STEEL TUBE INSTITUTE

CONDUIT COMMITTEE

Guidelines for Installing Steel Conduit/Tubing

2516 Waukegan Road, Suite 172
Glenview, IL 60025

TEL: 847.461.1701
FAX: 847.660.7981
steeltubeinstitute.org

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1. Scope

This guideline covers the installation of steel rigid metal conduit (RMC), steel intermediate metal conduit (IMC), and steel electrical metallic tubing (EMT). Conduit with a supplementary PVC coating is also included. These conduits are used as raceway systems for electrical wiring in residential, commercial, and industrial occupancies. This Guideline includes information on fittings and other applicable accessories necessary for a quality installation of these raceways. All information in this publication is intended to comply with the National Electrical Code® (NFPA Standard 70). Installers should always follow the NEC and/or state and local codes as applicable to the jurisdiction, and the manufacturers' instructions when installing electrical products and systems.

Installations must be performed "in a neat and workmanlike manner." This is one of the most basic and important requirements for electrical wiring in the National Electrical Code.

It is essential that the installer be concerned, informed, and have pride in the finished product. Maintaining the effectiveness of Code requirements depends on selecting the right product for the specific job, good installation workmanship, and proper maintenance during the life cycle.

This document is intended to enhance electrical safety by aiding the installer in meeting the "neat and workmanlike" requirements, reducing future repair needs, providing for future expansion to avoid electrical overload, creating an installation which will protect the wire conductors from mechanical abuse, and providing electrical continuity of the raceway system.

NOTE: For continuing updated information on this document, check ***steeltubeinstitute.org/steel-conduit***

2. Glossary

(As used in this Guideline)

Alternate corrosion protection
A coating(s), other than one consisting solely of zinc, which, upon evaluation, has demonstrated the ability to provide the level of corrosion resistance required on the exterior of the conduit. It is not prohibited that the coatings include zinc.

Approved
Acceptable to the authority having jurisdiction.

NOTE: "The authority having jurisdiction" is most often the electrical inspector, but could be a project manager or other final approval authority.

Authority having jurisdiction (AHJ)
The organization, office, or individual with the authority to determine which code requirements apply, how they are to be interpreted, and who gives final approval to the electrical installation. Some examples are the electrical inspector or other government entity and insurance underwriters.

Bend
A curvature of the conduit or tubing made so the raceway will fit a specific geometric location. This can be a factory elbow or can be a field bend of the raceway.

Circuit loading
Concentration of circuits in one raceway.

Conduit connection
Interface between conduit or tubing and other equipment.

Conduit joint
The coupling of two pieces of conduit or tubing, or coupling a length of conduit or tubing to a bend. NOTE: One of the most important elements of an electrical installation.

Coupling, integral
A coupling meeting the requirements of UL 514B which is assembled to the conduit, tubing, or elbow during manufacture and is not readily removable. The integral coupling of electrical metallic tubing is a "belled" end with set screws.

Coupling, standard conduit
As applied to IMC or steel RMC this is a threaded, straight-tapped means of joining two pieces of conduit. Such coupling meets the requirements of the applicable UL conduit standard.

Equipment grounding conductor
As defined in the NEC, it is the path by which a ground fault is transmitted to the overcurrent protection device.

NOTE: Steel conduit and tubing are called equipment grounding conductors, as are copper or aluminum wire.

Firestopping
Using approved materials (generally detailed by building codes or specifications) which fill the opening (annular space) around the conduit to prevent the spread of fire and smoke and assure the fire rating of the wall, floor, or ceiling being penetrated is not reduced.

Fire-resistance-rated assemblies
Construction materials assembled together then tested and rated for ability to inhibit the spread of fire for a specified period of time under specific test conditions. The rating is expressed in hours; e.g. 1 hour, 2 hour, etc. Information can be found in various laboratory "listing" directories.

Fitting, threadless
A fitting intended to secure, without threading, rigid or intermediate metal conduit or electrical metallic tubing to another piece of equipment (connector) or to an adjacent length of conduit or tubing (coupling).

Galvanized
Protected from corrosion by a specified coating of zinc which may be applied by either the hot-dip or electro-galvanized method.

Home run
The run of raceway between the panelboard/switchboard and the first distribution point.

Identified (for use)
As defined in the NEC.

NOTE: For the purposes of this Guideline the product has been evaluated for a specific purpose, environment or application and written documentation or labeling verifying this exists.

Penetration firestop system
A listed assemblage of specific materials or products that are designed, tested and fire resistance-rated in accordance with ASTM E814 to resist, for a prescribed period of time, the spread of fire through penetrations in fire-rated assemblies.

Primary coating
The corrosion protection coating evaluated by the listing authority and required by the applicable standard for listing.

Running threads
Continuous straight threads cut into a conduit and extended down its length — not permitted on conduit for connection at couplings.

Raceway
As defined in the NEC, this term includes more than steel conduit. In this Guideline it is steel rigid metal conduit, intermediate metal conduit, or electrical metallic tubing, designed for enclosing and protecting electrical, communications, signaling and optical fiber wires and cables.

Supplementary coating
A coating other than the primary coating applied to listed conduit/tubing either at the factory or in the field to provide additional corrosion protection where needed.

3. General Product Information

3.1 STEEL CONDUIT AND TUBING

The wall thickness and strength of steel make RMC, IMC, and EMT the wiring methods recognized as providing the most mechanical protection to the enclosed wire conductors. Additionally, a properly installed steel RMC, IMC or EMT system is recognized by the NEC as providing its own equipment grounding path.

3.1.1 STEEL RIGID METAL CONDUIT — RMC (FERROUS METAL)

(NOTE: While the scope of the National Electrical Code Article for Rigid Metal Conduit — Type RMC includes conduits manufactured from aluminum, stainless steel, red brass or other metals, they are not covered by this guideline.)

Steel Rigid Metal Conduit (RMC) is a listed taper-threaded metal raceway of circular cross section with a straight tapped coupling (see Figure 1) or an integral fitting (see Figure 4).

Threads are protected on the uncoupled end by color-coded thread protectors which keep them clean and sharp and aid in trade size recognition. Steel RMC is available in trade sizes ½ through 6. Thread protectors for trade sizes 1, 2, 3, 4, 5, and 6 are color-coded blue; trade sizes ½, 1½, 2½, 3½ are black, and trade sizes ¾ and 1¼ are red. (See Table 1 for Metric Trade Size Designators.) The nominal finished length of RMC with coupling is 10 feet (3.05m). Longer or shorter lengths of threaded or unthreaded conduit are also permitted with or without a coupling.

Figure 1: Steel Rigid Metal Conduit (RMC)

Steel RMC can have a primary coating of zinc, a combination of zinc and organic coatings, or a nonmetallic coating with or without zinc (such as PVC). Other supplementary coatings can be applied where additional corrosion protection is needed.

(NOTE: Contact suppliers with product-specific questions).

Special installation practices and tools are generally required for working with PVC-coated products. These practices are covered in Section 6.

Steel RMC is the heaviest-weight and thickest-wall steel conduit. Where galvanized by the hot-dip process, it has a coating of zinc on both the inside and outside. Electro-galvanized rigid has a coating of zinc on the exterior only, with corrosion-resistant organic coatings on the interior. Steel RMC with alternate corrosion protection generally has organic coatings on both the exterior and the interior surfaces. Galvanized RMC has no temperature limitations and can be used indoors, outdoors, underground, concealed or exposed. RMC with coatings that are not zinc-based sometimes has temperature limitations or is not listed for use in environmental air spaces; consult manufacturers' listings and markings.

3.1.2 INTERMEDIATE METAL CONDUIT — IMC (FERROUS METAL)

(NOTE: Stainless steel IMC is not covered by this guideline)

Intermediate Metal Conduit (IMC) is a listed taper-threaded metal raceway of circular cross section with a straight tapped coupling (see Figure 2) or an integral fitting (see Figure 4). Threads are protected on the uncoupled end by color-coded thread protectors which keep them clean and sharp, and aid in trade size recognition. IMC is available in trade sizes ½ through 4. Thread protectors for trade sizes 1, 2, 3, 4, are color-coded orange; trade sizes ½, 1½, 2½, 3½ are yellow; and trade sizes ¾ and 1¼ are green. (See Table 1 for Metric Trade Size Designators.) The nominal finished length of IMC with coupling is 10 feet (3.05m).

IMC has a reduced wall thickness and weighs about one-third less than RMC. The outside has a zinc based coating and the inside has an organic corrosion-resistant coating. IMC is interchangeable with steel RMC. Both have threads with a ¾ inch per foot (1 in 16) taper; use the same couplings and fittings; have the same support requirements; and are permitted in the same locations.

Figure 2: Intermediate Metal Conduit (IMC)

3.1.3 ELECTRICAL METALLIC TUBING — EMT (FERROUS METAL)

(NOTE: Stainless steel and Aluminum EMT are not covered by this guideline.)

Electrical Metallic Tubing (EMT), also commonly called thin-wall, is a listed steel raceway of circular cross section which is unthreaded, and nominally 10 feet (3.05m) long (see Figure 3). The outside corrosion protection is zinc-based and the inside has an organic corrosion-resistant coating. Trade sizes are ½ through 4. (See Table 1 for Metric Trade Size Designators.) EMT is installed by use of set-screw or compression-type couplings and connectors. EMT is permitted to have an integral coupling.

Electrical Metallic Tubing (EMT) is available in various factory-applied colors.

Figure 3: Electrical Metallic Tubing (EMT)

3.1.4 PVC-COATED CONDUIT

(See Section 6)

Figure 4: EMT, IMC and RMC with integral coupling

3.2 MANUFACTURED ELBOWS, NIPPLES, AND COUPLINGS

3.2.1 FACTORY ELBOWS

Elbows are bent sections of conduit or tubing used to change raceway direction or bypass obstructions. IMC and RMC elbows are threaded on each end. Elbows of the correct type and dimensions are an important element of the raceway installation.

