AMERICAN NATIONAL STANDARD

NECA 101-2001

Standard for Installing

Steel Conduits (Rigid, IMC, EMT)

NEIS®

Published by
National Electrical
Contractors Association

NECA

Jointly developed with
Steel Tube Institution
of North America

NECA 101–2001

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National Electrical Installation Standards™

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(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards™ are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS*™ are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

> Tubular steel raceways shall be installed in accordance with NECA 101, *Standard for Installing Steel Conduits (Rigid, IMC, EMT).*

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The installation and maintenance practices recommended by this publication are intended to comply with the edition of the National Electrical Code® (NEC) in effect at the time of publication. *NEIS*™ are not intended to duplicate NEC requirements nor to establish regulatory requirements for electrical construction. It is the responsibility of users of this standard to comply with state and local electrical codes when installing electrical products and systems.

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1. Scope

This standard 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 standard 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, applicable state and local codes, and 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 standard is intended to enhance electrical safety by (1) aiding the installer in meeting the "neat and workmanlike" requirements, (2) reducing future repair needs, (3) providing for future expansion to avoid electrical overload, (4) creating an installation which will protect the wire conductors from mechanical abuse, (5) and providing electrical continuity of the raceway system.

2. Glossary (as used in this Standard)

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

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 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

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 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. In addition, it is the path by which a 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 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-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 standard 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 required by the applicable standard for listing.

Running threads Continuous straight threads cut into a conduit and extended down its length.

Raceway As defined in the NEC, this term includes more than steel conduit. In this standard it is a round steel tube designed for routing electrical or optical fiber wires and cables and is used to mean rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

Supplementary coating A coating other than the primary coating applied to listed rigid metal conduit 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 metal conduit system is recognized by the NEC as providing its own equipment grounding path.

3.1.1 Rigid metal conduit — RMC (ferrous metal)

(NOTE: Conduits manufactured from aluminum, stainless steel, brass, silicon-bronze, or other metals are not covered by this standard.)

Rigid metal conduit (RMC) is a listed threaded metal raceway of circular cross section with a coupling which can be either a standard straight tapped conduit coupling or the integral type *(see Figure 1)*. Threads on the uncoupled end are covered by color-coded thread protectors which protect the threads, keep them clean and sharp, and aid in trade size recognition. Rigid metal conduit is available in trade sizes $^1/_2$ through 6. Thread protectors for trade sizes 1, 2, 3, 4, 5, and 6 are color-coded blue, trade sizes $^1/_2$, 1 $^1/_2$, 2 $^1/_2$, 3 $^1/_2$ are black, and trade sizes $^3/_4$ and 1-$^1/_4$ are red. (See Table 1 for Metric Trade Size Designators.) The nominal finished length of RMC *with coupling* is 10 feet.

Figure 1: Rigid Metal Conduit (RMC)
(Courtesy of Allied Tube & Conduit)

Rigid metal conduit can have a primary coating of zinc, a combination of zinc and organic coatings, or a nonmetallic coating (such as PVC). Supplementary coatings can be applied to all three 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.

Rigid metal conduit 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 approved corrosion resistant organic coatings on the interior. Rigid with alternate corrosion protection generally has organic coatings on both the exterior and the interior surfaces. Galvanized rigid metal conduit (RMC) has no temperature limitations and can be used indoors, outdoors, underground, concealed or exposed. Rigid metal conduit 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)

Intermediate Metal Conduit (IMC) is a listed threaded steel raceway of circular cross section with a coupling which can be either a standard straight-tapped conduit coupling or the integral type *(see Figure 2)*. Threads on the uncoupled end are covered by color coded thread protectors which protect the threads, keep them clean and sharp, and aid in trade size recognition. IMC is available in trade sizes $^1/_2$ through 4. Thread protectors for trade sizes 1, 2, 3, 4, are color-coded orange; trade sizes $^1/_2$, 1 $^1/_2$, 2 $^1/_2$, 3 $^1/_2$ are yellow; and trade sizes $^3/_4$ and 1 $^1/_4$ are green. (See Table 1 for Metric Trade Size Designators.) The nominal finished length of IMC *with coupling* is 10 feet.

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 approved organic corrosion-resistant coating. IMC is interchangeable with galvanized rigid metal conduit. Both have threads with a $^3/_4$-inch per foot taper; use the same couplings and fittings; have the same support requirements; and are permitted in the same locations.

3.1.3 Electrical metallic tubing - EMT (ferrous metal)

(NOTE: Aluminum EMT is not covered by this standard.)

