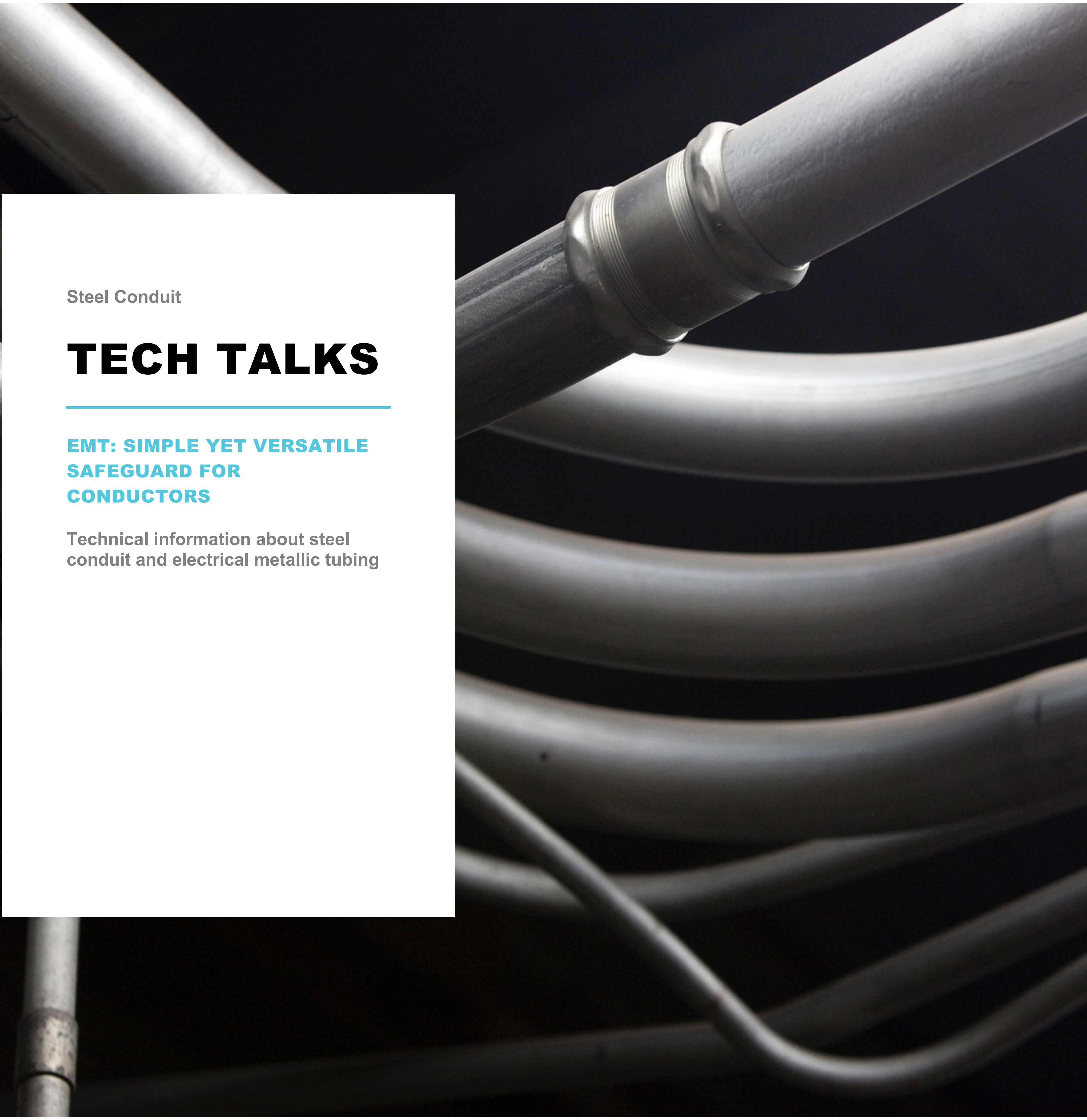
STEEL TUBE INSTITUTE



Steel Conduit

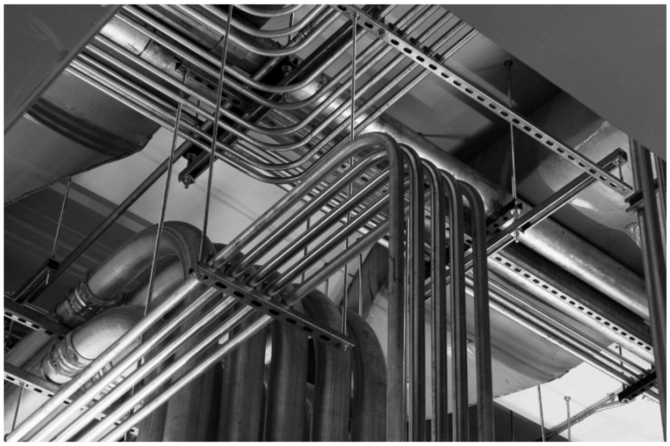
TECH TALKS

EMT: SIMPLE YET VERSATILE SAFEGUARD FOR CONDUCTORS

Technical information about steel conduit and electrical metallic tubing

ELECTRICAL METALLIC TUBING

Whether planning new construction, building an addition or renovating an existing building, choosing the correct wiring method can be crucial to the project. Depending on the type of installation, the wiring method may need to provide physical protection, be approved for exposed or concealed installations and wet locations, offer corrosion resistance and serve as an equipment grounding conductor. Electrical metallic tubing (EMT) can meet all of these installation needs, while also allowing for easy accommodation of future wiring changes. EMT is covered by Article 358 in the National Electrical Code® (NEC®). Section 358.2 defines EMT as "an unthreaded thin-wall raceway of a circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings." EMT is generally made from steel (ferrous) with protective coatings, or aluminum (nonferrous).



PHYSICAL PROTECTION

The NEC allows the use of EMT in areas subject to **physical damage**, but not in areas where it will be subject to **severe physical damage** during or after installation. Other popular branch circuit wiring methods, such as MC cable (Article 330), are not allowed where subject to any physical damage. In other words, EMT is considered a wiring method that offers more protection to conductors than MC cable does. In order to demonstrate that difference in physical protection, the Steel Tube Institute Conduit Technical Committee contracted with Intertek (ETL SEMKO) to perform comparative crush and impact testing. Read the complete report here:

ETL Test Report: EMT & MC Cable

The following sample configurations were chosen for testing:

- ½ EMT with 2 conductors of 14-gauge THHN
- ½ EMT with 3 conductors of 14-gauge THHN
- ¾ EMT with 2 conductors of 12-gauge THHN
- ¾ EMT with 3 conductors of 12-gauge THHN
- 14/2 aluminum MC cable with green grounding conductor
- 14/3 steel MC cable with green grounding conductor
- 14/3 aluminum MC cable with green grounding conductor
- 12/2 steel MC cable with green grounding conductor
- 12/2 aluminum MC cable with green grounding conductor
- 12/3 aluminum MC cable with green grounding conductor
- 12/3 steel MC cable with green grounding conductor

ETL used the crush test and impact test procedures from UL 1569, *Standard for Safety: Metal-Clad Cables* with deviations as the basis for the testing procedures. Deviations were made to the two tests in order to take both products to failure.

DEVIATIONS FROM STANDARD TEST METHODS

Impact tests were conducted on 3 ft. sections of EMT or MC cable instead of the required 10 impacts over a single continuous length of at least 11 ft. Additionally, instead of the 1.5 ft. drop height as specified in the standard, the maximum failure height of each sample was determined and reported.

Crush tests were conducted on 3 ft. sections of EMT or MC cable instead of the required ten (10) crush tests over a single continuous length of at least 100 in.