Factory-made elbows in both standard and special radius are readily available for all sizes of steel RMC, IMC, and EMT. Elbows with integral couplings are available in trade sizes 2½ through 4. Specialized large radius elbows, often referred to as "sweeps," are also available. They are custom ordered to solve various installation problems. Some typical uses of sweeps are to facilitate easier wire pulling, install conduit in limited or geometrically difficult spaces, provide specific stub-up length, or ease installation of communication or fiber optic cables.

Physical dimensions of factory-made elbows for RMC, IMC, and EMT vary between manufacturers. When installing factory elbows for a job, being aware of this variability can avoid installation problems. **Always measure to be safe.** To order factory elbows, you need to specify the raceway type, trade size, and angle of bend. If ordering a special radius elbow, the radius will also have to be specified.

3.2.2 NIPPLES

A nipple is a short length of conduit or tubing material which is used to extend the system. Nipples are used between conduit and items such as (but not limited to) fittings, boxes, and enclosures or between two boxes, two enclosures, etc. When nipples are used to extend a conduit run to an enclosure, box, etc., the percentage wire fill requirements shown in Chapter 9, Table 1 of the NEC apply; for example, 40-percent fill for three or more conductors.

Table 1: Metric Trade Size Designators for RMC, IMC, and EMT	
*English Trade Size	Metric Designator
½	16
¾	21
1	27
1¼	35
1½	41
2	53
2½	63
3	78
3½	91
4	103
5	129
6	155

*Identifier only; not an actual dimension

When a nipple is installed between boxes, enclosures, etc. and the nipple does not exceed 24 inches (610 mm), wire fill is permitted to be 60%. Factory-made RMC nipples are threaded on both ends and are readily available in all sizes in lengths 12 inches (305 mm) and under. Longer lengths are available by special order or may be field-fabricated.

3.2.3 COUPLINGS AND INTEGRAL FITTINGS

Each length of steel RMC and IMC is furnished with a coupling on one end. This conduit coupling is included in the UL conduit standards. Additional couplings may be purchased separately.

Steel RMC and IMC are also available with integral couplings. These integral couplings are listed to the UL fitting standard UL 514B which permits make-up by turning the fitting rather than the conduit (see Figure 4). EMT with an integral is also available.

For threadless fittings for use with RMC, IMC, and EMT, see section 4.3.

4. General Installation Practices

(NOTE: See Section 6 for installation practices for PVC-coated conduit and fittings.)

4.1 CONDUIT CUTTING AND THREADING GUIDELINES

Close attention to measuring the exact length of conduit needed is important for a quality installation.

4.1.1 CUTTING AND THREADING STEEL RMC AND IMC

(NOTE: Although coupling threads are straight tapped, conduit threads are tapered.)

Field threading is to be performed in accordance with the following procedures unless manufacturer's instructions differ. The operating and safety instructions should be read and understood prior to operating the equipment.

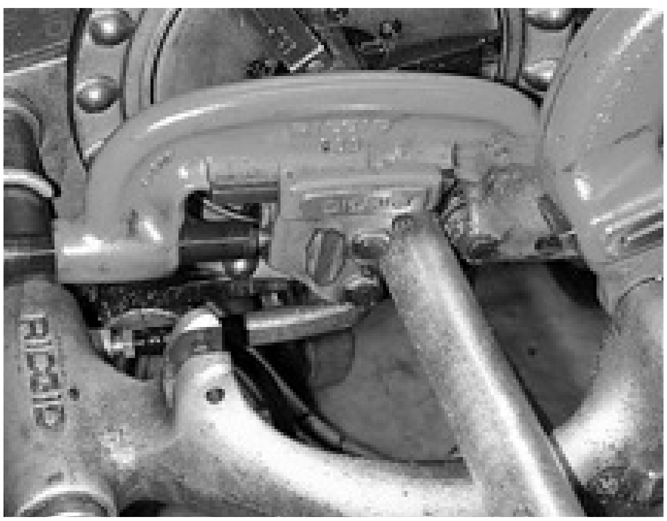

Figure 5: Lower the roll cutter to the desired length. Tighten the handle about one quarterture per each revolution and repeat until conduit is cut through.

a. Use a standard ¾ inch per foot (1 in 16) taper National Pipe Thread (NPT) die. The threads shall be cut full and clean using sharp dies. (See ANSI/ASME B.1.20.1-1983 (R2001) *Standard for Pipe Threads, General Purpose (Inch).*

b. Do not use worn dies. Although ragged and torn threads or threads which are not cut deep enough can be caused by poor threading practices; they can also indicate worn dies. If inspection shows this to be true, see Annex A for procedure to change dies.

c. To adjust the dies, loosen the screws or locking collar that hold the cutting dies in the head. When the screws or collar are loosened, the dies should move freely away from the head.

d. Screw the die head onto the threaded portion of a factory-threaded nipple or factory-threaded conduit until the die fits the factory thread. If the die head has an adjusting lever, set the head to cut a slightly oversized thread.

   (NOTE: This will ordinarily be one thread short of being flush with the face of a thread gauge when the gauge is hand tight. This is within the tolerance limits which allow the thread to be one thread short or long of being flush with the gauge face.)

e. Tighten the screws or locking collar so that the dies are tightly held in the head.

f. Remove the set-up piece of threaded conduit. The die is ready for use.

g. After adjusting the dies as outlined above, proceed as follows:

h. Cut the conduit with a saw or roll cutter. Be careful to make a straight cut (see Figure 5).

   (NOTE: If the die is not started on the pipe squarely, crooked threads will result. When using the wheel and roll cutter to cut pipe, the cutter must be revolved completely around the pipe. Tighten the handle about one quarter turn after each rotation and repeat this procedure until the pipe is cut through.)

Figure 6: The roll cutter will leave a burr on the inside diameter of the conduit. The burr must be removed to ensure that the wire insulation will not be damaged during pulling.

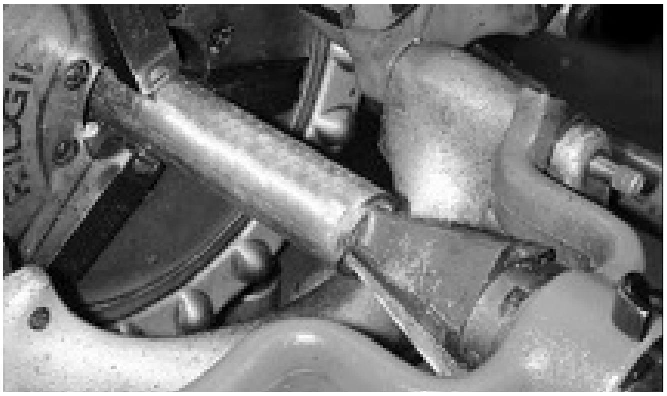

Figure 7: Insert the (flute) reamer into work piece and rotate until burr is removed.

Figure 8: A minimal amount of pressure will remove the burr completely and eliminate possible flaring of the conduit end.

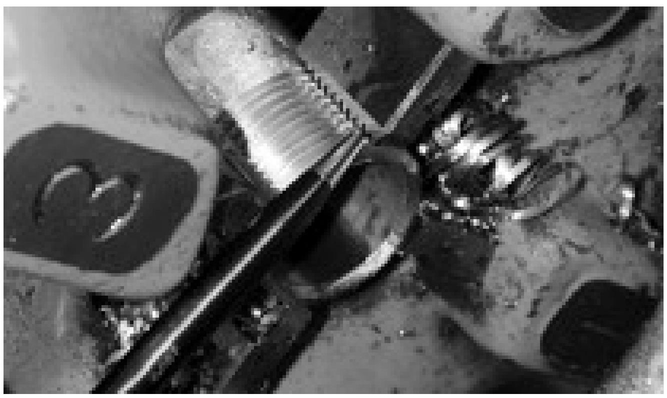

Figure 9: When proper thread length is achieved, the end of the conduit becomes flush with the ends of the die segments.

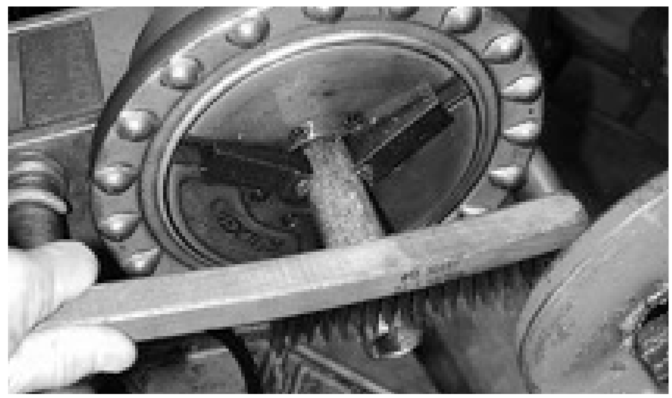

Figure 10: Wire brush the threads to remove any shavings or debris.

i. After cutting and prior to threading, ream the interior and remove sharp edges from the exterior (see Figures 6, 7 and 8).

   (NOTE: Reaming the conduit after threading will stretch or flare the end of the conduit.)

j. To start a universal die head, press it against the conduit end with one hand and turn the stock with the other (see Figures 10 and 11). With a drop head die, the stock remains stationary and the head rotates. After the dies have engaged for a thread or two, they will feed along without pressure.

k. Stop the cutting as soon as the die has taken hold and apply thread cutting oil freely to the dies and the area to be threaded (see Figure 9).

   (NOTE: Frequent flooding of the dies with a good grade of cutting oil will further safeguard against poor threads. The oil keeps the material lubricated and ensures a smoother cut by reducing friction and heat. Insufficient cutting oil will also cause ragged threads. The flow of the cutting fluid to the die head should be such that the cutting surfaces of the die segments are flooded. As a general rule, there is no such thing as too much oil at the die head.)

l. Thread one thread short of the end of the chaser.

   (NOTE: It is a good practice to thread one thread short to prevent butting of conduit in a coupling and allow the coupling to cover all of the threads on the conduit when wrench tight.)

m. Back the die head off and clean the chips from the thread (see Figure 10).

4.1.2 IMPORTANCE OF THREAD LENGTH

The length of the thread is important and the applicable UL requirements specify the manufactured length of the thread and the tolerance. A ring gauge is used to determine the correct thread length at the factory (see Figures 11 and 12). Good practice is to thread the conduit one thread short. This is to prevent conduit from butting inside the coupling. This practice will permit a good electrical connection between the conduits and couplings.

