during Test #2 is shown in Figure 3. The seven test specimens will include:

- A 914-mm (36 in) cable tray framed for 50-mm (2") air gap,
- A 914-mm (36 in) cable tray employing direct attachment of the Hemyc,
- A 305-mm (12 in) cable tray framed for 50-mm air gap,
- A 305-mm (12 in) cable tray employing direct attachment of the Hemyc,
- A small cable drop loop employing direct attachment of the Hemyc,
- A 46 cm x 61 cm x 20 cm (18" x 24" x 8") junction box employing direct attachment of the Hemyc suspended from the top of the furnace with separately protected (direct attachment, ceramic fiber blanket) supports, and
- A small cable drop loop framed for 50-mm air gap.



Test #2 Configuration Layout
Test Specimens Protected in Hemyc

- 2A - 305 mm (12") Cable Tray (direct attachment)
- 2B - 305 mm (12") Cable Tray (5 cm [2"] Air Gap)
- 2C - 914 mm (36") Cable Tray (direct attachment)
- 2D - 914 mm (36") Cable Tray (5 cm [2"] Air Gap)
- 2E - Cable Drop Loop (direct attachment)
- 2F - Cable Drop Loop (5 cm [2"] Air Gap)
- 2G - 46 cm X 61 cm X 20 cm (18" X 24" X 8") Junction Box (suspended by supports, enclosed in Hemyc by direct attachment)

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Figure 3. Example of Test Specimen Layout during Test #2 (Hemyc, Framed for 50-mm (2") Air Gap and Direct Attachment Configurations).

The cable trays will be supported from the furnace ceiling in a modified “U” configuration. The metal test deck of the test specimens will be adequately insulated to prevent interaction with the portion of the test specimens located outside the furnace and to protect the metal deck from structural failure during the 1-hour test. Each tray will include one sharp 90-degree transition from the horizontal span to one of the vertical legs. At the other transition a radius bend will be used. The cable trays will be modified and assembled to accommodate the right angle turn. The two vertical runs of these test articles will be approximately 0.9 m (36 in) along each leg inside the furnace and the horizontal span will be approximately 1.5 m (60 in) (See Figures A4 and A5 in Appendix A). The ERFBS will completely cover the test specimens within the furnace and extend through the test deck for a distance of 15 to 30 cm (6 – 12 in) above the test deck (See Figure A20 in Appendix A). All raceway supports shall be outside the furnace and shall not interfere with the ERFBS during testing.

The junction box will be supported from the furnace ceiling by Unistrut® channels (See Figure A6 in Appendix A). The junction box supports will be directly protected with a ceramic fiber blanket separately from the box.³ (Note: The junction box supports are not considered as part of this test and will not be instrumented; however any failure in their performance during the test will be noted and investigated as deemed appropriate.) Two wrapped cable bundles (one with air gap, the other without) will be dropped through the top of the furnace and looped in the furnace and routed back up through the test deck (See figure A9 in Appendix A).

3.4.3 Test #3

The final test will be conducted on ten test specimens, all of which will be wrapped with the M.T. 3-hour rated ERFBS without any framework to provide air gaps between the wrap and raceway. The nominal thickness of the M.T. ERFBS will be approximately

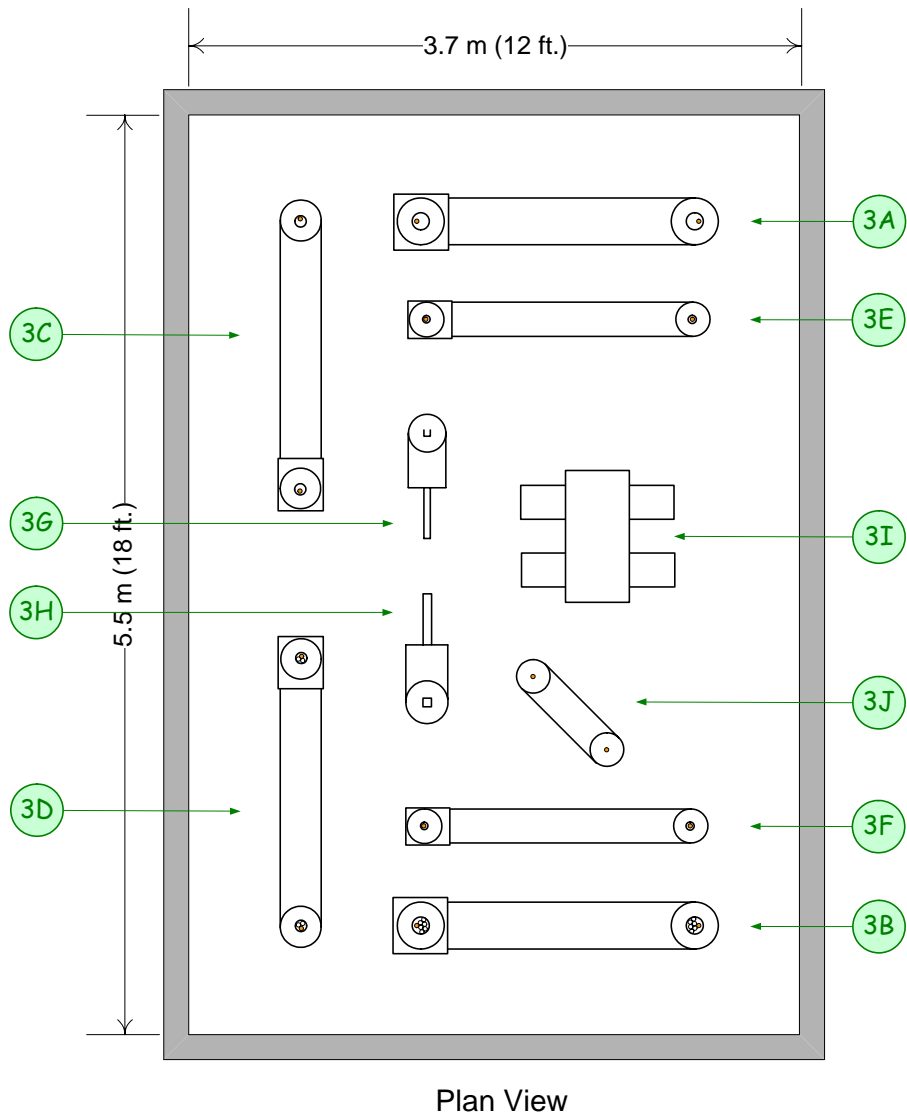
³ The junction box supports were protected with 50-mm (2”) thick raw ceramic fiber blankets (not Hemyc) in Test #2 and kept thermally isolated from the box.

133 mm (5¼ in) for the cable drop. The nominal M.T. thickness for conduits and junction boxes will be 95 mm (3¾ in).

Figure 4 shows a possible configuration of the test specimens in the furnace during Test 3. The test specimens protected with M.T. during Test #3 will include:

- A 103-mm (4 in) conduit without additional cables,
- A 103-mm (4 in) conduit loaded with the maximum fill (30%) of cables,
- A 27-mm (1 in) conduit and condolet LB assembly without cables,
- A 27-mm (1 in) conduit and condolet LB assembly with additional cables (30% fill),
- A 63-mm (2½ in) conduit and condolet LB assembly with no cables,
- A 63-mm (2½ in) conduit and condolet LB assembly with cables (30% fill),
- A small cable drop loop,
- A partially protected Unistrut® support assembly,
- A partially protected 5 cm x 5 cm (2" x 2") square steel tube support assembly, and
- A 46 cm X 61 cm X 20 cm (18" x 24" x 8") junction box

As in the other two tests, the conduit assemblies will be supported from the furnace ceiling in a modified “U” configuration. The metal deck of the test specimens will be adequately insulated to prevent interaction with the portion of the test specimens located outside the furnace and to protect the metal deck from structural failure during the 3-hour test. Each conduit will include one sharp 90-degree transition from the horizontal span to one of the vertical legs and a radius bend will be used for the other transition. A condolet fitting will be employed to provide the right angle turn. The two vertical runs of these test articles will be approximately 0.9 m (36 in) along each leg inside the furnace and the horizontal run will be approximately 1.5 m (60 in) (See Figures A1, A2, and A3 in Appendix A). The ERFBS will completely cover the test specimens within the furnace and extend through the test deck for a distance of 15 to 30 cm (6 – 12 in) above the test deck (See Figure A19 in Appendix A). All raceway supports shall be outside the furnace and shall not interfere with the ERFBS during testing.



Test #3 Configuration Layout
Test Specimens Direct Wrap with M.T.

3A - 103 mm (4") Conduit (0% Fill)	3F - 27 mm (1") Conduit (30% Fill)
3B - 103 mm (4") Conduit (30% Fill)	3G - Unistrut Support Structure
3C - 63 mm (2½") Conduit (0% Fill)	3H - 5 cm X 5 cm (2" X 2") Steel Support Structure
3D - 63 mm (2½") Conduit (30% Fill)	3I - 46 cm X 61 cm X 20 cm (18" X 24" X 8") J-Box
3E - 27 mm (1") Conduit (0% Fill)	3J - #8 AWG Bare Copper Wire Drop

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Figure 4. Example of Test Specimen Layout during Test #3 (M.T., Direct Wrap Configurations).

An M.T. ERFBS will be directly attached to the support structure analogs such that 30 cm (12 in) of their horizontal sections are exposed to the furnace environment. The junction box will be suspended from the test deck by Unistrut support members and protected with M.T. through direct attachment (See figure A6 in Appendix A).

The vertical run of the Unistrut will be approximately 0.9 m (36 in) within the furnace and the horizontal run will be 0.6 m (24 in) (See figure A8 in Appendix A).

The vertical run of the 5 cm x 5 cm (2 in. x 2 in) tube steel will be 0.9 m (36 in) in the furnace and the horizontal run will be 0.6 m (24 in) (See figure A7 in Appendix A).

One wrapped cable bundle will be dropped through the top of the furnace and looped in the furnace and routed back up through the test deck (See figure A9 in Appendix A).

3.5 Conduct of Tests

Each of the primary test runs will be conducted by exposing the test specimens to the time-temperature curve (Fig. 1) as specified in ASTM E 119, Standard Test Methods for Fire Tests of Building Construction and Materials. By this method, the temperature inside the furnace should reach 927 C (1700 F) at the end of the one-hour tests and 1052 C (1925 F) at the end of the 3-hour test. Figure 1 shows the desired temperature profile as a function of time. The time-temperature curve shall be maintained within the limits established in ASTM E 119.

Upon completion of each ASTM E 119 temperature run (one-hour and three-hours), the complete test assembly will be removed from the furnace and a hose stream will be applied to all of the test articles. The hose stream test will consist of a water stream applied at random to all exposed surfaces of the test specimens through a 38-mm (1½ in) fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa (75 psi) at a minimum discharge rate of 284 lpm (75 gpm) with the tip of the nozzle at a

maximum distance of 3 m (10 ft) from the test specimen. The hose stream application will be continued for at least 5 minutes upon completion of the test.

A visual inspection of all test articles will be conducted following the hose stream test. The purpose of the inspection will be to ascertain whether the ERFBS remained intact during the fire exposure and the cooling and mechanical impact of the hose stream test without developing any openings or breaches. Visible indications of an opening will include obvious tears or displacement of a barrier section or a view of the covered raceway through the fire barrier.

Photographs and video of the test specimens, both prior to and after disassembly, will be taken during the post-test inspection and recorded as part of the test documentation.

3.6 Instrumentation and Data Collection

The primary data to be generated in these tests will be component temperatures as indicated by insulated 24-gage Type-K thermocouples (Special Limit 32 to 2282°F range and 2°F or 0.4% tolerance value per ASTM E230-ANSI MC 96.1). The junction box temperatures will be monitored using Type-K thermocouples sheathed in Inconel. These thermocouples have been calibrated and certified to accuracies within 4°F of the comparison standard over a temperature range of 70°F to 1000°F. Test #1 will require the use of approximately 380 thermocouples to monitor the test specimen temperatures. Test #2 will require about 335 thermocouples. Approximately 400 thermocouples will be needed for Test #3. The outputs of the thermocouples will be sent to a computerized data collection unit for recording and storage. Each thermocouple's output will be recorded at least once per minute. It is expected that Teflon-coated thermocouples will be used during Test #3 to ensure that there will not be interference from any gases evolving from the M.T. ERFBS.