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 long *(see Figure 3)*. The outside corrosion protection is zinc based and the inside has an approved corrosion resistant organic coating. Trade sizes are $^1/_2$ 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 which is comprised of a "belled" end of the tube with set screws *(see Figure 4)*.

3.1.4 PVC-coated conduit — (See Section 6)

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.

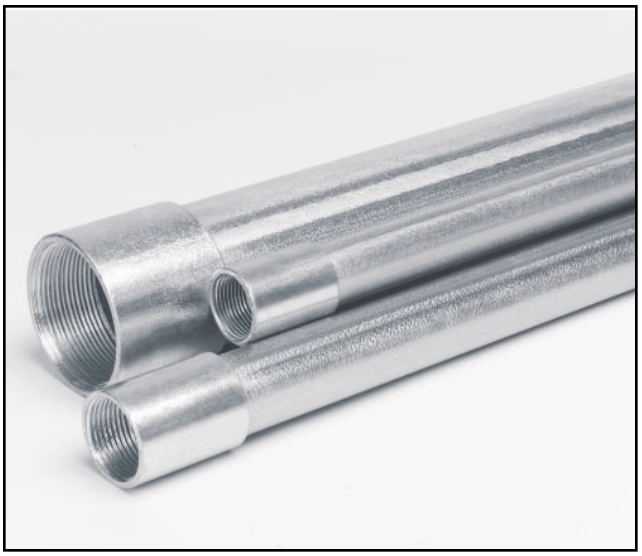

Figure 2: Intermediate Metal Conduit (IMC)
(Courtesy of Allied Tube & Conduit)

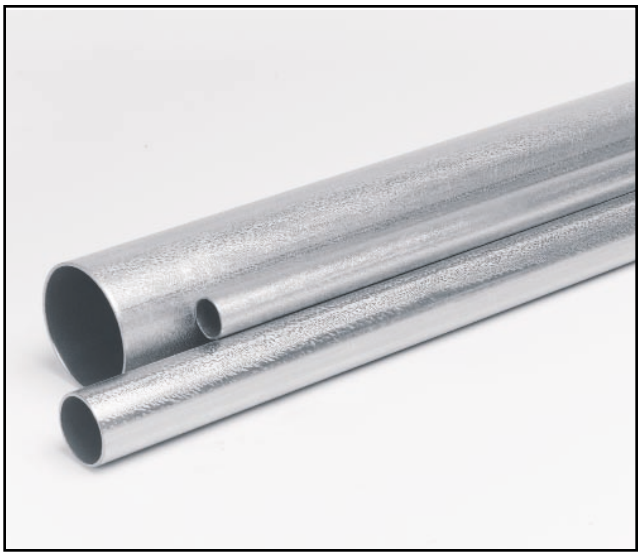

Figure 3: Electrical Metallic Tubing (EMT)
(Courtesy of Allied Tube & Conduit)

IMC and rigid 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 RMC, IMC, and EMT. Elbows with integral couplings are available in trade sizes 2 $^1/_2$ through 4. Specialized large radius elbows, which are 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 space, provide specific stub-up length, or enhance protection of communication or fiber optic cables during pulls.

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.

Table 1: Metric Trade Size Designators For RMC, IMC and EMT

*Trade Size Designator	
English	Metric
$^1/_2$	16
$^3/_4$	21
1	27
1 $^1/_4$	35
1 $^1/_2$	41
2	53
2 $^1/_2$	63
3	78
3 $^1/_2$	91
4	103
5	129
6	155

* Identifier only; not an actual dimension

Table 1

3.2.2 Nipples

A nipple is a short length of conduit or tubing material which is used to extend a conduit system. Nipples are used between conduit or tubing 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.
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.