To insure that the threads are properly engaged, the coupling should be made up hand-tight, then wrench tightened. Generally, wrench-tightening should not exceed three additional threads (see Figure 13). It should never be necessary to use an extension handle on a wrench to make up a tight joint. The only time an extension handle should be used is to dismantle a stubborn joint in an existing line.

A simple rule regarding the use of tools is to select the right type and the right size. The proper size wrench for a given conduit size trade is indicated in Table 2.

4.1.3 PROTECTION OF FIELD CUT THREADS

NEC Section 300.6 (A) requires that where corrosion protection is necessary and the conduit is threaded in the field, the thread shall be coated with an approved electrically-conductive, corrosion resistant compound (see Figure 20). Coatings for this purpose, listed under UL category "FOIZ" are available. Zinc-rich paint or other coatings acceptable to the AHJ may be used.

(NOTE: Corrosion protection is provided on factory-cut threads at time of manufacturing. Conduit, elbows, or nipples that are threaded anywhere other than at the factory where the product was listed are considered field cut.)

Table 2: Proper Wrench Size

Conduit Trade Size	Wrench Size
under ½	10"
½	12"
¾–1¼	14"
1½	18"
2–2 ½	24"
3–4	36"
5–6	48"

Figure 11: Threads should be checked with a NPT-L1 threaded ring gauge to ensure proper make up.

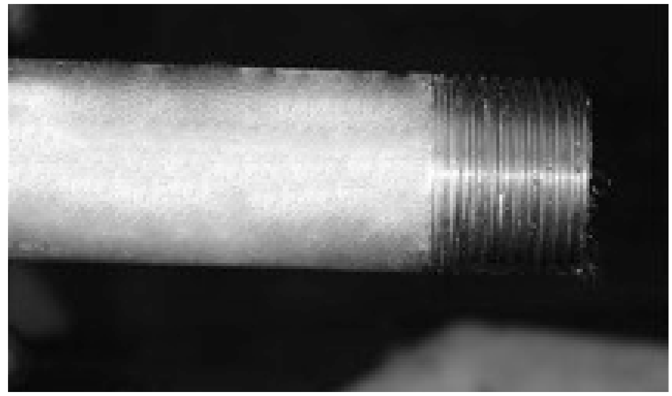

Figure 12: A proper thread should be free from chips or tears over the entire length.

4.1.4 CUTTING EMT

Cut the EMT square using a hack saw or band saw. Do not use roll-type tubing cutters.

(NOTE: Roll-type cutters require reaming which flares the wall of EMT, making fittings difficult to install.)

A tool designed for the purpose is best for reaming the inside of EMT. Where side cutter pliers or other general tools are used, take special care not to flare the ends.

4.2 BENDING GUIDELINES

The variety of electrical installations makes field bending necessary. While a full range of factory elbows are readily available, they do not address the variability of stubs, back-to-back, offset, and saddle bends encountered in the field-routing of conduit and EMT. These most commonly-used types of bends can be quickly, efficiently, and economically made by a knowledgeable and experienced installer. The skills needed to obtain a level of proficiency are readily learned and require knowledge of basic mathematics, industry terminology and bending tools. Manufacturers of bending equipment publish manuals for each specific bender model which provide excellent in-depth information on bending conduit. The information in this section is supplemental to that provided by the manufacturers. **Contact bender manufacturers for complete information.**

4.2.1 GENERAL INFORMATION

a. Read and understand all the bender manufacturers' operating and safety instructions before operating their equipment.

b. It is extremely important that the bender, its components and accessories are matched to the conduit type and size being bent because of the forces being applied. When using a power bender, it is important that pins are in the proper pin holes for the conduit size.

c. Although the National Electric Code allows up to 360 degrees between pulling points, using as few bends as possible, and none exceeding 90 degrees, will make wire pulling easier. The fewer total degrees between pulling points and the use of shallow bends combine to reduce the strain created by pulling wire. For multi-conductor control cable and communications cable, it is recommended that runs be limited to two 90 degree bends (a total of 180 degrees) per EIA/TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.

d. Before placing the conduit in the bender, accurately measure and mark the conduit with a thin line that goes completely around the conduit. This will assure the mark is visible if the conduit needs to be rotated.

e. The minimum radius shall comply with NEC, Chapter 9, Table 2, and the measurement shall be made to the centerline of the bend. See EIA/TIA-569 Commercial Building Standard for Telecommunications Pathways and Splices for guidance on bend radius for conduit and tubing used with communication and optical fiber cables.

Figure 13: The coupling must be assembled wrench tight.

f. Where hand benders do not have degree markings, degrees of bend shall be measured to the inner edge of the conduit; the surface that fits in the groove.

g. Where it is necessary to compensate for spring back, slightly over-bend.

h. When using a hand bender, choose a solid, flat surface. Pin the conduit firmly to the surface with steady foot pressure sufficient to keep the conduit and bender marks aligned and the conduit nestled in the groove throughout the full arc of the bend.

4.2.2 BENDING STEEL RMC

(NOTE: Benders recommended for a larger size range may be capable of bending some sizes below their primary range if so equipped.)

Trade sizes ½, ¾ and 1 can be bent with a hand-type bender. Trade sizes 1¼ and 1½ require a power bender or a mechanical ratchet-type bender. Bend trade sizes 2 and larger on a power bender.

Do not put conduit ends in the hook or bending shoe of the bender because thread damage and end flattening will occur.

When an EMT bender is designated as suitable for bending rigid conduit, a bender shoe one trade size larger than the conduit to be bent is to be used. Using the EMT bender will result in a slightly larger radius.

4.2.3 BENDING IMC

A full shoe or universal bender is the preferred bending tool for IMC. Limit hand bending to trade sizes ½, ¾, and 1. To make hand bending of trade size 1 easier, use a two position foot-pedal bender. This allows more weight to be applied for leverage.

Trade sizes 1¼ and 1½ require a power bender or a mechanical ratchet-type bender. Trade sizes 2 and larger require a power bender.

(NOTE: Benders recommended for a larger size range may be capable of bending some sizes below its primary range if so equipped.)

4.2.4 BENDING EMT

Use a bender of the correct trade size designed for bending EMT. EMT trade sizes ½, ¾ and 1 can be bent with hand benders because of the thinner wall. Use a mechanical ratchet-type bender for trade sizes 1¼ and 1½. Use a power bender for trade sizes 2 and larger.

(NOTE: Bending EMT in an oversized EMT bender will flatten the bend and possibly kink the tube.)

When making a short radius bend, straightening stubs in concrete, or applying greater than normal stress to bend ½ or ¾ EMT, place a mandrel into the EMT to support the wall. Any object that can be inserted to support the wall and is flexible enough to be bent and is removable can be used. A spring, rope, or hose are typical items used. Use a lubricant to aid in extracting the mandrel.

Knocked-down EMT stubs which can be bent using a hand bender (½ through 1) can be straightened by placing the bender handle over the stub and pulling back to the desired position. If kinked, insert a drift-pin, working it back and forth while inserting; this should force the tube back to round.

To shift the position of a stub of a vertical run when the stub is slightly out of line, remove handle from bender and place bender head on the EMT with the step-end of bender down. Brace bender head with your foot and apply pressure against tube and pull. Over-bend the stub slightly beyond the intended position to compensate for spring-back. Place handle back into bender and bend to desired vertical position.

When a stub or horizontal run is located close to the floor, remove concrete from around the EMT raceway. Put the bender in the stub with the step-end down, brace with your foot and bend.

(NOTE: If step-end is not down, the bender could get wedged during the bending process.)

To bend EMT coming out of a wall, remove handle and insert a close nipple. Thread a 90 degree pipe elbow onto the nipple and thread the handle into the elbow. The handle will parallel the bender center. This provides clearance to swing the handle down to make the bend.

4.3 FITTINGS FOR USE WITH STEEL RMC, IMC, AND EMT

(NOTE: See Section 6 for PVC-coated conduit)

4.3.1 SIZE AND RACEWAY TYPE

Before installing a fitting or a raceway support, review the packaging labels containing specific applications for which the fitting or raceway support is recommended and/or listed.

(NOTE: Do not take applications for granted. Many fitting designs look the same but may contain subtle construction differences designed to enhance performance in particular applications. Listed fittings contain required, informative markings and any specific conditions for use. For specific selection and installation guidelines, consult NEMA FB2.10, "Selection and Installation Guidelines for Fittings for Use with Nonflexible Metallic Conduit and Tubing".)

Fittings and raceway supports shall be used only with conduit of the trade size indicated on the fitting or raceway support or its smallest unit shipping container.

4.3.2 FITTINGS FOR SPECIAL APPLICATIONS

Threadless fittings intended for use in wet locations are marked "Wet locations" on the fitting or its smallest unit shipping container. Fittings marked "Raintight" are suitable for use in "Wet Locations". "Wet Locations" fittings are sometimes referred to as "Raintight".

A threadless fitting designed for use in wet locations that requires a gasket or sealing ring installed between the fitting and a box shall be installed only with the specific component marked on the fitting's smallest unit shipping container.

(NOTE: "Wet Locations" or "Liquidtight" fittings are not necessarily suitable for use in applications where submersion in water is expected. "Wet Locations" fittings are not necessarily considered "Liquidtight. "Liquidtight" fittings are intended for use in typical wet locations and also in "wet" industrial environments which may contain machine oils and coolants.)

RMC and IMC fittings for use in industrial applications involving sprayed mineral oils and coolants are marked "Liquidtight" on the fitting or its smallest unit shipping container. Threadless fittings intended for embedment in poured concrete are marked "Concrete-tight" or "Concrete-tight when taped" or "Wet Locations" on the fitting's smallest unit shipping container.

(NOTE: Taping is adequate to prevent the entrance of concrete aggregate into the raceway or box. Concrete aggregate consists of cement combined with inert material such as coarse sand. When hardened, such aggregate may be abrasive and might pose a risk to abrade conductor insulation or effectively reduce the area inside the raceway. Fittings listed as"Wet Locations" are also "Concrete-tight". The term "Raintight" has been removed from UL 514B as the result of NEC changes that removed the term in reference to EMT and Rigid fittings. The term "Wet Locations" is now required.)