Figures A10 through A18 in Appendix A show the preferred attachment locations of the thermocouples on the test specimens. Routing the thermocouples for monitoring the tray temperatures will be by laying the bundles in the tray at the entry point and branching the

thermocouples off for mechanical attachment to the tray rails and bare copper conductor at the appropriate locations (See figures A13 and A14 in Appendix A). Similarly, for the cable drop thermocouples, the thermocouples will be bundled with the cable drop cables at the points of entrance and exit at the ceiling of the furnace and branching off the thermocouples for attachment to the bare copper conductor wire at 150-mm (6 in) spacing intervals (See figure A18 in Appendix A).

Each conduit will have thermocouples mechanically fastened to the side or bottom surface located along the outside perimeter of the “U” shape (See Figures A10, A11, and A12, in Appendix A). The routing of thermocouples for monitoring the temperature of the conduit will require that a series of small thermocouple bundles be placed around the circumference of the conduit and run to their individual attachment locations between the conduit and ERFBS. In order to minimize the effect of these small bundles on the test results, the conduit thermocouples will be run in underneath the ERFBS from both ends of the test specimen. The bare copper wire routed through the interior of each conduit test specimen will be instrumented with thermocouples installed with a maximum spacing of 150-mm (6 in) along its length. The junction boxes and condolet fittings will have at least one thermocouple attached to each side located at or as closely as possible to the geometric center of the side walls.

Note that the thermocouple locations indicated in these figures are for information purposes only. The thermocouples will be installed, except as noted, at 150-mm (6 in) intervals along the conduits, cable tray rails, and bare #8 copper wires in accordance with the guidance provided in Supplement 1 to Generic Letter (GL) 86-10. The instrumented bare #8 copper wire will be embedded within the copper wire bundles of the “loaded” raceways to protect the thermocouples from physical damage when the bundles are pulled through the raceways. Thermocouples will be attached to the raceway vertical legs located 25-mm (1 in) above the top of the test deck and 25-mm (1 in) below the exposed surface of the insulation on the bottom of the test deck.

3.7 Follow-on Tests

The decision to plan and conduct follow-on tests will be made by NRC (RES) on the basis of the primary test results.

4 REPORTING AND DOCUMENTATION

For each test conducted, the testing laboratory shall produce a draft report within two weeks of completion of the test. Each draft report (including electronic data and color photographs) will be submitted to SNL for a one-week comment period. The draft report will contain a summary of the thermocouple data and a simple analysis on the effects of cable mass on ERFBS performance. Upon receipt of comments, the test laboratory shall issue the final test report within two weeks to SNL. The final report shall contain all thermocouple data (including plots and location maps), QA documentation and construction drawings and ERFBS installation details. Thermocouple data plots will include graphs of (1) each individual temperature monitored during the test, (2) graphs of the average and maximum temperatures recorded for each test specimen exterior surface as a function of time, and (3) graphs of the average and maximum temperatures recorded for each test specimen instrumented bare #8 conductor as a function of time. SNL shall review the final report for accuracy and transmit the complete laboratory report to NRC (RES) within one week.

The test data will be analyzed and the fire barrier performance will be evaluated based on the acceptance criteria.

It should be recognized that the possibility exists that these test results may form the technical basis for broad acceptance of these fire protection systems by NRC, or provided the basis for enforcement action or backfit requirements, as deemed appropriate.

5 REFERENCES

10 CFR, Part 50, Appendix R, Fire Protection Program for Operating Nuclear Power Plants.

Supplement 1 to Generic Letter 86-10, Fire Endurance Test Acceptance Criteria for Fire Barrier Systems used to Separate Redundant Safe Shutdown Trains within the Same Fire Area, March 25, 1994.

ASTM E 119 – 00a, Standard Test Methods for Fire Tests of Building Construction and Materials.

A Test Specimen Configuration Details and Thermocouple Location Plan

These diagrams are not to scale and indicate test specimens assembly and thermocouple installation details for illustrative purposes only.

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

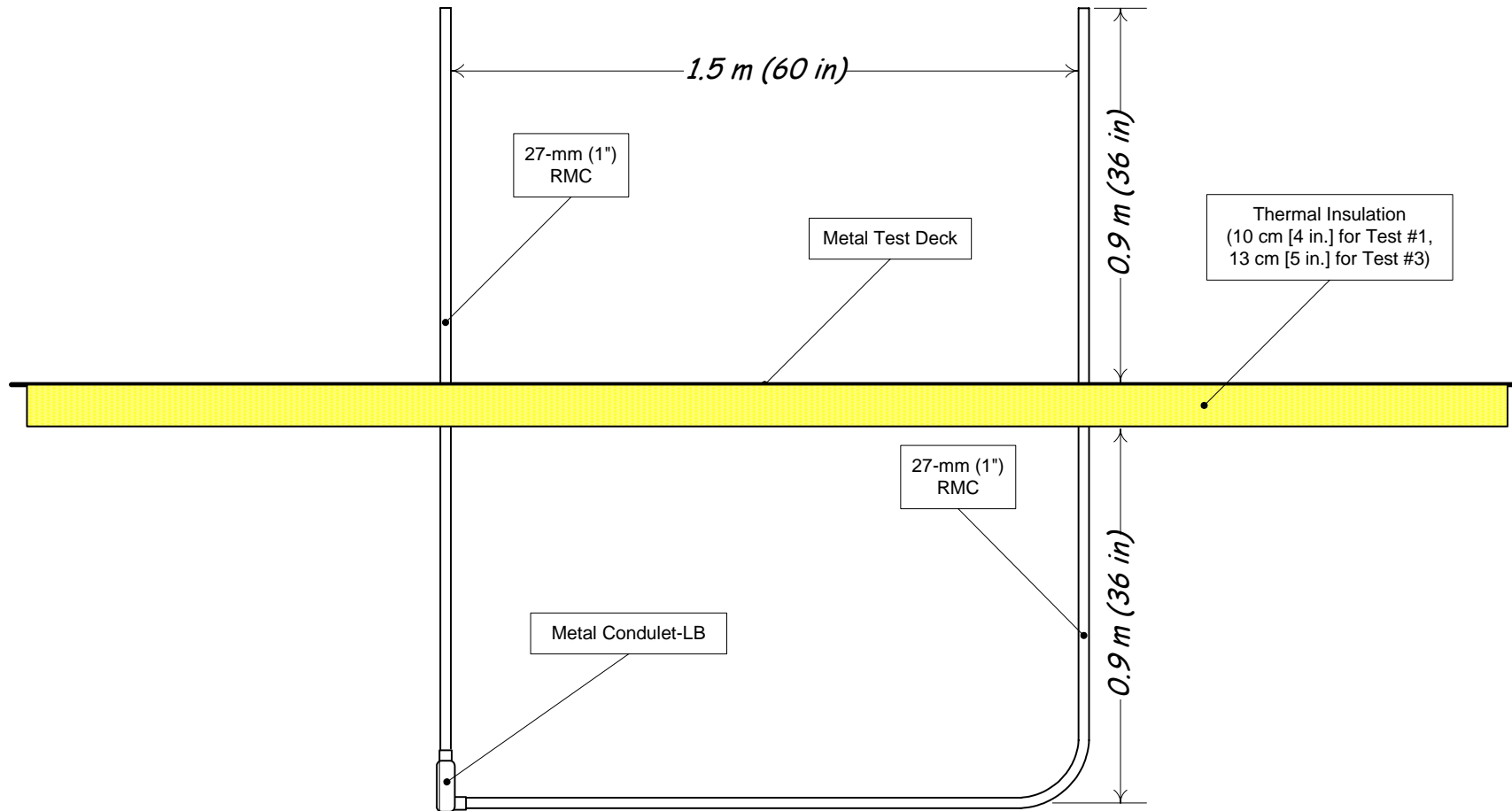


Figure A1: 27-mm (1-in) rigid metal conduit test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

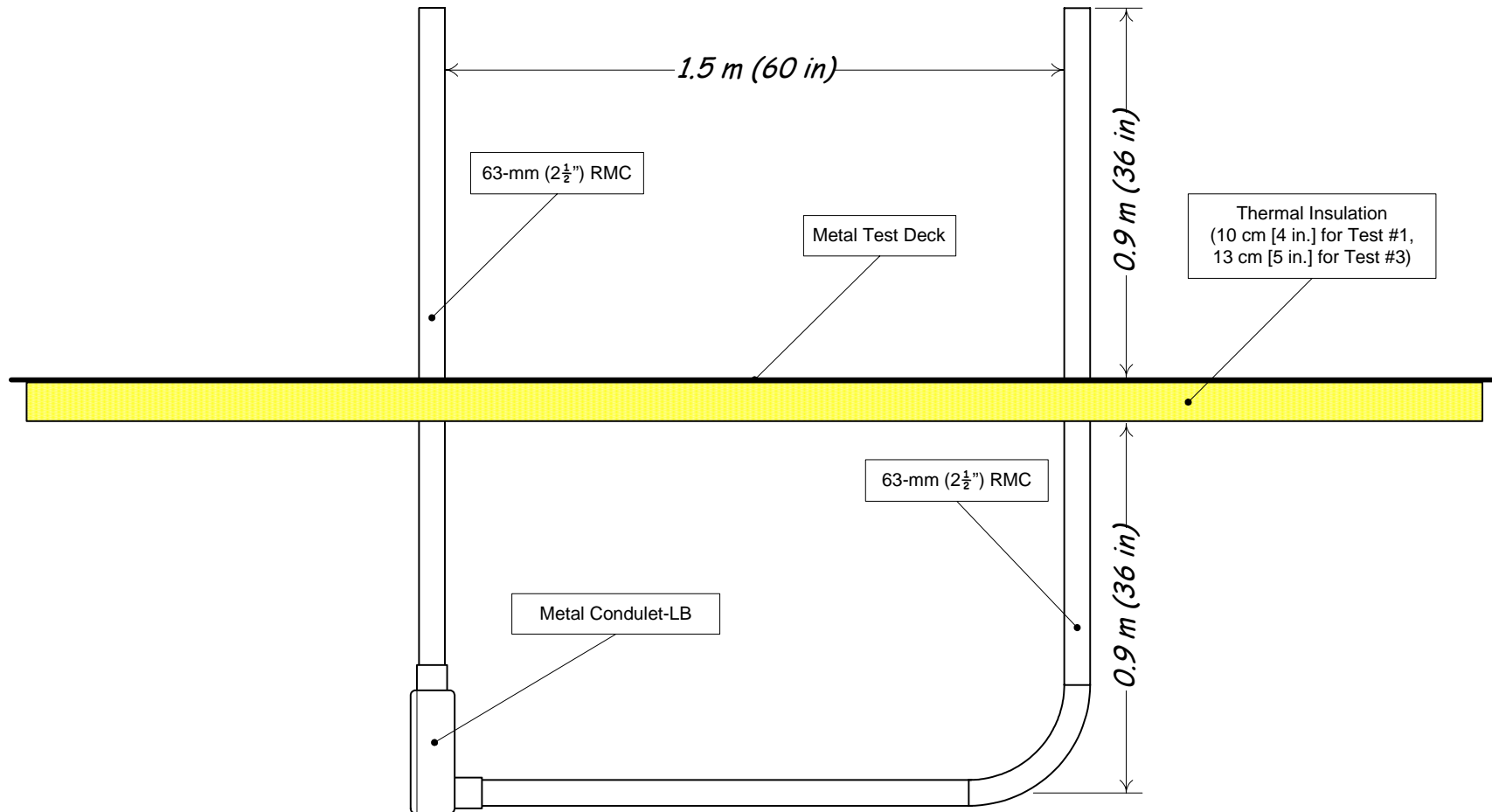


Figure A2: 63-mm (2½-in) rigid metal conduit test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