CRUSH TEST

The crush test was performed in accordance with UL 1569, Section 25, Crushing Test – All Cable with slight deviations, as referenced above. **The importance of the crush test is that it shows the raceway's ability to endure field hazards such as construction variables, structure shifts and physical abuse (such as forklift damage or construction workers stepping on the raceway).**

For each product type, three samples, each measuring 3 ft. long, were used for testing. Each test sample was placed into an Instron universal testing machine and laid over a steel rod with a ¾ in. diameter. The top compression plate was a flat plate that measured 2 in. wide. All of the insulated circuit conductors in the length of EMT were connected in series with a buzzer and its supply circuit, one leg of which was earth-grounded. All grounding conductors in the test length were connected to the conduit body, to all metal parts of the compression apparatus, to earth ground and to the grounded supply wire. Each sample was tested at a compression rate of 0.50 ± 0.05 in. / min until one or more of the indicators signaled that contact occurred between the circuit conductors or between one or more of the circuit conductors and any grounding conductor, the conduit body or both. The maximum load obtained at the moment of contact was recorded. The three test results were averaged and reported in Table 1. Below are the results of the crush test, which show that EMT clearly outperforms MC cable, validating the NEC allowable uses for EMT and MC cable:

Table 1 Crush Test Results

Sample Type	Point of Failure
½ EMT with two 14 AWG conductors	1,809 lbf
½ EMT with three 14 AWG conductors	1,845 lbf
¾ EMT with two 12 AWG conductors	2,155 lbf
½ EMT with three 12 AWG conductors	2,016 lbf
14/2 aluminum MC cable with green grounding conductor	1,011 lbf
14/3 steel MC cable with green grounding conductor	808 lbf
14/3 aluminum MC cable with green grounding conductor	834 lbf
12/2 steel MC cable with green grounding conductor	848 lbf
12/2 aluminum MC cable with green grounding conductor	792 lbf
12/3 steel MC cable with green grounding conductor	720 lbf
12/3 aluminum MC cable with green grounding conductor	895 lbf

IMPACT TEST

The impact test was conducted in accordance with UL 1569 Section 24, Impact Test, with minor deviations. **The impact test is an important indicator of the raceway's ability to handle mechanical abuse. One example of such mechanical abuse would be an item being dropped on the raceway during the construction process.**

For each product type, three samples, each measuring 3 ft. long, were used for testing. Test samples were placed into an impact test apparatus and laid over a steel rod with a ¾ in. diameter. All of the insulated circuit conductors in the length of EMT were connected in series with a 3-W 120-V neon lamp to one of the energized conductors of a 208-V 48–62 Hz 4-wire grounded-wye a-c supply circuit. The insulated grounding conductor in the test length of the tubing was connected to the conduit body, to all parts of the impact apparatus, to earth ground and to the grounded supply wire. Each test sample was impacted at the center of each 3 ft. section using an impact weight of 10 lb. The impact weight was a solid rectangular block of steel, with the impact face measuring 2 x 6 in. The impact weight was raised to the required drop height. A release mechanism allowed the impact weight to fall freely in the guides of the impact apparatus and strike the sample. Upon impact, the neon lamps were observed to see if they lit, indicating momentary or other contact between the circuit conductors or between one or both of the circuit conductors and the grounding conductor, conduit body or both. The maximum impact height was reported for three consecutive failures. Below, in Table 2, are the results of the impact test, which show that EMT clearly outperforms MC cable, validating the NEC allowable uses for EMT and MC cable:

Table 2 Impact Test Results

Sample Type	Point of Failure
½ EMT with two 14 AWG conductors	96" without failure; wires still moved freely
½ EMT with three 14 AWG conductors	96" without failure; wires still moved freely
¾ EMT with two 12 AWG conductors	96" without failure; wires still moved freely
½ EMT with three 12 AWG conductors	96" without failure; wires still moved freely
14/2 aluminum MC cable with green grounding conductor	Failure at 24"; wires were pinched
14/3 steel MC cable with green grounding conductor	Failure at 30"; wires were pinched
14/3 aluminum MC cable with green grounding conductor	Failure at 24"; wires were pinched
12/2 steel MC cable with green grounding conductor	Failure at 30"; wires were pinched
12/2 aluminum MC cable with green grounding conductor	Failure at 24"; wires were pinched
12/3 steel MC cable with green grounding conductor	Failure at 26"; wires were pinched
12/3 aluminum MC cable with green grounding conductor	Failure at 24"; wires were pinched