4.3.2.2 EXPANSION AND DEFLECTION FITTINGS

Expansion fittings shall be installed where significant temperature differentials are anticipated. When conduit is installed as outdoor raceway spans between buildings, attached to bridges, on rooftops, etc., where expansion and contraction would result from the direct heat of the sun coupled with significant temperature drops at night, the full coefficient of expansion shall be applied in determining the need for expansion fittings. Table 3 shows length changes for steel conduit and tubing at selected temperature differentials.

(NOTE: Where the conduit is not exposed to the direct heat of the sun, expansion fittings are not generally necessary because the coefficients of expansion for steel and common building materials are so similar. In conduit or tubing runs where expansion fittings are installed, provisions shall be made for the raceway to slide through the supports so that

when expansion or contraction occurs it will allow the fitting to open and close properly. One way to accomplish this is to place a short sleeve over the raceway at each support large enough to allow the raceway to move freely with normal expansion and size support clamps to the sleeve size.)

Strong consideration should be given to the use of deflection fittings or other approved means when crossing a construction joint used in buildings, bridges, parking garages, or other structures. Structural construction joints will experience shear and lateral loads due to gravity, expansion and contraction and movement of the structure. Where significant expansion is expected, expansion fittings can be installed in-line with a deflection fitting or a combination expansion/deflection fitting can be used.

Figure 14A: Expansion fitting.

4.3.3 INSTALLING FITTINGS

4.3.3.1 THREADLESS FITTINGS

Threadless fittings shall not be assembled to threaded RMC or IMC unless specifically recommended by the fitting manufacturer. Where threadless fittings are to be assembled to steel RMC, IMC and EMT, conduit ends shall:

a. have squarely cut ends, free of internal and external burrs, and circular form as provided from the factory,

b. be free from dirt or foreign matter on the surface of the conduit to be inserted into the fitting, and

c. have the ends of the conduit or tubing assembled flush against the fitting's end stop. Careful consideration shall be given to the torque applied to the fitting's securement means.

   (NOTE: All threadless fittings listed to UL 514B are tightened to a specific torque value which can be seen in the table below for compression type fittings. All set-screw fittings except for No. 8 or No. 6 fittings are tightened to a torque of 35 lbf-in. No. 8 fittings are tightened for 20 lbf-in and No. 6 fittings are tightened to 12 lbf-in. After being tightened to this torque value, the fittings are subjected to several performance tests including a pull out test ranging from 200 lbf to 1000 lbf. Performance of the fitting may be reduced by over- or under-torqueing the fitting's securement means.)

Tightening Torque Values for Compression Type Fittings

Fitting Trade Size	Recommended Tightening Torque (lbf-in)	Force Used During UL Certification Pull Test
½	300	1334 N (300 lbf)
¾	500	2002 N (450 lbf)
1	700	2668 N (600 lbf)
1 ¼	1000	3114 N (700 lbf)
1 ½	1200	3559 N (800 lbf)
2	1600	4450 N (1000 lbf)
2 ½	1600	4450 N (1000 lbf)
3	1600	4450 N (1000 lbf)

4.3.3.2 SET-SCREW TYPE

The length of screws provided with set-screw type fittings varies. The appropriate torque for some designs is reached when the head of the screw touches a screw boss on the fitting. This cannot be universally relied upon, however. Screws on certain fitting designs, particularly larger trade sizes, can offer more than one tightening option including screwdriver (Slot, Phillips, or Robertson-square drive) and bolt head for wrench application (hex or square). Greater mechanical advantage and torque can generally be achieved with a wrench. Where tightening options for both screwdriver and wrench application are offered, torque should be limited to that which can be applied by the screwdriver.

4.3.3.3 COMPRESSION (GLAND) TYPE

Generally, most compression gland nuts achieve maximum securement after hand tightening and then wrench tightening one or two additional turns.

Table 3: Expansion Characteristics of Steel Conduit and Tubing Coefficient of Thermal Expansion = 0.65 x 10 -5in./in./°F*							
Temperature Changes in **Degrees F**	Length Change Steel Conduit **in./100 feet**	Temperature Changes in **Degrees F**	Length Change Steel Conduit **in./100 feet**	Temperature Changes in **Degrees F**	Length Change Steel Conduit **in./100 feet**	Temperature Changes in **Degrees F**	Length Change Steel Conduit **in./100 feet**
5	0.04	55	0.43	105	0.82	155	1.21
10	0.08	60	0.47	110	0.86	160	1.25
15	0.12	65	0.51	115	0.90	165	1.29
20	0.16	70	0.55	120	0.94	170	1.33
25	0.20	75	0.59	125	0.98	175	1.37
30	0.23	80	0.62	130	1.01	180	1.40
35	0.27	85	0.66	135	1.05	185	1.44
40	0.31	90	0.70	140	1.09	190	1.48
45	0.35	95	0.74	145	1.13	195	1.52
50	0.39	100	0.78	150	1.17	200	1.56

** A fine print note in section 300.7(B) of the NEC® refers the user to the expansion characteristics of PVC, Table 352.44(A) for rigid non-metallic conduit and suggests multiplying the lengths in that table by 0.20 in order to obtain a nominal number for steel conduit. Since the coefficient of steel conduit is between 2–3 times less than that of PVC conduit you would need more expansion fittings for PVC conduit, for a given temperature and length than for steel conduit. We have used the coefficient of expansion of steel, rather than the 0.20 multiplier, to calculate the exact length of change figures in Table 3.*

Prior to embedment in poured concrete, all threadless fittings, including those marked "Concrete-tight," shall be taped adequately to prevent the entrance of concrete aggregate where they will be embedded more than 24 inches or where the pour area will be subjected to a concrete vibrator. Tape shall be applied after the fitting is assembled and secured to the conduit.

4.3.3.4 THREADED FITTINGS

Threaded joints, both fitting to conduit and fitting to threaded integral box entries, shall be made up wrenchtight.

(NOTE: Avoid excessive force. Generally a force equivalent to hand-tight plus one full turn with an appropriate tool is recommended. This should assure engagement of at least three full threads.)

Conduit bodies generally have an integral bushing to provide a smooth surface for conductors when pulled. This bushing is often mistaken for a conduit end stop. It is not necessary that the conduit be inserted flush against this bushing to assure a secure joint.

4.3.4 ATTACHMENT TO BOXES AND SUPPORT

Prior to attachment to a box, enclosure or a threadless coupling, RMC, IMC and EMT shall be supported at intervals required by the NEC, using raceway supports intended for the purpose and secured by hardware acceptable to the local jurisdiction.

*(NOTE: The variability of mounting surfaces, expected loads, and application environments will determine the appropriate support options and securement hardware. Project specifications normally calculate support requirements based on the **minimum** spacing intervals given in the NEC. Using closer support intervals than are required by the NEC is an acceptable option to heavier supports and mounting hardware **in some applications.**)*

Properly align the raceway, fittings, and knockouts to provide secure mechanical and electrical connections. Allow sufficient conduit length to complete engagement of the conduit and fittings at joints and entries.

Conduit bushings shall not be used to secure threaded RMC or IMC to a box or enclosure. A locknut shall always be assembled between a conduit bushing and the inside of the box or enclosure.

EMT connectors are permitted to be assembled into threaded entries of boxes, conduit bodies or internally threaded fittings having tapered threads (NPT). EMT fittings designed to NEMA FB 1 "Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies," have straight threads (NPS). Threaded openings where these fittings are intended to be used are permitted to have either tapered (NPT) or straight (NPS) threads. Care should be taken to ensure that the threaded entry will accommodate a minimum of 3 full engaged threads of the fitting.

Where a locknut is provided with a fitting as the means of securement to a box or enclosure, the locknut is to be secured by hand-tightening to the enclosure plus ¼ turn using an appropriate tool.

(NOTE: While securing the locknut, take care to avoid excessive pressure when gripping the body of the fitting is necessary.)

Do not rely upon locknuts to penetrate nonconductive coatings on enclosures. Coatings shall be removed in the locknut contact area prior to raceway assembly to assure a continuous ground path is achieved. Touch up bare area as needed after installation.

4.3.5 VERIFICATION OF INSTALLATION

After the raceway is fully installed and supported, and prior to installing conductors in the raceway, all fittings and locknuts shall be re-examined for secureness (see 5.5).

4.4 SUPPORT OF STEEL CONDUIT/TUBING

Support and securely fasten all raceways in place in accordance with NEC requirements.

4.4.1 SUPPORTING

Follow all Code requirements for spacing of supports and frequency of securing RMC, IMC and EMT. The requirement to securely fasten raceways within the specified distance from each "termination point" includes, but is not limited to, outlet and junction boxes, device boxes, cabinets, and conduit bodies. Each raceway shall be so secured. Do not omit any supports.

(NOTE: Proper support and secure fastening protects the raceway joint during maintenance in the area of the raceway; this will help ensure a continuous ground path. Good workmanship in this area improves safety for the installer, other workers and the public.)

4.4.2 SECURING AND FASTENING

Raceways are permitted to be mounted directly to the building structure. Assure that supporting means and their associated fasteners are compatible with the mounting surface from which they are supported. Raceway supports shall be installed only on conduit of the trade size indicated on the fitting or its smallest unit shipping container.