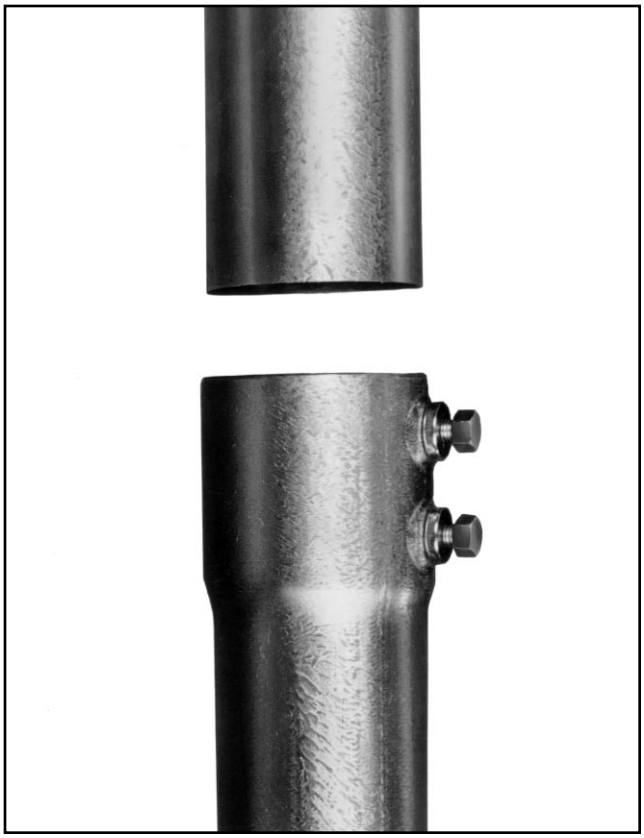

Figure 4: EMT with integral coupling
(Courtesy of Allied Tube & Conduit)

3.2.3 Couplings

Factory-made couplings for EMT, IMC, and RMC are readily available in all conduit sizes. Integral couplings are available on trade sizes $^1/_2$ through 4 of RMC, IMC, and EMT. On EMT this is a belled end of the conduit with specific set-screws. For IMC and RMC it is a coupling which permits joint make-up by turning the outside coupling rather than the conduit.

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 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.**

a) Use a standard $^3/_4$ inch per foot taper National Pipe Thread (NPT) die. The threads shall be cut full and clean using sharp dies.

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.

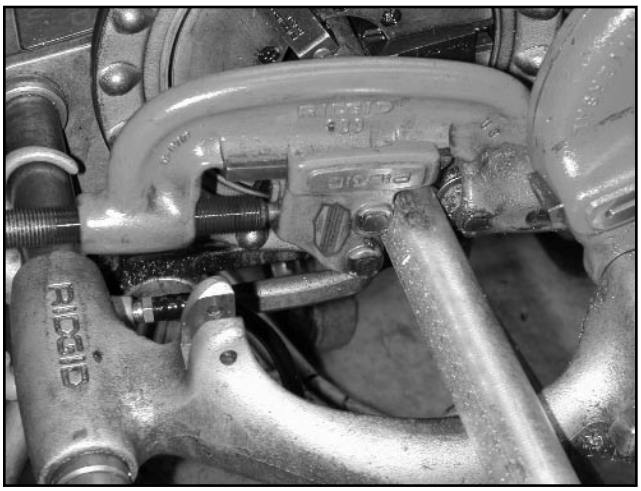

Figure 5: Lower the roll cutter to the desired length. Tighten the handle about one quarter turn per each revolution and repeat until the conduit is cut through.
(Courtesy of Wheatland Tube)

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.
(Courtesy of Wheatland Tube)

(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.)

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 oval 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 insures 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.)

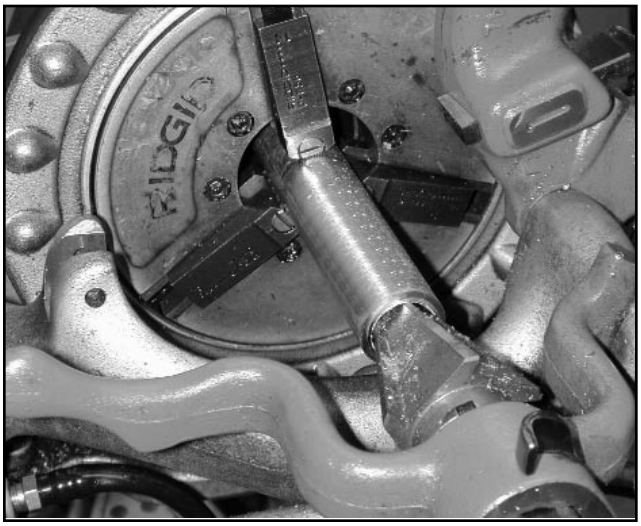

Figure 7: Insert the (flute) reamer into work piece and rotate until burr is removed.
(Courtesy of Wheatland Tube)

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

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

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.

Figure 9: When proper thread length is achieved the end of the conduit becomes flush with the ends of the die segments.
(Courtesy of Wheatland Tube)

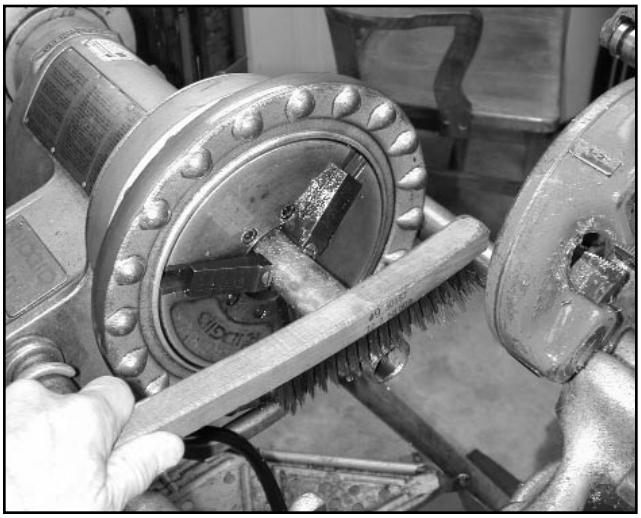

Figure 10: Wire brush the threads to remove any shavings or debris.
(Courtesy of Wheatland Tube)