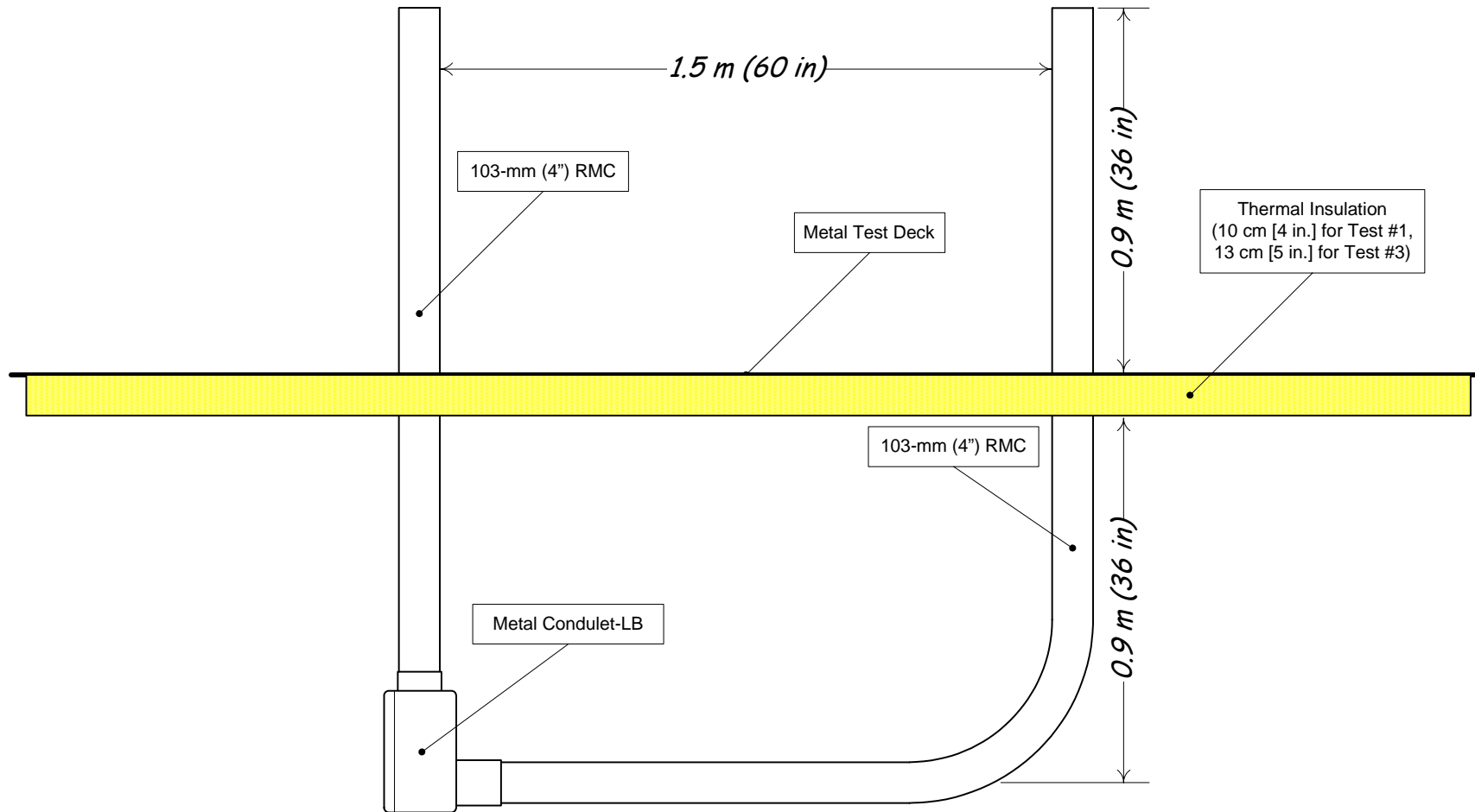


Figure A3: 103-mm (4-in) rigid metal conduit test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

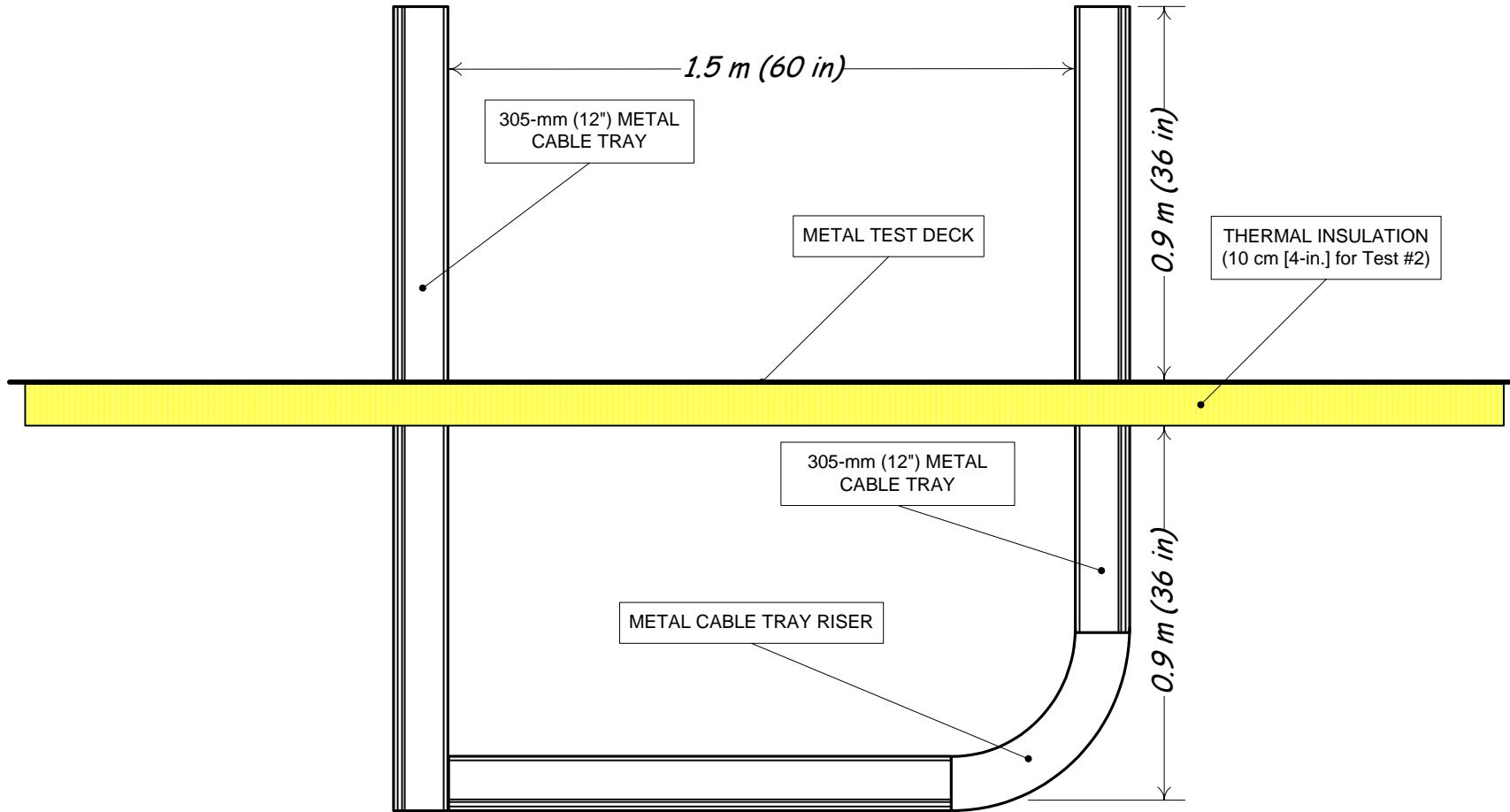


Figure A4: 305-mm (12-in) cable tray test specimens (side view with dimensions). Cable trays will be ladder type, 18-gage galvanized steel with 10 cm (4 in) high side rails and 23 cm (9 in) rung spacing.

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

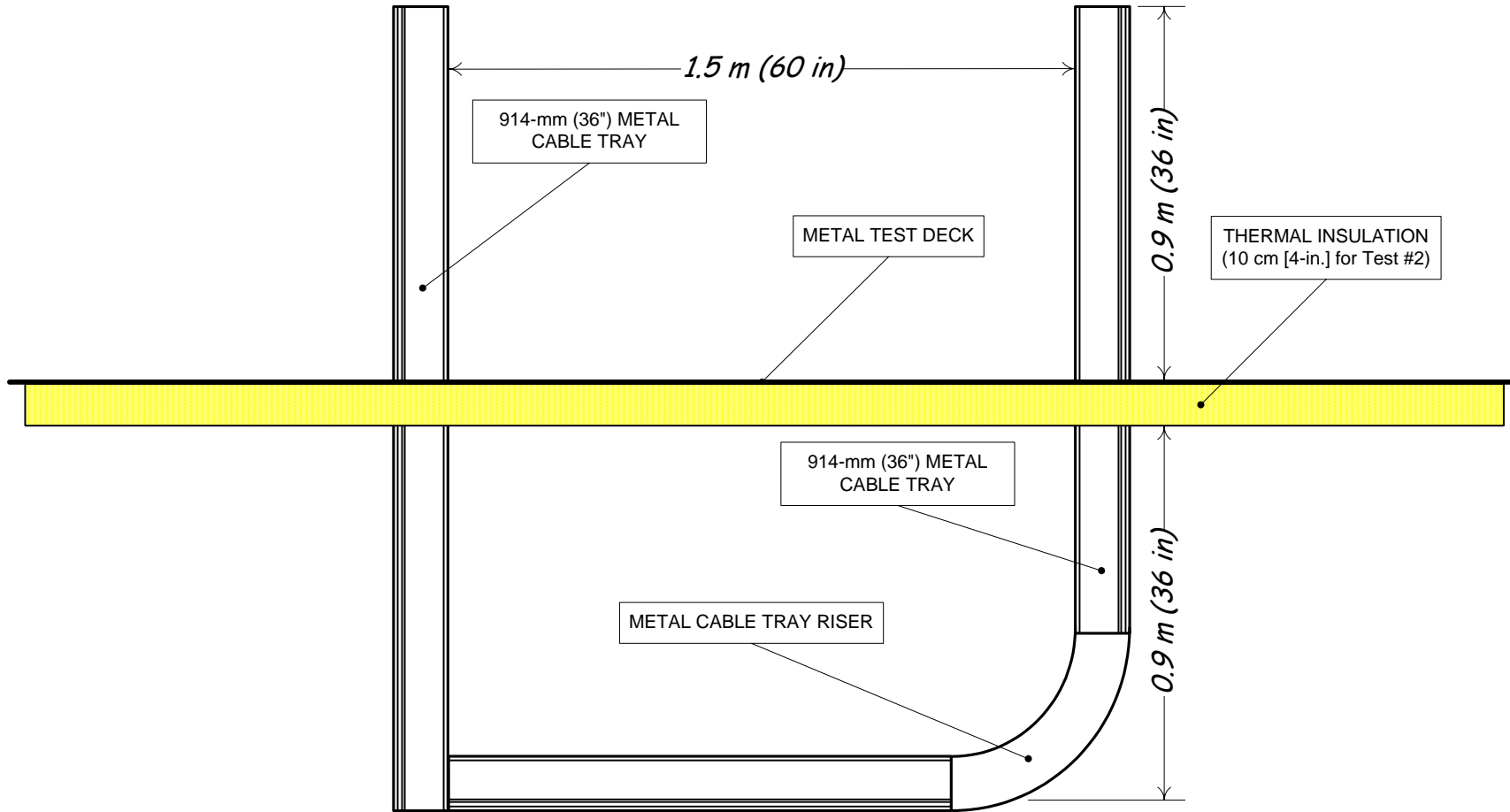


Figure A5: 914-mm (36-in) cable tray test specimens (side view with dimensions). Cable trays will be ladder type, 18-gage galvanized steel with 10 cm (4 in) high side rails and 23 cm (9 in) rung spacing.