The following supporting and fastening methods are recommended (also see 4.3.4 "Note"):

a. Steel conduit/tubing **exposed on masonry surfaces, plaster, drywall or wood framing members:** One-hole straps, two-hole straps, conduit hangers, or similar products intended for the purpose, securely fastened with appropriate hardware. Conduit or tubing in trade sizes ½ through 1 are permitted to be supported by nail-straps in wood framing members.

b. Steel conduit/tubing **mounted on metal framing members:** One-hole straps, two-hole straps, conduit hangers or similar products intended for the purpose, fastened with metal screws or rivets. When using clamp-on supports, add screws, rivets, beam clamps, or similar means for extra support, unless the clamp-on supports are the hammer-on or press-on type.

c. Steel conduit/tubing **run through openings in metal or wood studs:** Such openings can be used for support where the openings are no more than 10 feet apart. Secure fastening at termination points is still required. Be sure to secure the conduit or tubing to the framing member where the raceway transitions to vertical and within three feet of the termination, as required by the NEC.

d. Steel conduit/tubing **suspended below ceilings or structural members such as beams, columns, or purlins, or in ceiling cavities:** These raceways are best supported by lay-in pipe hangers. The pipe hangers are to be supported by threaded rod, which is, in turn, fastened in place by beam clamps or similar devices. Strut-type channel can also provide secure support. Raceways are not permitted to lie on the suspended ceiling. In fire-rated ceiling cavities, support by the ceiling wires is not permitted unless tested as part of the fire-rated assembly. A separate support system must be installed for the conduit/tubing. Where this system is wire, it shall be identified as the raceway support. Conduit/tubing support wires must be secured at both ends. In non-fire-rated ceiling cavities, the ceiling wires can be used for support where installed in accordance with the manufacturer's instructions.

e. **Groups of conduit/tubing:** Mount on strut-type channels, and secure in place with strut-type channel straps identified for the particular channel and raceways. Channel shall be fastened in place by means suitable to the mounting surface.

f. **Support at new concrete pours:** In these cases, place approved channel inserts into the concrete pour. Raceways will be mounted to the channels later in the construction process.

g. **Structural steel members:** Where raceways are mounted inside the web of I-beams, column-mount supports are permitted to support the conduit.

4.5 FIRESTOPPING AND FIRE BLOCKING

Steel RMC, IMC, and EMT do not require fire resistance ratings. Fire resistance ratings apply only to assemblies in their entirety. Building codes consider steel conduit and tubing to be non-combustible. Fire testing is not required by the UL standard to which these products are listed, however, steel RMC, IMC and EMT have been exposed at UL to the ASTM E119 time temperature curve for up to four hours in duration. This was done during testing of annular space filler and the temperature reached almost 2000 degrees F. The conduit/tubing was still intact at the end of the test. This information is contained in a report entitled Annular Space Protection of Openings Created by Penetrations of Tubular Steel Conduit—a review of UL Special Services Investigation Investigations File NC546 Project 90NK111650, which is available for downloading at steelconduit.org. Since the conduit/tubing was tested without conductors, the condition of the insulation of the conductors within cannot be verified when subjected to that temperature.

4.5.1 PENETRATION OF FIRE-RESISTANCE-RATED ASSEMBLIES

The raceway installer shall determine if the walls, floors, or ceilings are fire-rated prior to installing raceway systems. Penetration openings shall be properly filled for fire safety, using approved materials. The NEC and building codes require that openings around raceways which penetrate a fire-resistance-rated assembly be sealed to prevent the spread of fire and smoke from one area migrating into another. (NOTE: This can be accomplished by use of a listed penetration firestop system, or by use of annular space filler in accordance with building code exceptions.) There are many listed penetration firestop systems which can be used with steel conduit/tubing to seal openings; the listing instructions shall be strictly followed.

(NOTE: It is often incorrectly assumed that if steel conduit or EMT penetrates a fire-resistance-rated assembly, these products also must be "fire-resistance-rated." Steel conduit and EMT are noncombustible and do not require a "fire resistance rating". The codes require that the annular space around the steel conduit be properly filled so that the fire-resistance-rating of the assembly is maintained.)

Most building codes permit openings around steel RMC, IMC, and EMT that are penetrating concrete or masonry to be filled with cement, mortar, or grout. However, since local codes sometimes vary, the local requirements should be checked prior to installation. Also, project specifications often describe exactly how these openings are to be filled, even though the codes might permit other methods. Firestop systems listed for use with steel conduit/EMT are permitted to fill the space surrounding the conduit or tubing.

In all cases, the raceway installer shall use materials which assure that fire-resistance- ratings of the penetrated assembly are not degraded by the installation of a raceway system.

4.5.2 PENETRATION OF NON-FIRE-RATED ASSEMBLIES

In non-fire-rated assemblies, when noncombustible penetrating items such as steel conduit and EMT connect not more than three stories, the space around the penetration must be filled with an approved noncombustible material to resist the passage of flames and products of combustion. This is called fireblocking.

If the penetrant connects not more than two stories, the annular space filler does not have to be noncombustible, but it must be an approved material that resists the page of flame the products of combustion.

4.5.3 THERMAL PROTECTION OF STEEL RACEWAYS

The NEC and local or state code requirements for fire protection of emergency systems and fire-pump circuits be reviewed prior to installing these circuits. Local codes sometimes vary from the NEC. Steel raceways withstand fire; however, ordinary conductor insulation melts when exposed to elevated temperatures and a short circuit can be created. This is the reason for special protection of emergency and fire-pump circuits.

Methods of thermal protection include putting the conduit/tubing in a fire-rated enclosure such as a chase (horizontal or vertical), embedding in concrete, using a listed wrap system for protection from fire or using circuit integrity cables within conduit as part of a listed Electrical Circuit Protective System. (See UL Fire Resistance Directories (Category FHIT).

(NOTE: Fire wraps can affect the temperature of the conductors and the need for ampacity derating must be determined. It is also important to determine that the support system is protected and will withstand the fire exposure.)

The NEC does not require these thermal protection methods for emergency systems where conduit is installed in a fully sprinklered building. Local codes shall be consulted and the requirements of the applicable code and/or project specification must be followed.

4.6 CORROSION PROTECTION

Steel RMC, IMC and EMT are typically galvanized to provide excellent corrosion protection. Sometimes supplementary corrosion protection is required if the installation is in a "severely corrosive" environment. See Sections 4.6.1 through 4.6.4 below for information on these types of environments and recommended supplementary protection methods. Specifics on installing steel conduit with a factory-applied PVC coating are contained in Section 6 of these Guidelines.

4.6.1 INSTALLED IN SOIL

Where installed in contact with soil, steel RMC and IMC do not generally require supplementary corrosion protection unless:

a. Soil resistivity is less than 2000 ohm-centimeter or

b. Local experience has confirmed that the soil is extremely corrosive. The authority having jurisdiction has the authority to determine the need for additional protection.

   (NOTE: Soils producing severe corrosive effects have low electrical resistivity, expressed in ohm centimeters. Local electric utilities commonly measure the resistivity of soils. The authority having jurisdiction has the authority to determine the necessity for additional protection.

EMT in direct contact with the soil generally requires supplementary corrosion protection. However, local experience in some areas of the country has shown this to be unnecessary.

4.6.2 TRANSITION FROM CONCRETE TO SOIL

Where steel RMC, IMC, and EMT emerge from concrete into soil, it is recommended that protection be provided a minimum of 4 inches on each side of the point where the raceway emerges. In areas such as coastal regions, use the same method of protection for EMT emerging from concrete into salt air to lengthen the service life. Examples of protection include paint, tape, and shrink-tubing.

4.6.3 INSTALLED IN CONCRETE SLAB

Where installed in a concrete slab below grade, determine if EMT requires supplementary protection for that location. RMC and IMC do not require supplementary corrosion protection in this application.

4.6.4 SUPPLEMENTARY PROTECTION METHODS

Where supplementary corrosion protection is required for the conduit or EMT, the authority having jurisdiction must pre-approve the method selected. Following are typical methods of providing supplementary corrosion protection:

a. A factory-applied coating which is additional to the primary coating for conduit or tubing.

b. A coating of bitumen.

c. Paints approved for the purpose. Zinc-rich paints or acrylic, urethane or weather stable epoxy-based resins are frequently used. Oil-based or alkyd paints should not be used. Surface preparation is important for proper adherence. For best results, the conduit/EMT should be washed, rinsed and dried. It should not be abraded, scratched or blasted since these processes could compromise the protective zinc layer. A compatible paint primer or two coats of paint adds protection.

d. Tape wraps approved for the application. Wraps must overlap and cover the entire surface of the conduit/EMT and all associated fittings. Shrink wraps are available that will protect the conduit and fittings without requiring a heat source.

e. Couplings and fittings can also be shrink-wrapped.

4.7. EQUIPMENT GROUNDING USING STEEL CONDUIT

4.7.1 STEEL CONDUIT AS EQUIPMENT GROUNDING CONDUCTOR

Steel RMC, IMC and EMT are recognized by the NEC as equipment grounding conductors. Using a supplemental equipment grounding conductor in the form of a copper, aluminum, or copper-clad aluminum conductor in addition to the raceway is a design decision, except where the NEC requires it in some specific installations such as patient care areas in NEC 517.13. Steel conduit is the main equipment grounding conductor regardless of whether a supplemental equipment grounding conductor is installed. In the event of a fault, the raceway will carry most of the current and therefore must be continuous. For this reason, each raceway must be installed securely and with tight joints to provide mechanical and electrical continuity.

4.7.2 CONTINUITY OF GROUNDING PATH

The NEC states that the path to ground in circuits, equipment and metal enclosures for conductors shall be permanent and continuous. Complying with guidelines in the Fittings section 4.3 and Support section 4.4 is the major factor in maintaining electrical continuity. Using less than the NEC required supports or failing to properly tighten joints can cause discontinuity in a raceway system, which would result in the failure to carry a ground fault. Good installation workmanship is critical.

The NEC further requires that the path to ground have the capacity to safely conduct any fault current likely to be imposed and have sufficiently low impedance to limit the voltage to ground to cause operation of the circuit protective device. Steel RMC, IMC and EMT are "conductors" permitted to carry current in the event of a ground fault. All three have been tested and they all meet the NEC requirements when properly designed and installed (see Annex B).

4.7.3 MAXIMUM LENGTH OF STEEL CONDUIT/EMT

Copper, aluminum and copper-clad aluminum equipment grounding conductors must be sized according to NEC Table 250.122. Just as with these types of "wire" equipment grounding conductor, conduit runs and couplings must be properly sized. The installed length of any wiring method will impact the operation of the overcurrent device. In the event of a phase to neutral or phase to conduit ground fault, the length of the particular conduit run determines safe operation, assuming proper overcurrent protection has been provided. For a phase to phase fault, it is the conductor length which determines safe operation. See Annex B for Tables that show examples of the maximum run lengths for steel RMC, IMC and EMT.