GROUNDING CAPABILITIES

NEC Sections 358.60 and 250.118(4) allow the use of EMT as an equipment grounding conductor. In 1994, the Steel Conduit / EMT Section of the National Electrical Manufacturer's Association (NEMA) contracted with the Georgia Institute of Technology to develop a testing program that would provide documentation to show that steel rigid conduit, IMC and EMT met all the requirements for equipment grounding conductors in NEC Article 250, and validate the values shown in the well-known Soares Book on Grounding, which was being updated by the International Association of Electrical Inspectors (IAEI).

Georgia Tech was asked to develop a test program to determine the following:

"Do steel EMT, IMC and RMC conduit in a specific system perform effectively as equipment grounding conductors with (a) the capacity to safely conduct any fault current likely to be imposed on them, and (b) sufficiently low impedance to limit the voltage to ground and facilitate the operation of the circuit protective devices, as stated in Section 110.10 and Section 250.4 of the National Electrical Code (NEC)?" (A.P. Sakis Meliopoulos & Elias N. Glytsis, 1994)

GROUNDING CAPABILITIES

Georgia Tech was able to investigate the above issues through: (a) modeling of steel conduit enclosed multi-conductor systems, (b) laboratory testing of several representative steel conduit types under low currents for the purpose of characterizing the magnetic material, (c) computer simulation of steel conduit-enclosed secondary distribution systems, (d) full-scale testing of steel conduit-enclosed power systems under high fault current, (e) full-scale measurement of arc voltage for various fault current levels, and (f) analysis of full-scale test results and conclusions. The full test report and results can be viewed here: Meliopoulos & Elias N. Glytsis, 1994)

Modeling and Testing of Steel EMT, IMC and Rigid (GRC) Conduit

Modeling and Evaluation of Conduit Systems for Harmonics and Electromagnetic Fields

A summary of the results showed that steel EMT allowed the flow of a higher fault current than an equipment grounding conductor as listed in the NEC Table 250.122 and that steel EMT met all the requirements of Article 250 of the NEC. The testing also showed that supplemental grounding conductors in secondary power systems enclosed in steel EMT are not necessary, although they may be required by the NEC in certain special installations such as health care facilities or by the designer / specifying engineer.

CORROSION PROTECTION

The NEC allows the use of EMT in corrosive environments including concrete, direct burial and in wet locations “where protected by corrosion protection and approved as suitable for the condition.” EMT has a factory corrosion protective coating applied to the exterior that can be zinc or it can be a nonmetallic or other type of alternate corrosion-resistant coating. ACRAC, the factory-applied interior coating, may be of zinc or be an organic coating, which meets the requirements of UL 797 Safety Standard for Electrical Metallic Tubing – Steel and complies with the NEC requirements for corrosion protection. In addition to the primary corrosion protection, the use of one or more supplementary coatings is permitted. Since the supplementary coating or coatings are in addition to the primary corrosion-resistant coating, they are not required to meet the requirements for the primary coating. However, it is not prohibited to have more than one as the primary coating. Supplementary coating(s) not evaluated as primary protection will be marked on the listing label.

When installing EMT in corrosive environments or wet locations, it is important to select a fitting that is also suitable for that application.
For more information on corrosion protection of EMT and steel conduit, click here:

Steel Conduit Tech Talk: Corrosion Protection

IN SUMMARY

EMT offers superior physical protection to conductors as compared to MC cable, and also has the ability to easily change and update circuits. EMT has an excellent corrosion protection coating and can be depended on for a long service life. Steel EMT’s surface area offers a low impedance current path, making it an optimal option for use as an equipment grounding conductor.

Therefore, the next time you need a simple, versatile and tough wiring method ...THINK EMT!