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

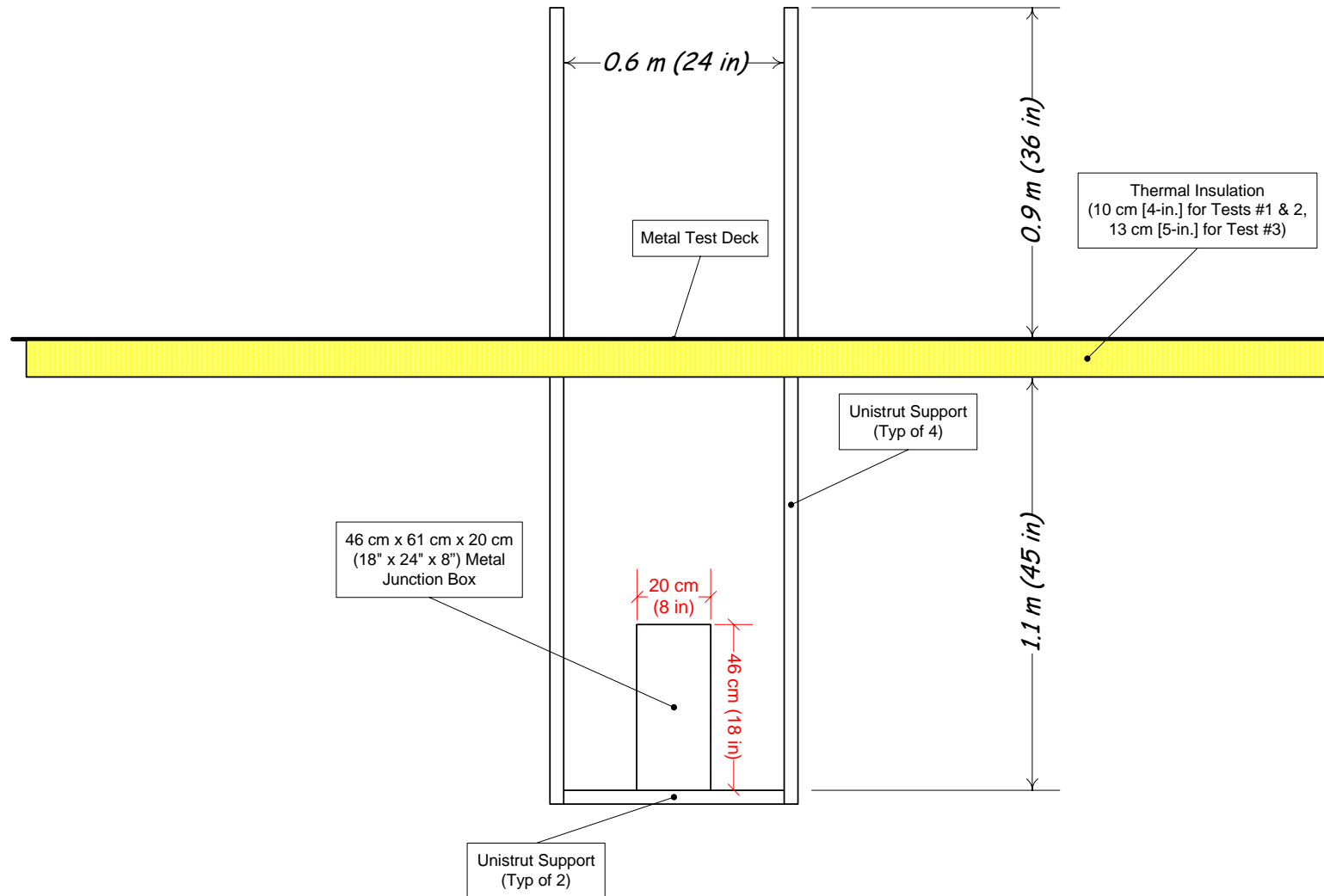


Figure A6 (a): Junction box test specimens (front elevation view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

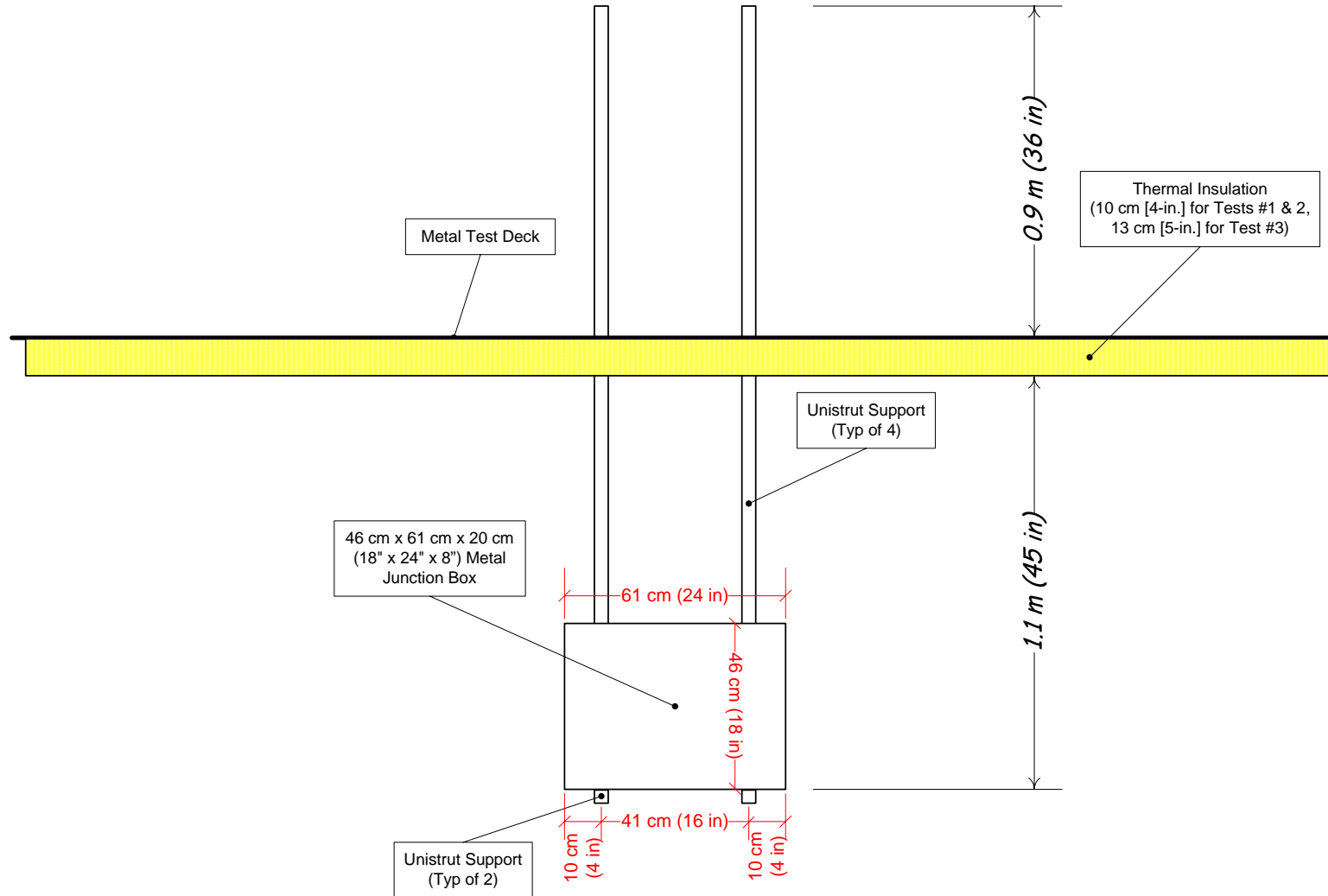


Figure A6 (b): Junction box test specimens (side elevation view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

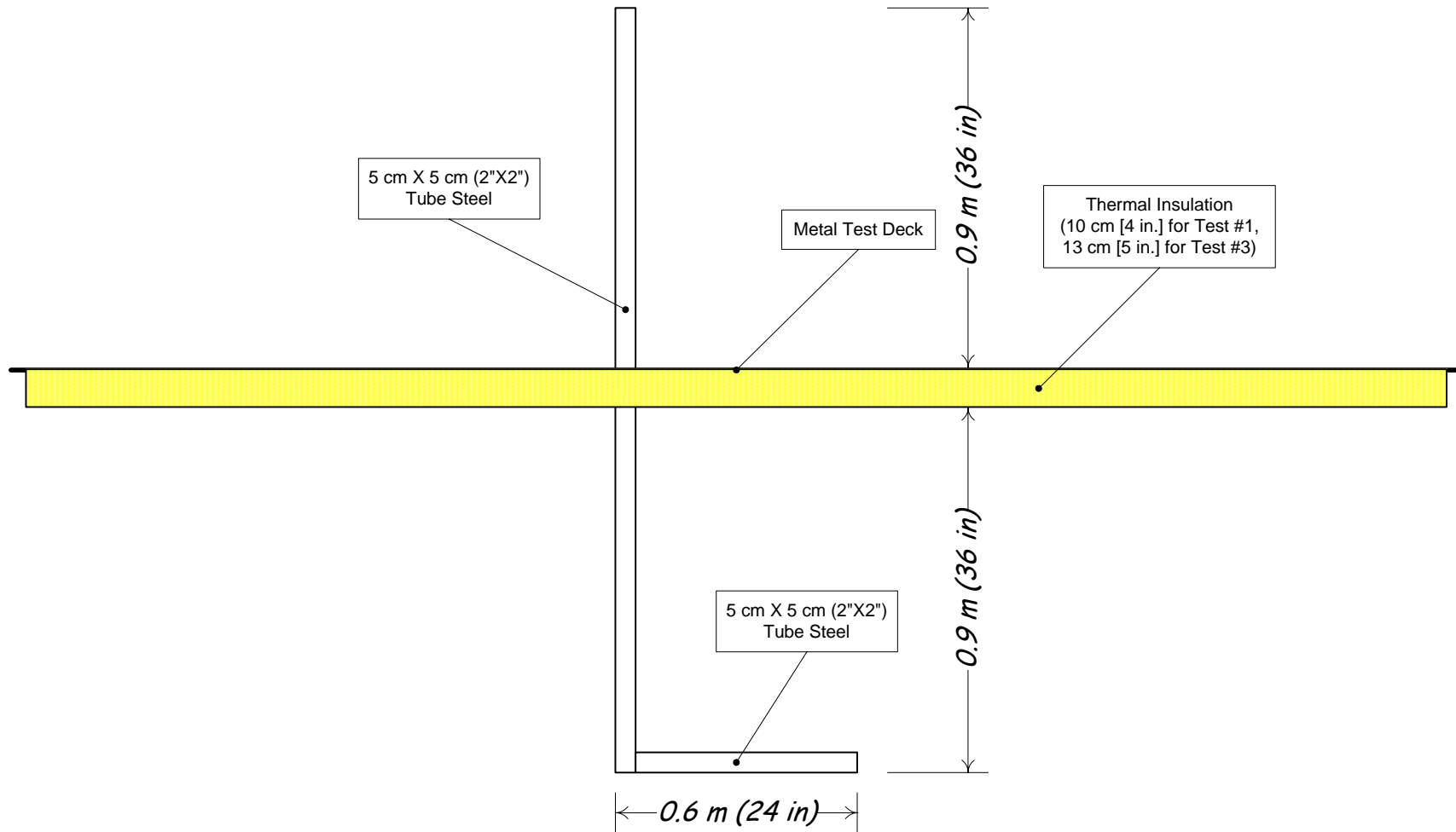


Figure A7: Tube steel support structure test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