4.7.4 CLEAN THREADS

Threads must be clean to ensure electrical continuity of the assembled raceway system. Leave the thread protectors on the conduit until ready to use. Wipe field-cut threads with a clean cloth to remove excess oil and apply an electrically conductive rust resistant coating (see 4.1.3).

4.7.5 CONTINUITY OF THE RACEWAY SYSTEM

The NEC does not permit certain circuits to be grounded. However, steel raceways and all metal parts likely to become energized must still have assured continuity and be bonded together and run to a grounding electrode to prevent electric shock.

4.7.6 BONDING

Bonding is used to provide electrical continuity so that overcurrent devices will operate and shock hazards will not be present. This is the "finishing touch" for a metallic raceway system and close attention is to be paid to detail. All fittings, lugs, etc., shall be securely made up.

Bonding around steel raceway joints/couplings is not necessary when EMT, IMC, and RMC are properly made up as recommended in this installation guideline. A secure joint provides excellent low impedance continuity. Bonding is not required because this joint already meets the NEC definition of bonding.

Metal raceways for feeder and branch circuits operating at less than 250 volts to ground shall be bonded to the box or cabinet. Do one or more of the following:

1. Use listed fittings.
2. For steel RMC or IMC, use two locknuts one inside and one outside of boxes and cabinets.
3. Use fittings, such as EMT connectors, with shoulders that seat firmly against the box or cabinet, with one locknut on the inside of boxes and cabinets.

   (NOTE: Remove paint in locknut areas to assure a continuous ground path. Repaint or cover any exposed area after installation is completed.)

4.7.7 SERVICE RACEWAY SYSTEM BONDING

A service raceway system includes service equipment enclosures, meter fittings, boxes, etc., and requires special consideration for bonding the enclosures to the raceways where the connection relies on locknuts only. Service equipment must be connected with threaded bosses and fittings such as locknuts, wedges, and bushings of the bonding type.

Standard locknuts are not to be used on circuits over 250 volts to ground where the raceway is terminated at concentric or eccentric knockouts. The raceway must be bonded to the enclosure using the same methods as noted above for service raceway systems; or boxes and enclosures listed for bonding are to be used.

4.7.8 ADDITIONAL BONDING CONSIDERATIONS

Expansion fittings and telescoping sections of metal raceways shall be listed for grounding or shall be made electrically continuous by the use of equipment bonding jumpers or other suitable means in accordance with NEC 250.98.

5. Specific Installation Requirements

5.1 GENERAL

a. All exposed steel RMC, IMC and EMT shall be run parallel or perpendicular to walls and ceilings.

b. A sufficient number of home run conduits/tubing shall be installed so that excessive circuit loading will be eliminated.

c. If home runs are to be concealed by the finish of the building (except for suspended ceilings), the minimum size of home run conduit and tubing shall be trade size ¾.

d. The minimum size for steel conduit/tubing in industrial occupancies shall be trade size ¾.

(NOTE: Minimum size requirements in (c) and (d) are to provide room for future expansion of circuits in locations that are difficult to access.)

e. Overhead service conductors shall be run in steel RMC, IMC or EMT. When used for mast installations supporting the overhead drop, EMT shall be supported by braces or guys, in accordance with NEC 225.17.

f. EMT shall not be used where damage severe enough to damage the conductors within is likely to occur.

g. Sufficient expansion fittings for the application shall be installed (see 4.3.2).

h. Where corrosion protection is required, field cut threads shall be protected with an approved electrically conductive, corrosion-resistant coating. For extended service life in wet or damp environments, it may be desirable to also apply this coating to exposed factory threads after installation.

i. Steel conduit/tubing shall not be used to support enclosures except as permitted by the NEC.

j. Splices or taps shall not be made inside RMC, IMC, or EMT.

k. All conductors and neutrals of the same circuit and all equipment grounding conductors shall be contained within the same conduit/tubing.

(NOTE: This is extremely important in alternating current (AC) applications.)

l. The conduit/tubing system shall be installed complete, including tightening of joints, from termination point to termination point prior to the installation of conductors.

m. Cutting and threading shall comply with Section 4.1 or Section 6.3, as applicable.

n. Bending shall comply with Section 4.2.

o. Supports shall comply with Section 4.4.

5.2 PROTECTION FROM EMI

For protection against EMI, steel conduit or steel tubing with steel fittings shall be used.

(NOTE: Steel RMC offers maximum shielding against EMI, due to its thicker wall. IMC and EMT also have excellent shielding capabilities. (See Annex B).

5.3 STEEL CONDUIT/TUBING INSTALLED IN CONCRETE

a. All steel conduit and EMT runs through concrete shall be fully made up and secured to reinforcing rods to prevent movement during the concrete pour.

b. Conduit and EMT stubs installed in poured floors shall be effectively closed immediately after installation. Suggested means for closing are wrapping with a heavy grade of tape, installation of a capped bushing, or plugs designed for the purpose. Stubs shall remain closed during construction, or until the raceway is extended to a termination point.

(NOTE: This is to protect threads from damage and to prevent debris from entering the conduit before and after the concrete pour.)

c. Comply with Sections 4.6.2 and 4.6.3 of this document for supplementary corrosion protection.

d. Conduit shall be supported to prevent damage prior to and during the concrete pour.

e. When nonmetallic conduits/tubing are used in or under floor slabs or concrete pours, change to steel conduit prior to exiting the floor or slab.

Where completion of the raceway system will be delayed, the stub shall be marked in some manner to indicate a supplemental equipment grounding conductor is required because the entire run is not metal, and therefore not electrically continuous.

(NOTE: This is necessary to assure that a change in installer does not result in thinking the entire run is metal and, therefore, that no supplemental equipment grounding conductor is necessary.)

f. Section 4.3.2 shall apply for requirements regarding taping of joints in concrete.

5.4 COMMUNICATION CIRCUITS

a. Steel conduit/tubing for low voltage or communications circuits shall terminate in boxes, enclosures, or wireways.

b. If steel RMC. IMC or EMT raceways are installed for future use, pull wires shall be provided and the raceways shall be plugged.

c. Stub raceways for communications circuits are permitted in a suspended ceiling space, basement space or similar area, rather than running the raceway unbroken from outlet to outlet. When the stub-in method is used, a connector, bushing, or other fitting shall be installed at the end of the raceway to protect the cable. Pull wires are to be installed in all stub-in raceways and provisions are to be made to prevent debris from entering the conduit or EMT.

d. Bends shall be limited to two 90 degree bends. See Section 4.2.1 (c).

5.5 UNDERGROUND SERVICES

a. Where subject to physical damage, steel IMC or RMC shall be used to bring the underground service conductors out of the ground to the meter or disconnect.

b. Where underground service conduits enter a building, they shall be sealed.

   (NOTE: This is done to prohibit the entry of moisture which might accumulate due to differences in outdoor and indoor temperatures and to keep ground water and rodents, etc. from entering the building.)

5.6 VERIFICATION OF INSTALLATION

All steel RMC, IMC and EMT systems shall be electrically and mechanically continuous, and shall be tested after conductor installation to assure continuity. Simple continuity tests are permitted, but shall be made between the service panel and the last outlet in each branch circuit.

6. Installation Practices for PVC–Coated Conduit and Fittings

There are three types of PVC-coated conduit; couplings are supplied separately.

1. Primary PVC coating over bare steel which is a listed rigid conduit for environmentally suitable locations. The listing label will indicate the PVC coating has been investigated for primary corrosion protection.
2. A PVC coating over listed galvanized steel conduit. This is a supplementary coating intended for added protection in severely corrosive locations. The listing label will indicate the PVC coating has not been investigated for primary corrosion protection.
3. A primary PVC coating over a primary coating of zinc. This is also intended for severely corrosive locations. The listing label will indicate both the zinc and PVC coatings have been investigated as primary corrosion protection.

These PVC-coated raceways are generally installed as a system, which means the fittings, conduit bodies, straps, hangers, boxes, etc., are also coated. There are, however, installations where only a coated elbow is used in a galvanized conduit run, such as where emerging from the soil or concrete.

(NOTE: Manufacturers' instructions are very important when installing PVC-coated products and systems, and special tools are generally required.)

Figure 14: Commercial yoke vise used to protect the PVC coating of PVC-coated conduit.

6.1 TOOLS

To minimize installation damage to the PVC coatings, use tools specially designed for PVC-coated conduit or standard tools that have been appropriately modified for installing PVC-coated conduit. Standard tools which have not been modified could damage the coatings and shall not be used to install PVC-coated conduit. For repairing damage to the PVC coating see Section 6.6.

6.2 CLAMPING (VISING) PVC-COATED CONDUIT

Various manufacturers offer modified jaws for use in standard vises to protect the coating (see Figure 14). When using either a "jaw type" or a chain type" vise, the PVC-coated conduit can also be protected by half-shell clamps. These are available as a manufactured clamp or can be made in the field from RMC as follows.

Figure 15: Field-fabricated half shell clamps used with chain vise to protect PVC-Coated conduit.

6.2.1 CLAMPING SLEEVES MADE FROM STEEL RMC

a. Make two half-shell pieces by first cutting two 6- inch pieces of standard conduit one trade size larger than the PVC-coated conduit to be clamped.
b. Use a band saw to cut the 6-inch conduit sections lengthwise. Make the cut slightly off center. This creates two half shells, one smaller than the other.

c. Discard the larger pieces and use the two smaller pieces to protect the conduit in the vise. Deburr any sharp edges. Properly made clamping sleeves will have a gap between the two pieces when positioned on the conduit (see Figure 15).

d. Where proper tooling for making a sleeve is not available, protect the PVC coating in the vise by wrapping the area to be clamped with sandpaper, emery cloth or cardboard. The coarse side of emery cloth or sandpaper should face the PVC coating.

(NOTE: This is the least desirable method and should be avoided by planning ahead.)

6.3 CUTTING AND THREADING PVC-COATED CONDUIT

For full cutting and threading instructions for PVC coated conduit, contact the conduit manufacturer. The following provides general guidance.

6.3.1 CUTTING AND REAMING

Cutting with a saw is the preferred method. However, a roller cutter is acceptable providing the conduit is properly clamped. See Section 4.1 for conduit cutting and threading guidelines.

6.3.2 HAND THREADERS (MANUAL AND MOTORIZED)

a. If PVC-coated conduit is cut with a hacksaw or a band saw, and a hand-threader is used, trim the coating at an angle all the way around the conduit before threading. This is sometimes called pencil cut or bevel cut and enables the die teeth on the threader to engage the conduit (see Figure 16). Be sure to follow the instructions in 6.2.1 for clamping conduit, and ensure that the conduit is securely held in the vise.

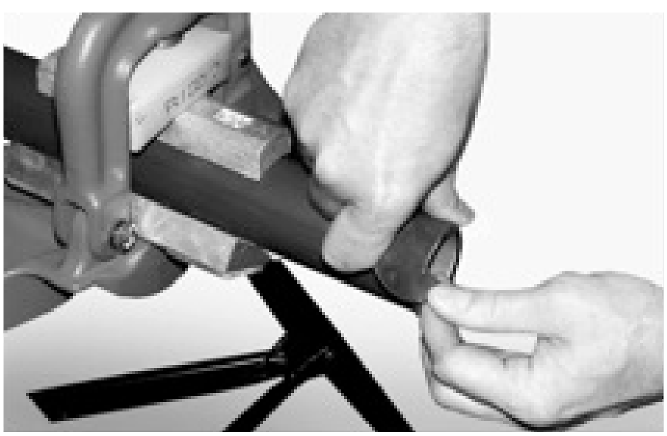

Figure 16: Utility knife used to apply “pencil-cuts” to PVC coating to allow the conduit easier entrance into the cutting die.

b. A standard die head must be modified (machined) for use with PVC-coated conduit. To make this modification, the guide sleeve must be bored to allow the coated conduit to enter the die. The inside diameter must be increased by 110 mils (0.11 inch).

(NOTE: The PVC coating shall not be removed to allow use of standard non-machined die heads.)

6.3.3 ROTATING MACHINES

a. Rotating machines with jaws that cut through the PVC coating shall not be used.

b. Long strips of metal or PVC from the threading can foul the die head and collapse the conduit. Make a series of longitudinal cuts in the PVC coating (i.e., along the conduit), in the area to be threaded, to permit the removal of PVC in small pieces and avoid fouling the die head. The thread protector can be used as a length guide for the cuts (see Figure 17).

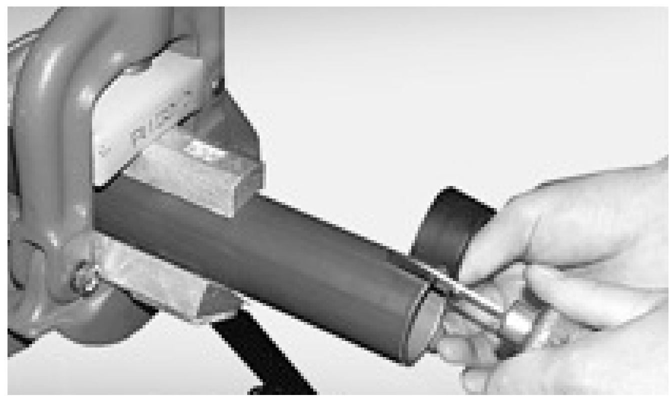

Figure 17: Before threading PVC-coated conduit, make a series of cuts along the axis of the conduit to break-up threading chip.

c. Following the cutting operation, use a reamer to remove rough edges (see Figure 18).

6.3.4 THREAD PROTECTION

The NEC requires in 300.6 that where corrosion protection is necessary and the conduit is threaded in the field, the thread shall be coated with an approved electrically-conductive, corrosion resistant compound (see Figure 20).

Coatings for this purpose, listed under UL category “FOIZ” are available. Zinc-rich paint or other coatings acceptable to the AHJ may be used. (NOTE: Corrosion protection is provided on factory-cut threads at time of manufacturing.)

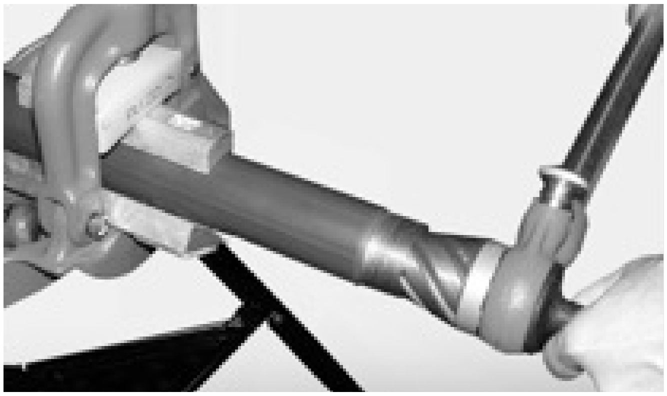

Figure 18: Using reamer to remove rough edges of cut PVC-coated conduit.

6.4 BENDING PVC-COATED CONDUIT

Manufactured elbows are available in a variety of radii. For field-bending, do the following:

6.4.1 HAND BENDING OF SMALL CONDUIT SIZES

To bend PVC-coated conduit, use an EMT bender one trade size larger than the conduit being bent. This is to avoid damaging the coating. For example, to bend trade size ¾ PVC-coated conduit, use a trade size 1 EMT bender.

6.4.2 BENDING COATED CONDUIT

a. A bender with shoes made specifically to bend PVC-coated conduit is preferred. Otherwise, for trade sizes ½ through 1½, use an electric bender (see Figure 19) with EMT shoes one size larger than the PVC-coated conduit. A hand bender can also be used to bend the smaller trade sizes.

Figure 19: Bender with special shoes required for bending PVC-coated conduit.

Figure 20: Application of UL listed electrically conductive occasion protection compound on field-cut threads.

b. Trade sizes 2 and larger should be bent with a hydraulic bender.

c. Do not use lubricants on bending shoes.

6.4.3 HYDRAULIC BENDERS

a. Most manufacturers of hydraulic benders offer special shoes for PVC-coated conduit. Use these special shoes when possible.

b. If regular shoes are used, their sides must be modified to allow for the coating thickness. Some installers have done this by grinding or milling. Such modification is not recommended as it can create a safety hazard.

6.5 INSTALLING PVC-COATED CONDUIT

6.5.1 PIPE WRENCHES AND PLIERS

PVC-coated conduit requires special wrenches to protect the coating. Pipe wrenches specially designed with fine teeth are available for use with PVC-coated conduit. Strap wrenches can also be used. Slip-joint pliers of the Channel-Lock™ type, specially equipped with wide jaws, are also available to protect the coating.

(NOTE: For PVC-coated conduit, wrench sizes are the same. However, the jaw of the wrench must be specially designed for PVC-coated conduit. If not available, a strap wrench should be used.) Do not use ordinary slip-joint pliers or standard pipe wrenches with PVC-coated conduit.

6.5.2 SLEEVES ON COUPLINGS AND FITTINGS

a. Sleeves on PVC-coated conduit couplings and fittings are provided to insure continuous coating protection. Protection is added because the coating is separate, not continuous, between a section and fitting. This provides protection and makes the coating more resistant to corrosion penetration, but the coating is not continuous.

b. To make the sleeve softer in cold weather applications, soak the coupling or fitting in warm water.

c. To make installation easier, silicon sprays can be applied to the inside diameter of the sleeve.

6.5.3 THREADLESS FITTINGS

Threadless fittings shall not be used with PVC-coated RMC or IMC.

6.5.4 ENGAGEMENT OF THREADS

Since the threads are not visible because they are covered by PVC sleeves, take extra care to be sure that the threads are fully engaged and made up wrench tight.

6.6 PATCHING DAMAGED AREAS

Even when following recommended practices, the PVC coating is sometimes damaged during installation. This destroys the coating protection and provides for entry of corrosive elements. Damaged areas shall be patched, following the raceway manufacturers' instructions.

6.7 EQUIPMENT GROUNDING AND BONDING

General considerations for equipment grounding using steel conduit are covered in Section 4.7. When expansion joints are used in PVC-coated conduit systems, it is recommended that an expansion fitting containing an internal bonding jumper be used. If using an expansion fitting without an internal bonding jumper, an external bonding jumper should be installed. Generally, this will require removing a portion of the PVC coating from the conduit where the jumper will be attached, installing the jumper, and then repairing the surrounding coating with touch up compound provided by the manufacturer. Specific instructions from the PVC-coated conduit manufacturer should be followed for proper installation.

ANNEX A: Threading Conduit

Threading as a method of joining steel conduit has proven to be a sound and dependable method through decades of service. Some major advantages of threaded joints are:

1. Simple hand tools can be used to dismantle and replace sections of existing conduit systems.
2. Conduit can be threaded in the shop or on the job site.
3. It is a safe method to use for installations in hazardous locations.
4. When properly cut and made up, a threaded joint retains the maximum wall and ensures electrical conductivity.

Successful threading requires close attention to all of the details. The threading operation is simple, yet precision is the key. The correct dies must be selected for the conduit being threaded and the dies must be sharp. A proper cutting lubricant must be used. Both manual and power driven threading equipment are available. In general, the nominal length of thread has been cut when the front surfaces of the thread chasers are flush with the end of the conduit. For all conduit sizes, the threads are cut at an angle of 60 degrees (the angle included between the thread flanks). The thread tapers 1 in 16 or ¾ inch per foot on diameter.

A.1 CHANGING DIES

The necessary procedures for changing threading dies are dependent on the specific threader being used. To provide good workmanship, be sure to refer to the manufacturer's instructions.

Make certain that the machine and die head are clean. If chips are allowed to accumulate in the machine components, problems will result. Occasionally disassemble the die head and remove any accumulation of foreign material. This practice will increase the life of the die head and promote better threads. When cutting threads, occasionally check the condition of the dies. Make certain the dies are not getting dull or chipped and that conduit material is not fusing or welding to the cutting edges. If a problem persists with the threads that are being cut, carefully look at the threads. If the leading flank of a thread is deformed, it probably is caused by something different than if the receding flank is deformed. If only the first few threads are deformed, the problem is different than if the deformation exists over the full length.