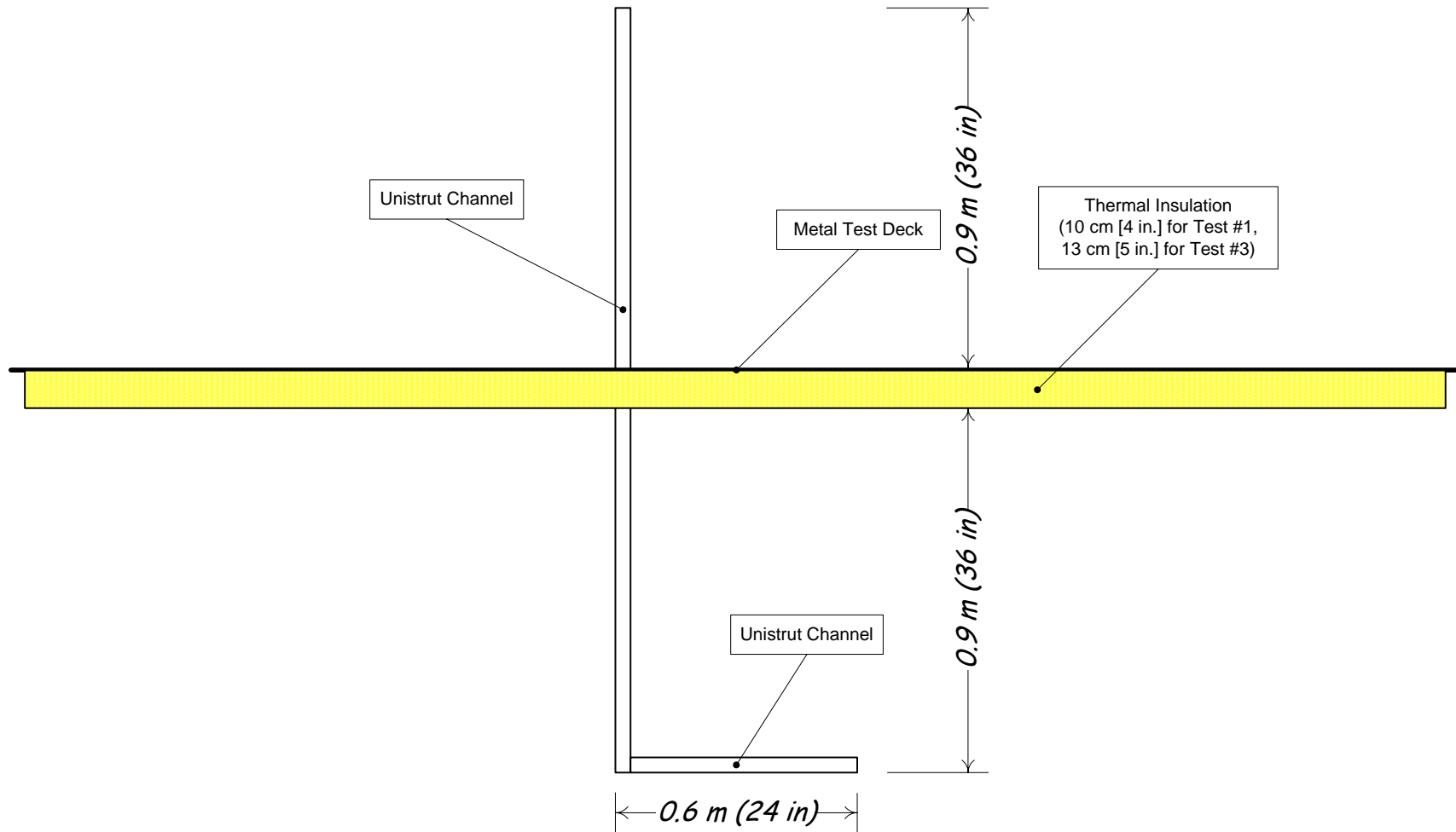


Figure A8: Unistrut® support structure test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

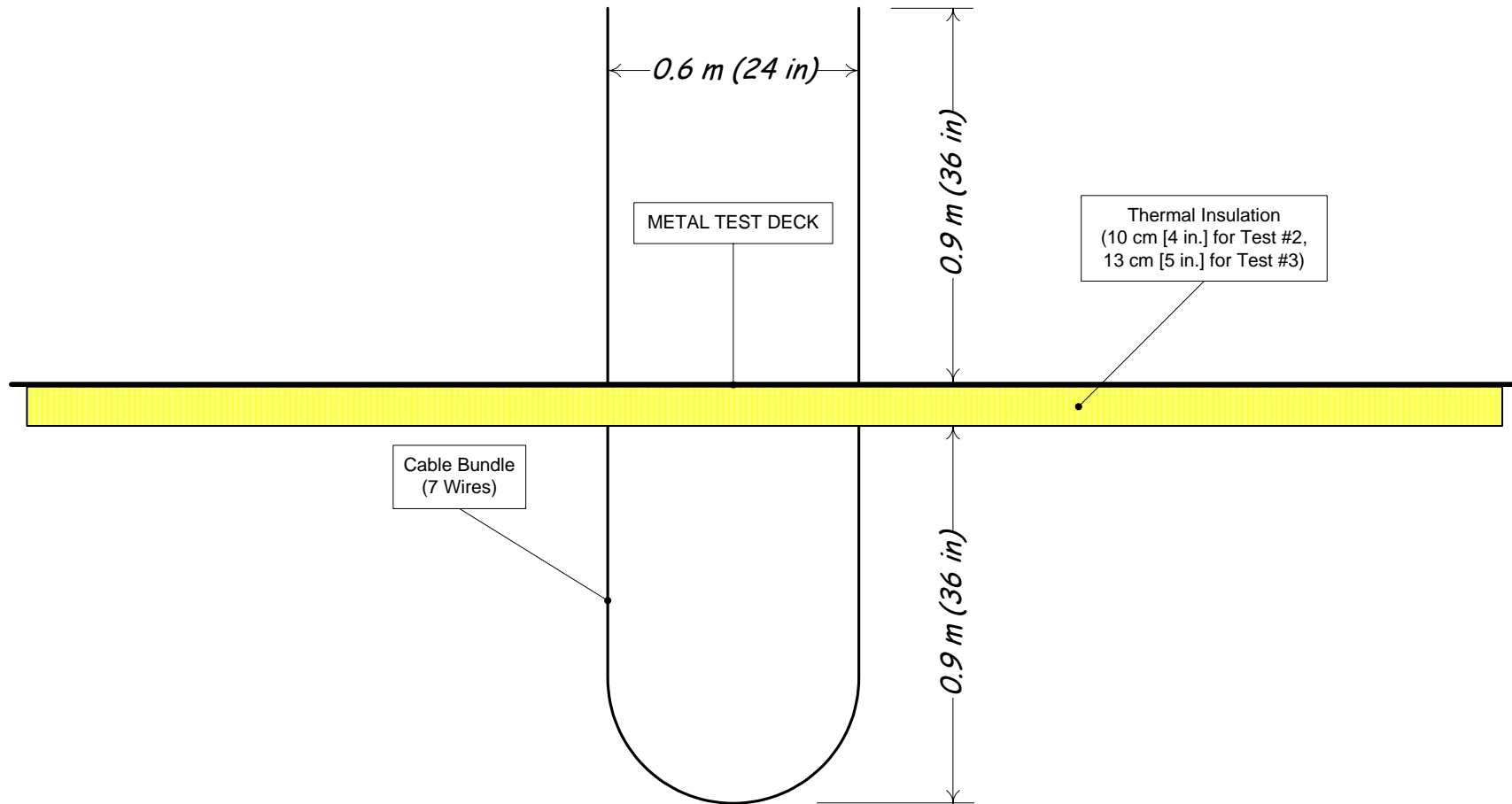


Figure A9: Unsupported cable-drop test specimens (side view with dimensions).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

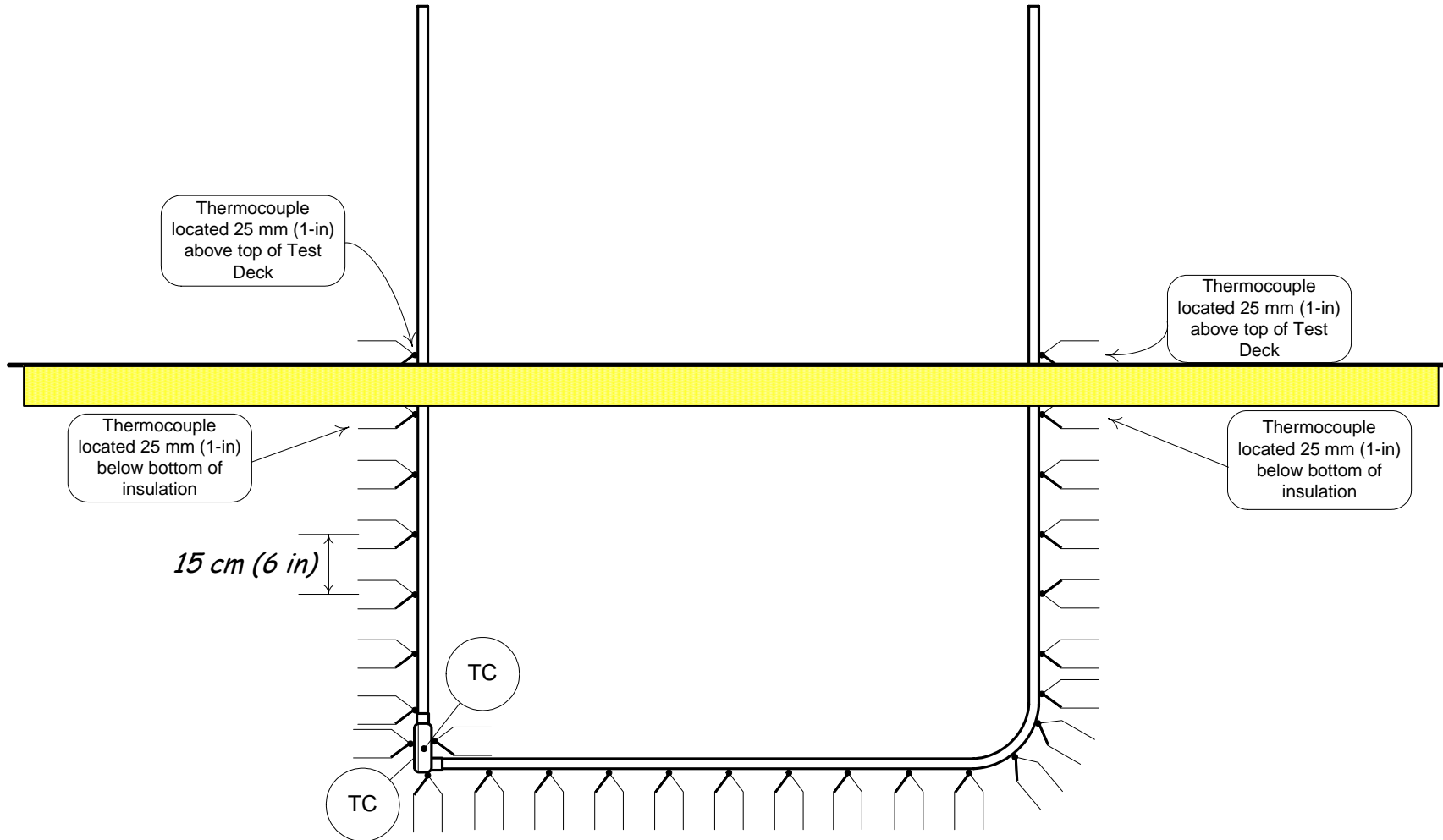


Figure A10: Thermocouple placement on 27-mm (1-in) conduit test specimens (additional thermocouples to be attached—at 150-mm [6-in] spacing intervals—to a bare #8 copper wire routed through conduit).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

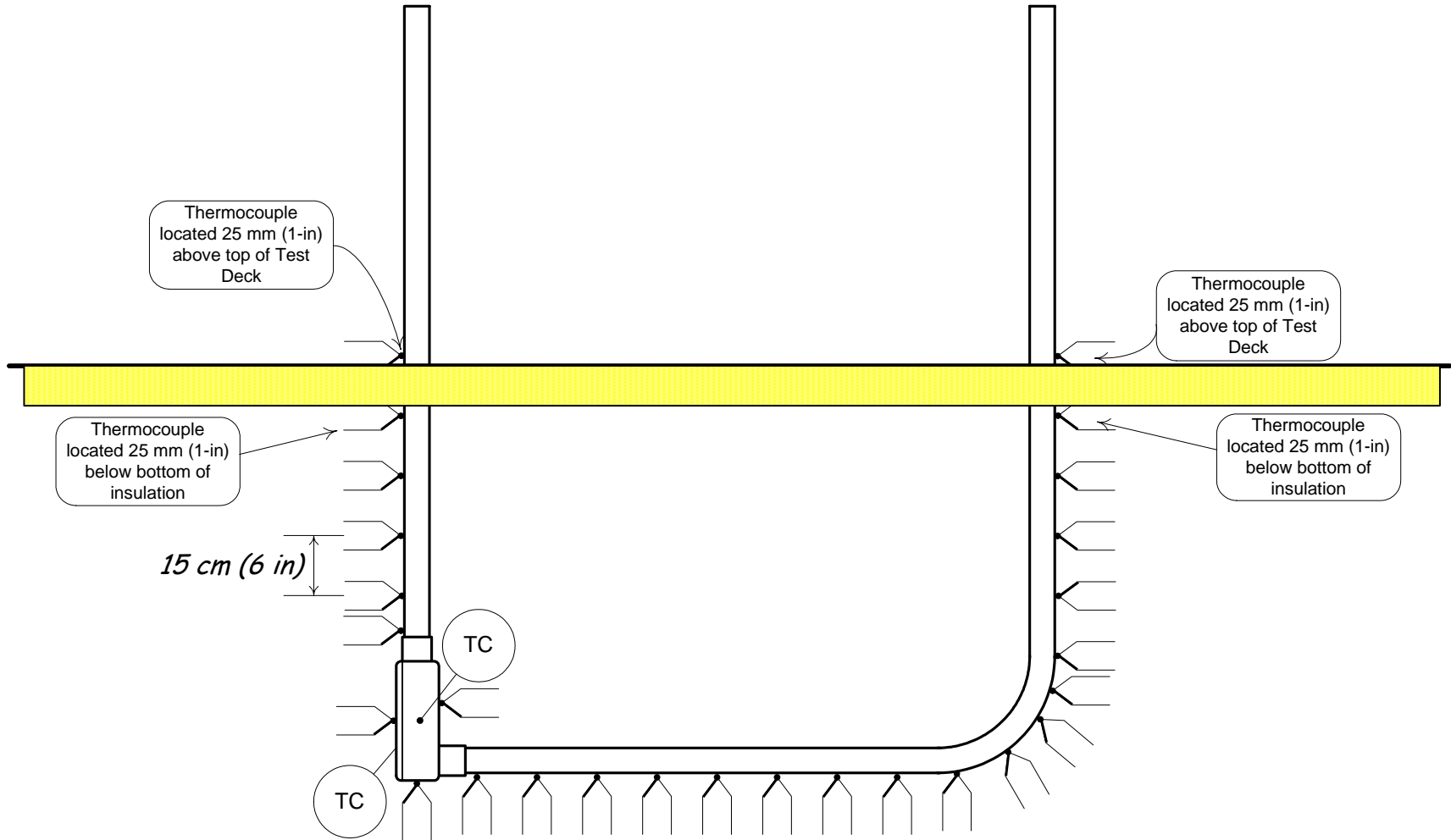


Figure A11: Thermocouple placement on 63-mm (2½-in) conduit test specimens (additional thermocouples to be attached—at 150-mm [6-in] spacing intervals—to a bare #8 copper wire routed through conduit).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

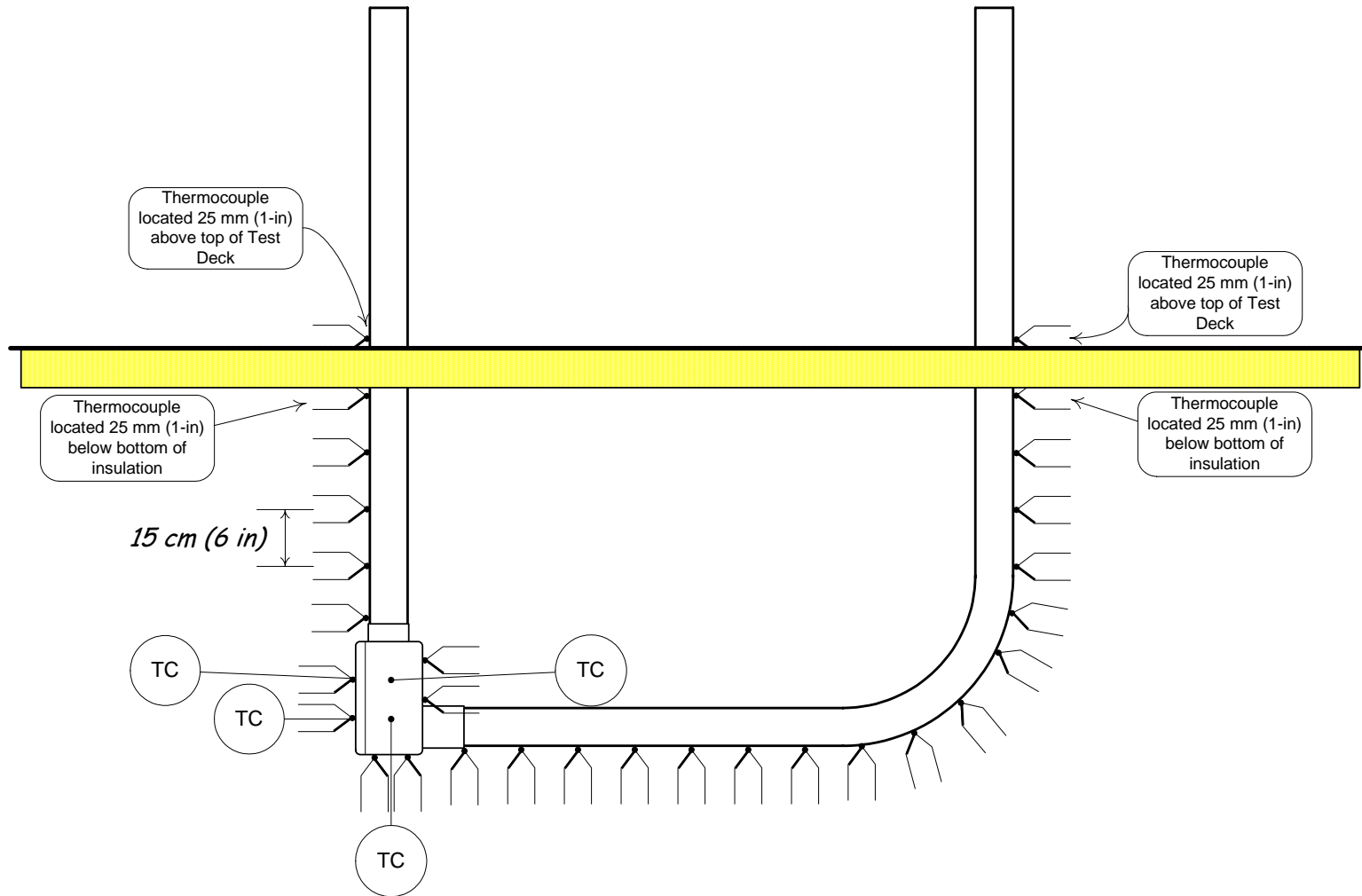


Figure A12: Thermocouple placement on 103-mm (4-in) conduit test specimens (additional thermocouples to be attached—at 150-mm [6-in] spacing intervals—to a bare #8 copper wire routed through conduit).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

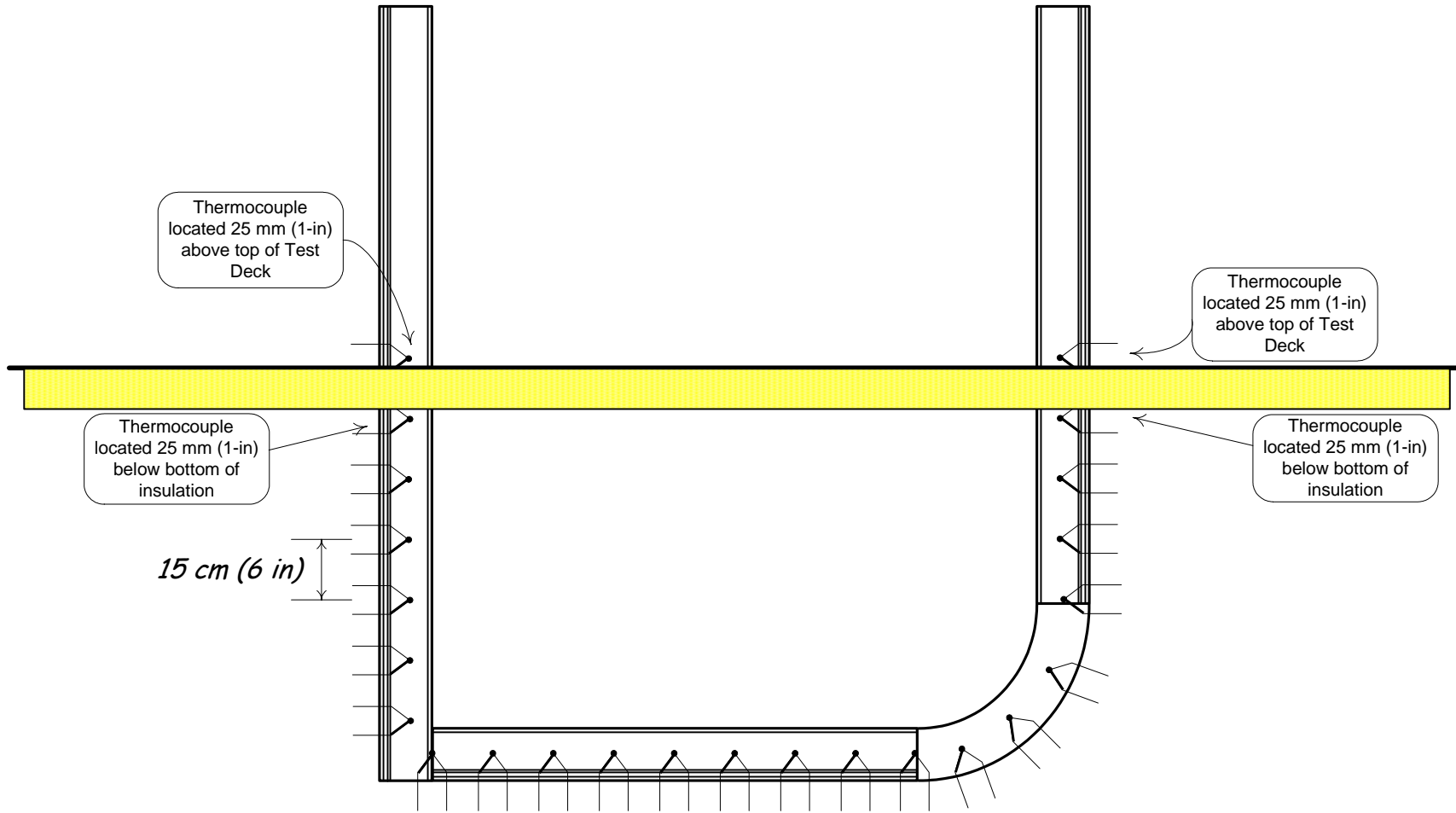


Figure A13: Thermocouple placement on 305-mm (12-in) cable tray test specimens (side view only, additional thermocouples to be attached at 150-mm [6-in] spacing intervals on other side rail and to a bare #8 copper wire routed along the mid-axis of the tray on the bottom of the rungs).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

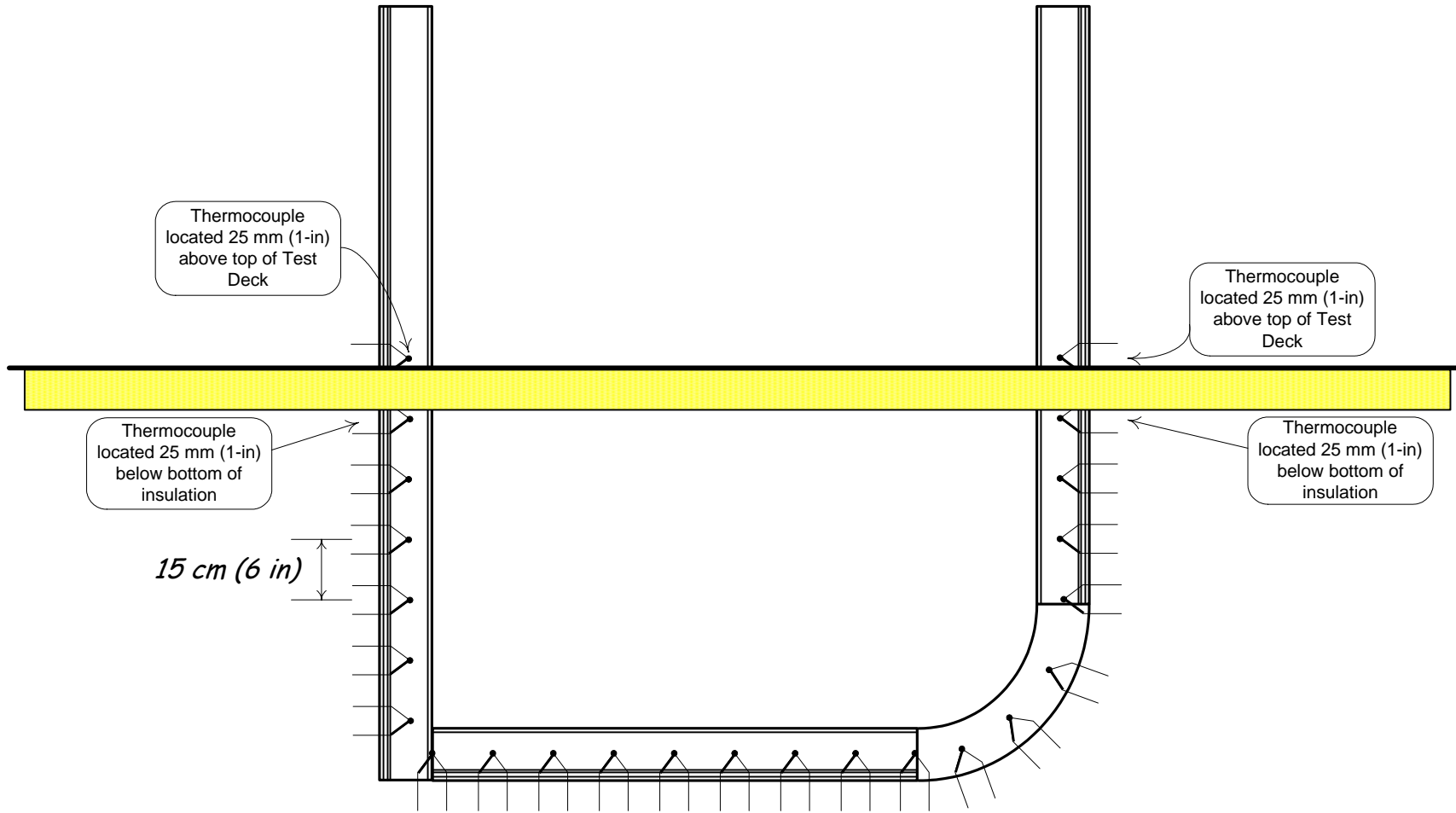


Figure A14: Thermocouple placement on 914-mm (36-in) cable tray test specimens (side view only, additional thermocouples to be attached at 150-mm [6-in] spacing intervals on other side rail and to a bare #8 copper wire routed along the mid-axis of the tray on the bottom of the rungs).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