A.2 SOME CAUSES OF COMMON THREADING PROBLEMS

TORN THREADS:

1. Improper cutting fluid
2. Poor cutting fluid flow
3. Dies are not ground for material being cut
4. Dies are worn
5. Speed is too fast
6. Material is too hard

WAVY THREADS:

1. Dies are not ground for material being cut
2. Dies are too tight in the die head
3. Not enough bearing

DIES CHIPPING ON TEETH:

1. Improper cutting fluid
2. The material is too hard
3. Poor cutting fluid flow
4. Speed is too fast

METAL FUSING TO DIES:

1. Improper cutting fluid
2. Poor cutting fluid flow
3. Speed is too fast
4. Dies are dull

DIES WEAR OUT QUICKLY:

1. Improper cutting fluid
2. Speed is too fast
3. Incorrect die sharpening
4. Incorrect die material used

SQUEALING DURING CUTTING:

1. Improper cutting fluid
2. Poor cutting fluid flow

RAGGED OR CHATTERED THREADS:

1. Dies are getting worn out and are dull

ANNEX B: Grounding and EMI

Steel conduit and tubing have been proven to be excellent equipment grounding conductors, safely providing a low impedance path in the event of a ground fault on the system. Steel conduit and tubing have also been proven to be very effective in reducing electro-magnetic interference at power frequencies. Magnetic field reduction in steel conduit incased power systems is on the order of 70 to 95 percent.

COMPUTER MODEL DEVELOPED

For the past forty years, the following excellent publications have served as key industry resources for information on grounding:

- R.H. “Dick” Kaufman (General Electric), GER 957A “Some Fundamentals of Equipment Grounding Circuit Design”, IE 1058.33 November 1954, Applications and Industry Vol. 73, Part II
- J. Philip Simmons, “IAEI Soares Book on Grounding”
- Eustace C. Soares (Pringle Switch), “Grounding Electrical Distribution Systems for Safety”

In the early 1990’s, the members of the Steel Conduit and Tubing Section of the National Electrical Manufacturers Association (NEMA) provided funding to the Georgia Institute of Technology, School of Electrical and Computer Engineering, to develop a computer model on grounding. The model was validated by field tests consisting of arc voltage testing and fault current testing on thirteen 256-foot runs of steel RMC, IMC, and EMT, installed with a variety of couplings. Results of the research, conducted by Dr. A. P. Sakis Meliopoulos, P.E. and Dr. Elias N. Glytsis, P.E., were published in May 1994 as “Modeling and Testing of Steel EMT, IMC, and Rigid (GRC) Conduit, Part 1.” This research was completed again with additional variables being considered and with more advanced equipment in 2018 and 2019. This testing reaffirmed the validity of steel conduit as a grounding conductor and for use in mitigating electro-magnetic interference. Details of this updated research can be found at **steeltubeinstitute.org/resources/gemi-analysis-research**

This research on grounding and additional research on EMI provided the data for a software analysis program (for the WINDOWS operating system) called GEMI, Grounding and Electro Magnetic Interference.

The GEMI program allows the user to quickly calculate and size equipment grounding conductors and determine a safe run length to comply with the National Electrical Code using steel rigid metal conduit (RMC), intermediate metal conduit (IMC), electrical metallic tubing (EMT), and copper or aluminum conductors. **See Tables on pages 28 and 29 for examples of calculations from the GEMI software analysis program.**

It also allows the user to calculate the EMF density of a network design for conduit enclosed circuits.

GEMI software is available from the Steel Tube Institute (STI) or it can be downloaded from the STI Conduit Committee web site: **steeltubeinstitute.org/steel-conduit/product-overview-benefits**

Maximum length of steel conduit/EMT that may safely be used as an equipment-grounding circuit conductor. Based on a ground-fault current of 400% of the overcurrent device rating. Circuit 120 volts to ground; 40 volts drop at the point of fault. Ambient temperature 25°C.

Copper Equipment Grounding Conductor AWG Size***	Copper Circuit AWG Conductors	Maximum Length of Run (in feet) using Copper Equipment Ground Conductor	Aluminum Equipment Grounding Conductor AWG Size***	Aluminum Circuit AWG Conductors	Maximum Length of Run (in feet) using Aluminum Equipment Grounding Conductor	For Copper and Aluminum: Overcurrent Device Rating Amperes 75°C**	For Copper and Aluminum: Fault Clearing Current 400% O.C. Device Rating Amperes
14	14	253	12	12	244	15	60
12	12	300	10	12	226	20	80
10	10	319	8	8	310	30	120
10	8	294	8	8	232	40	160
10	6	228	8	4	221	60	240
8	3	229	6	1	222	100	400
6	3/0	201	4	250 kcm	195	200	800
4	350 kcm	210	2	500 kcm	204	300	1200
3	600 kcm	195	1	900 kcm	192	400	1600
2	2-4/0	160	1/0	2-400 kcm	163	500	2000
1	2-300 kcm	160	2/0	2-500 kcm	161	600	2400
1/0	3-300 kcm	134	3/0	3-400 kcm	131	800	3200
2/0	4-250 kcm	114	4/0	4-400 kcm	115	1000	4000
3/0	4-300 kcm	106	250 kcm	4-500 kcm	107	1200	4800
4/0	4-600 kcm	93	350 kcm	4-900 kcm	97	1600	6400
250 kcm	5-600 kcm	78	400 kcm	5-800 kcm	79	2000	8,000
350 kcm	6-600 kcm	*	600 kcm	6-900 kcm	*	2500	10,000
400 kcm	8-500 kcm	*	600 kcm	8-750 kcm	*	3000	15,000
500 kcm	8-1000 kcm	*	800 kcm	8-1500 kcm	*	4000	16,000
700 kcm	10-1000 kcm	*	1200 kcm	10-1500 kcm	*	5000	20,000
800 kcm	12-1000 kcm	*	1200 kcm	12-1500 kcm	*	6000	24,000

*Calculations necessary
** 60°C for 20- and 30-ampere devices
*** Based on NEC Chapter 9, Table 8

The table shows examples of calculations from the GEMI (Grounding and ElectroMagnetic Interference) analysis software program. Reprinted from Soures Book on bonding and Grounding, 10th edition, by permission of the International Association of Electrical Inspectors.

Maximum length of steel conduit/EMT that may safely be used as an equipment-grounding circuit conductor. Based on a ground-fault current of 400% of the overcurrent device rating. Circuit 120 volts to ground; 40 volts drop at the point of fault. Ambient temperature 25°C.						
Trade Size	Conductors AWG	Overcurrent Device Rating Amperes 75°C*	Fault Clearing Current 400% O.C. Device Rating Amperes	Maximum length of Rigid Run in feet	Maximum Length of IMC Run in feet	Maximum Length of EMT Run in feet
½ (16)	3-12	20	80	384	398	395
	4-10	30	120	364	383	358
¾ (21)	4-10	30	120	386	399	404
	4-8	50	200	334	350	332
1 (27)	4-8	50	200	350	362	370
	3-4	85	340	357	382	365
1 ¼ (35)	3-2	115	460	365	392	391
1 ½ (41)	3-1	130	520	377	402	407
	3-2/0	175	700	348	377	364
2 (53)	3-3/0	200	800	363	389	390
	3-4/0	230	920	347	375	367
2 ½ (63)	3-250 kcm	255	1020	356	368	406
3 (78)	3-350 kcm	310	1240	355	367	404
	3-500 kcm	380	1520	327	338	370
	3-600 kcm	420	1680	314	325	353
4 (103)	3-900 kcm	520	2080	310	320	353
	3-1000 kcm	545	2180	304	314	347

The table shows examples of calculations from the GEMI (Grounding and ElectroMagnetic Interference) analysis software program. Reprinted from Soures Book on bonding and Grounding, 10th edition, by permission of the International Association of Electrical Inspectors.

ANNEX C: Reference Standards

This publication, when used in conjunction with the National Electrical Code and steel conduit manufacturers' literature, provides sufficient information to install steel conduit. The following associations and publications may also provide useful information:

National Fire Protection Association (NFPA)
One Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
Phone: (617) 770-3000
nfpa.org

NFPA 70, National Electrical Code (ANSI)
(Published by NFPA)

National Electrical Manufacturers Association (NEMA)
1300 17th St. N, #900
Arlington, VA 22209
Phone: (703) 841-3200
nema.org

NEMA FB 1
Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies

NEMA FB 2.10
Selection and Installation Guidelines for Fittings for use with Non-Flexible Metallic Conduit or Tubing

Steel Tube Institute
(STI) Conduit Committee

Annular Space Protection of Openings Created by Penetrations of Tubular Steel Conduit

Modeling and Evaluation of Conduit Systems for Harmonics and Electromagnetic Fields

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

GEMI (Grounding and ElectroMagnetic Interference) Analysis Software

TECH TALK Bulletins on corrosion protection, grounding, through penetrations, etc.

ABOUT STEEL TUBE INSTITUTE™

The Steel Tube Institute (STI) was founded in 1930 and sponsors cooperative member efforts to improve manufacturing techniques for conduit and other tubular steel products and informs customers and fabricators about these products' utility and versatility. It is headquartered in Glenview, Illinois.

ALLIED TUBE & CONDUIT

16100 S. Lathrop Avenue
Harvey, IL 60426
TEL: (708) 339-1610
FAX: (708) 339-0615

alliedeg.us

NUCOR TUBULAR PRODUCTS: REPUBLIC CONDUIT

7301 Logistics Drive
Louisville, KY 40258
TEL: (800) 840-8823
FAX: (502) 995-5873

nucortubular.com

WESTERN TUBE

P.O. Box 2720
Long Beach, CA 90801-2720
TEL: (800) 310-8823
FAX: (310) 604-9785

westerntube.com

WHEATLAND TUBE

1 Council Avenue
P.O. Box 608
Wheatland, PA 16161
TEL: (800) 257-8182
FAX: (724) 346-7260

wheatland.com

STEEL TUBE INSTITUTE

2516 Waukegan Road, Suite 172
Glenview, IL 60025

TEL: 847.461.1701
FAX: 847.660.7981
steeltubeinstitute.org