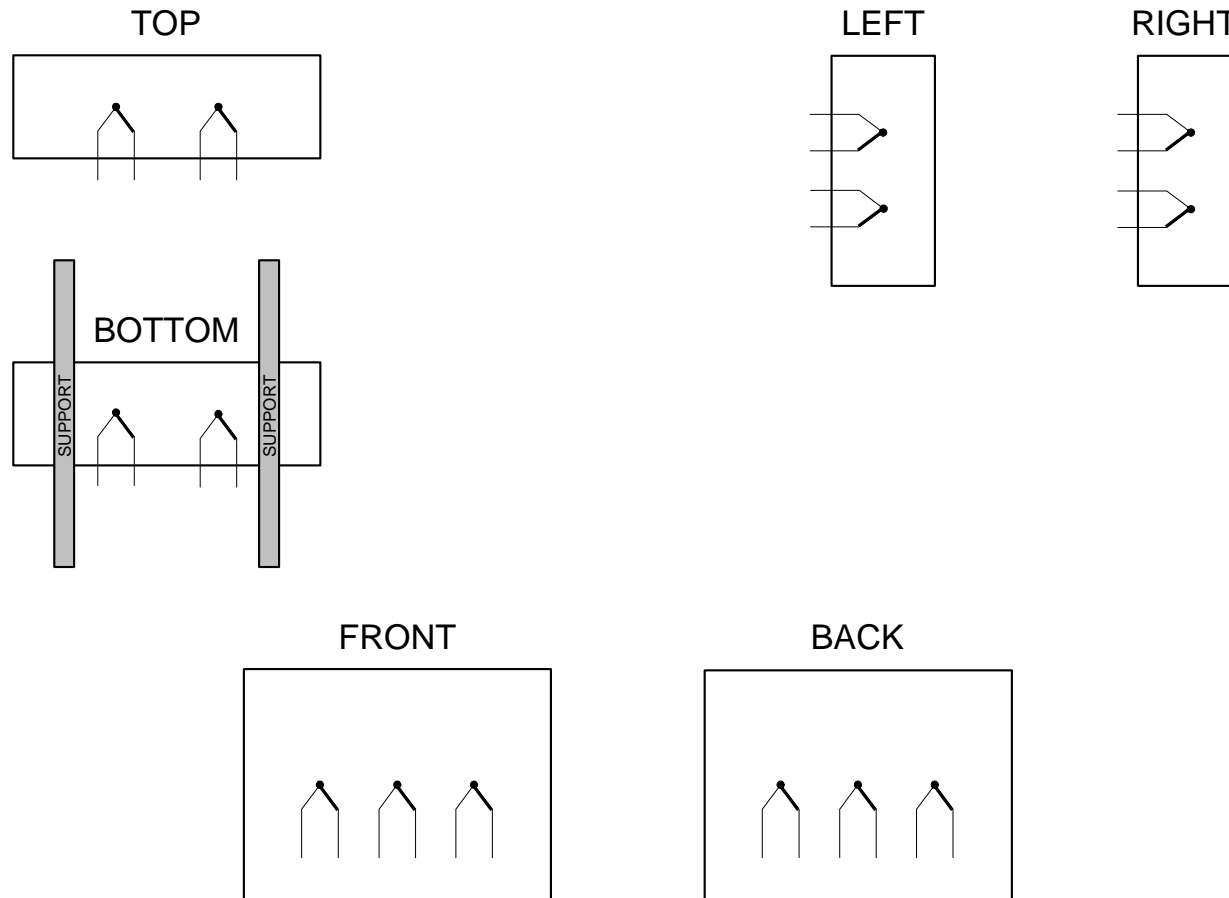


Figure A15: Thermocouple placement on junction box test specimen surfaces (no bare #8 copper conductor wire will be located inside the box and no thermocouples will be used to monitor the status of the junction box supports).

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

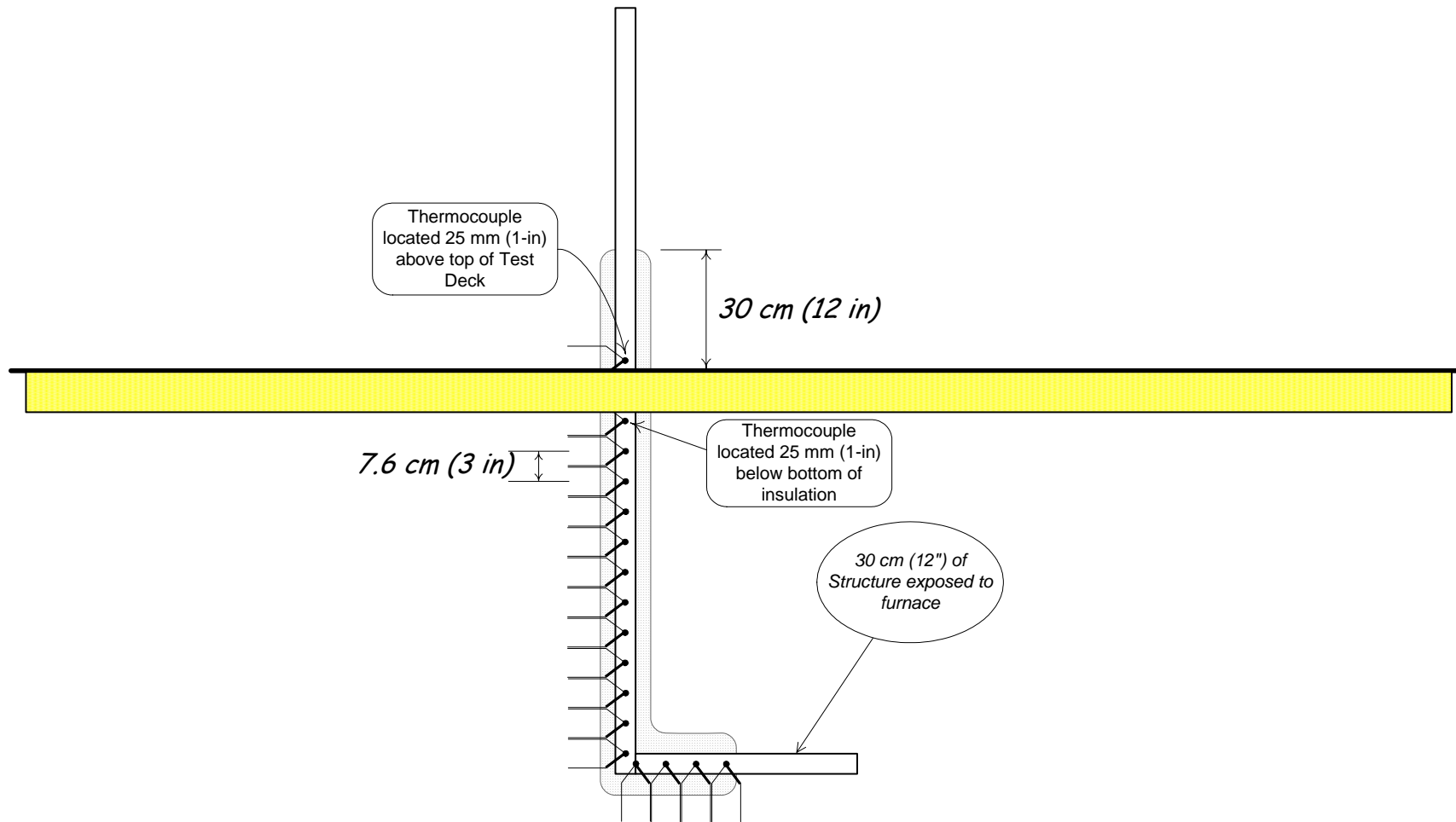


Figure A16: Thermocouple placement on tube steel support structure test specimens. (Note: ERFBS silhouette shown for reference only.)

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

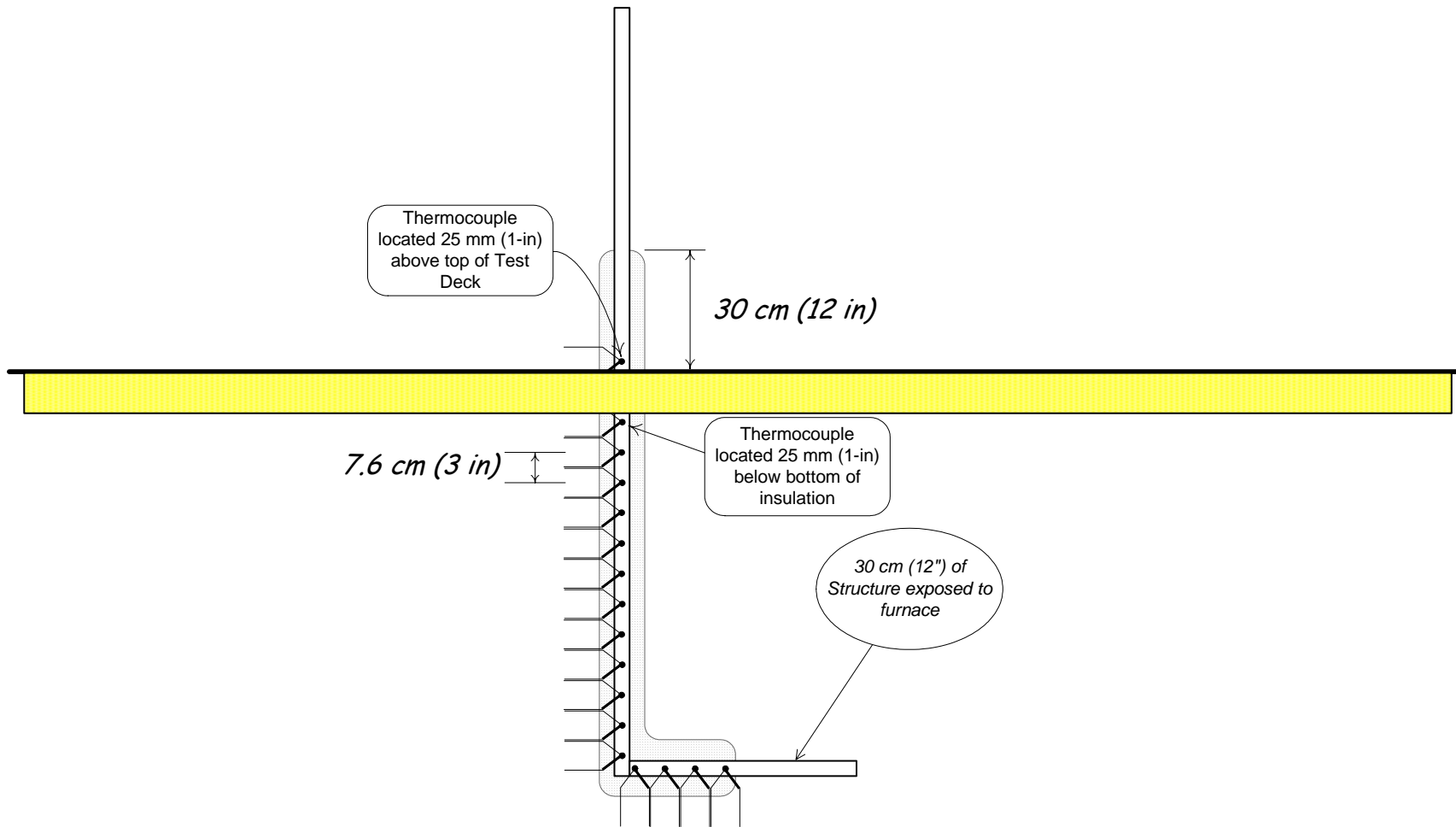


Figure A17: Thermocouple placement on Unistrut® channel support structure test specimens. (Note: ERFBS silhouette shown for reference only.)

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

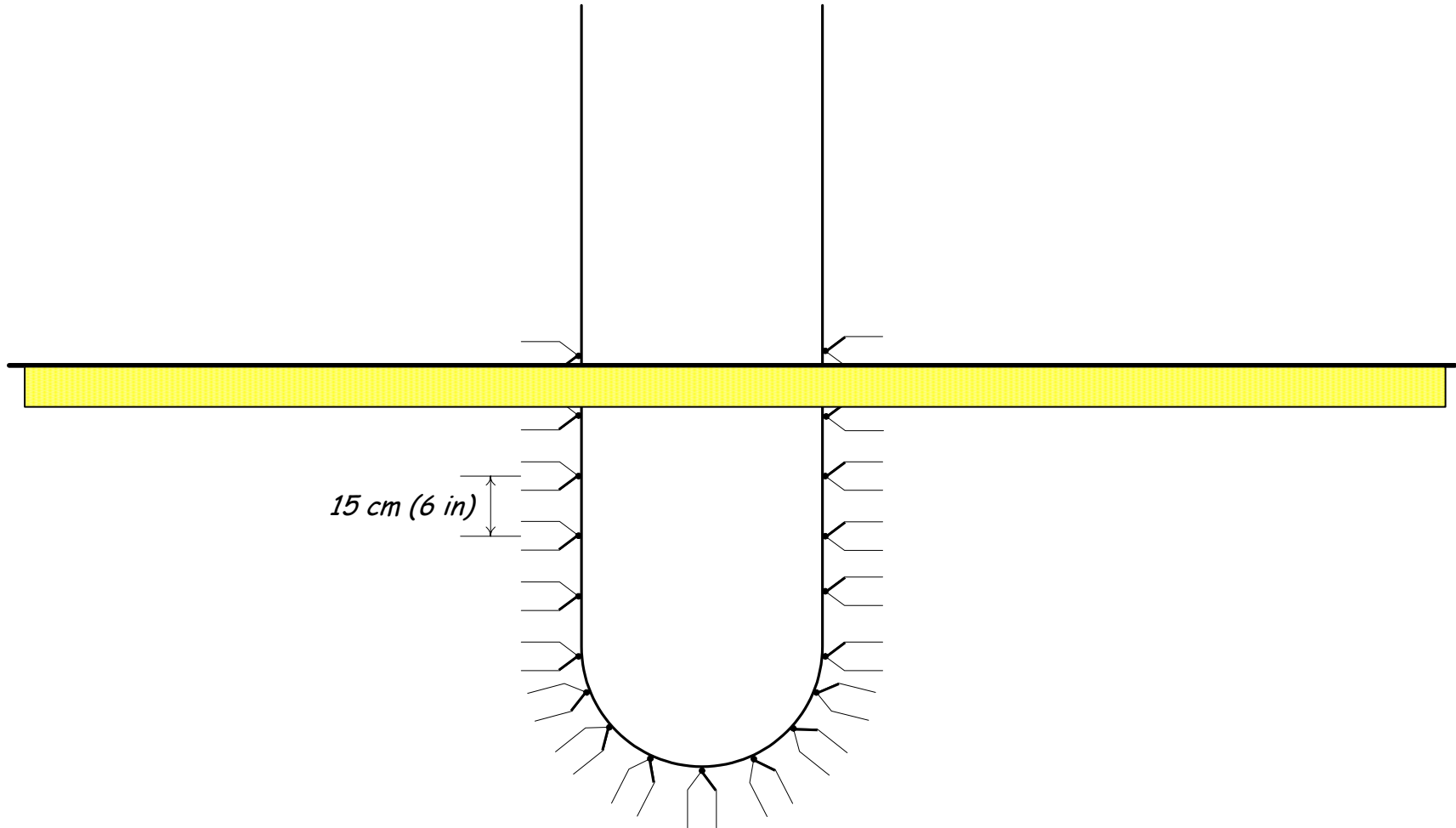


Figure A18: Thermocouple placement on unsupported cable drop test specimens.

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

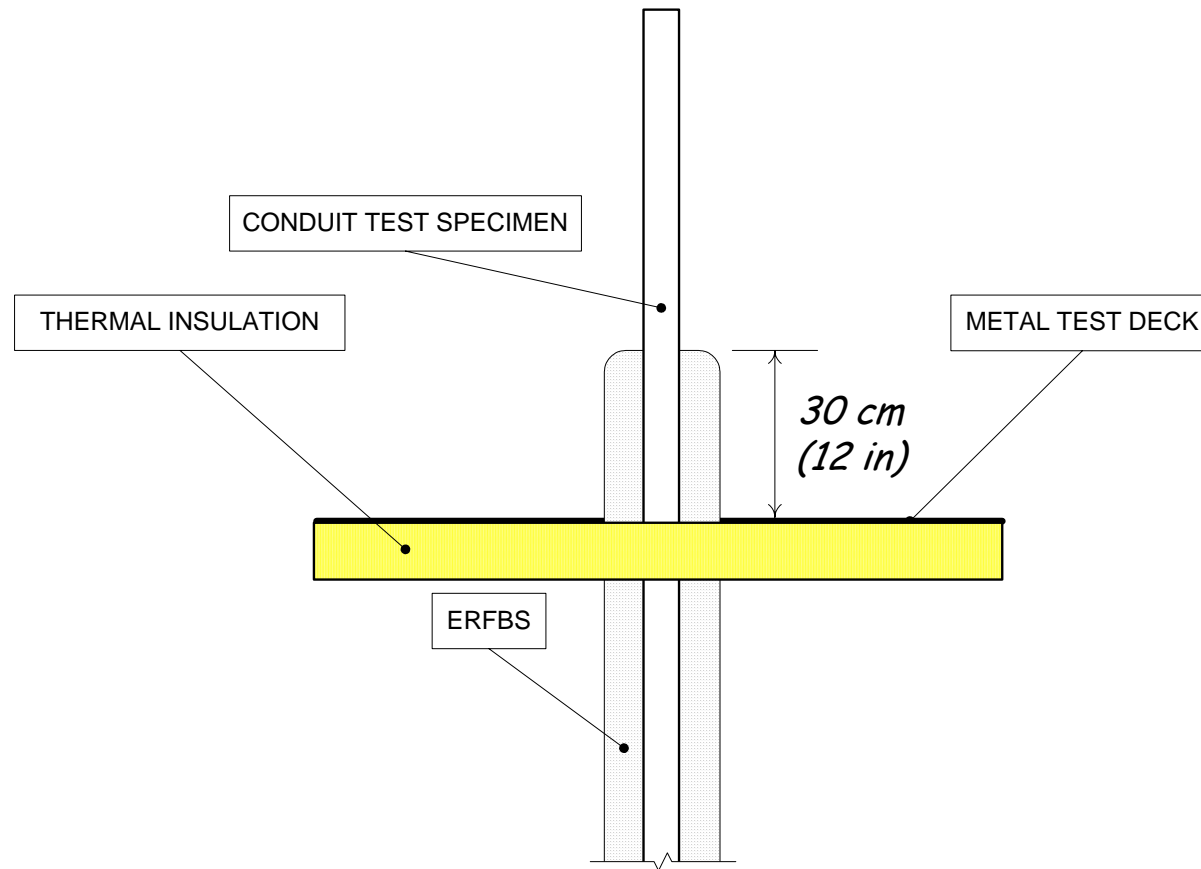


Figure A19: Detail of conduit test specimen direct attachment ERFBS extension through the test deck.

Appendix A: Test Specimen Configuration Details and Thermocouple Location Plan

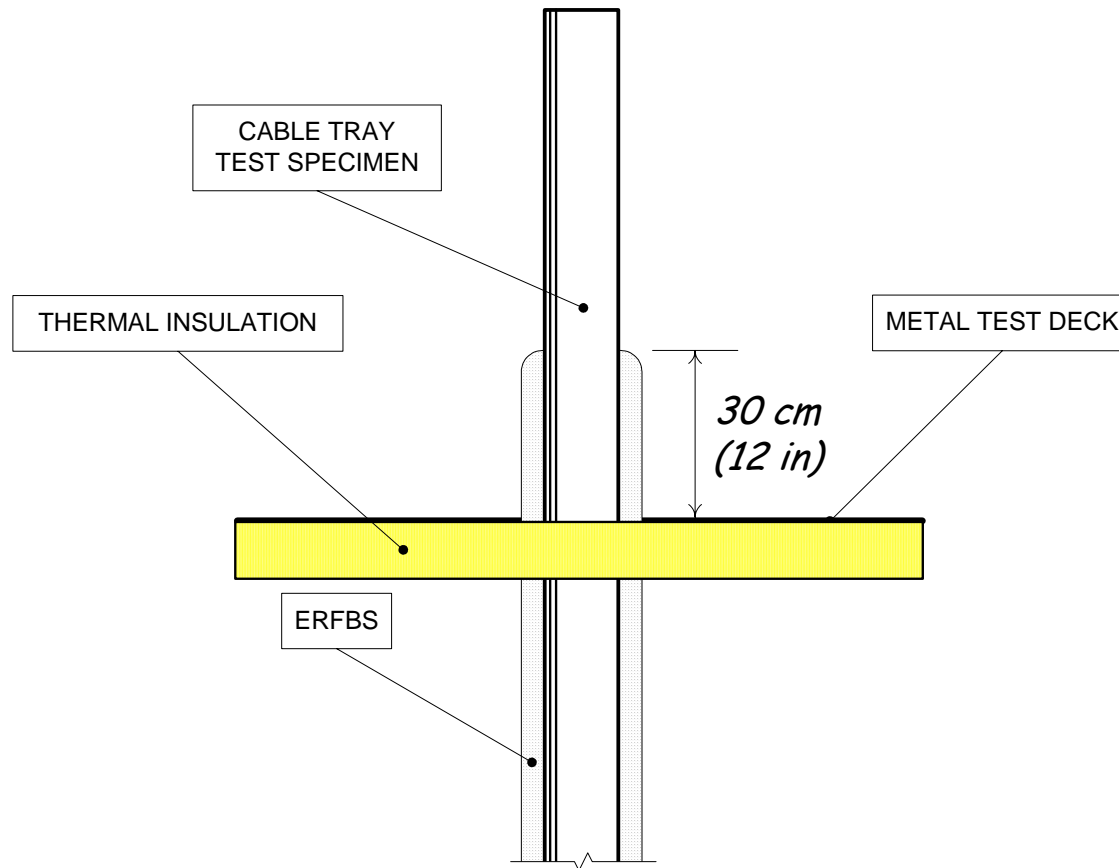


Figure A20: Detail of cable tray test specimen direct attachment ERFBS extension through the test deck.

***B* Email Correspondence from NEI to NRC Regarding Predominant Industry Practices for Hemyc**

The message below is the body of an email from Fred Emerson, NEI, to Mark Salley, NRC, dated January 18, 2005, with subject heading, “Hemyc – Predominant Industry Practices.”

Appendix B: Email Correspondence From NEI to NRC Regarding Predominant Industry Practices for Hemyc

Answer: The industry is essentially evenly split between using an overlapping joint method and the butt joint with a collar method for conduits. Typically trays use the overlapping joint method with an overlapping joint of 2 inches.