To insure that the threads are properly engaged, the coupling should be made up hand-tight, then wrench-tightened. 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.

4.1.2 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.

Table 2: Proper Wrench Sizes

Conduit Trade Size	Wrench Size
under $^1/_2$	10”
$^1/_2$	12”
$^3/_4$ through 1 $^1/_4$	14”
1 $^1/_2$	18”
2 - 2 $^1/_2$	24”
3 - 4	36”
5 - 6	48”

4.2 Bending Galvanized Conduit and Tubing

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. These most commonly used types of bends can be quickly, efficiently, and economically made by a knowledgeable and experienced installer.

Figure 11: Threads should be checked with a NPT-L1 threaded ring gauge to ensure proper make up.
(Courtesy of Wheatland Tube)

The skills needed to obtain a level of proficiency are readily learned and require a 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, consider using as few bends as possible to make wire pulling easier. The fewer total degrees and the use of shallow bends combine to reduce the strain created by pulling wire. For multiconductor control cable and communica-

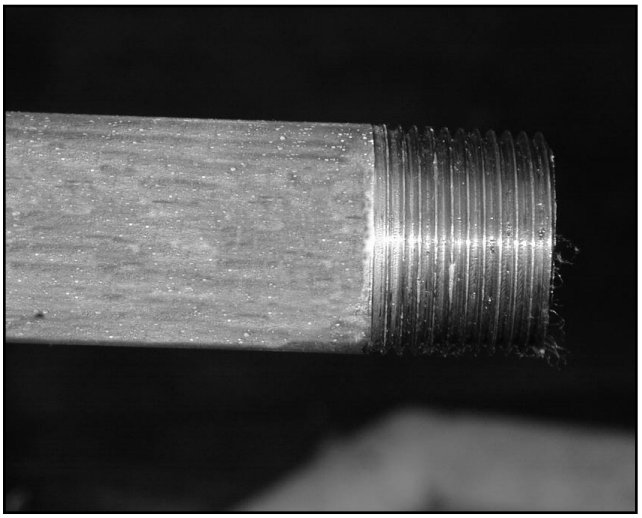

Figure 12: A proper thread should be free from chips or tears over the entire length.
(Courtesy of Wheatland Tube)

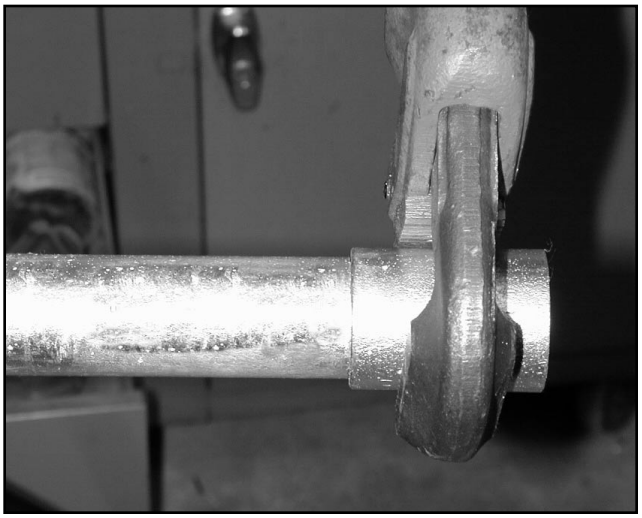

Figure 13: When assembled wrench-tight the coupling will cover all threads.
(Courtesy of Wheatland Tube)

tions cable, runs should be limited to two 90° bends (a total of 180°).

d) 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) All radius measurements shall be made to the centerline of the bend.

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) Slight overbending may be necessary to compensate for springback.

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 galvanized rigid metal conduit (RMC)

When an EMT bender does not prohibit bending rigid conduit, a bender shoe one trade size larger than the conduit to be bent can be used. Using the EMT bender will result in a slightly larger radius.

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

Trade sizes $^1/_2$, $^3/_4$, and 1 can be bent with a hand-type bender. Trade sizes 1 $^1/_4$ and 1$^1/_2$ require a power bender or a mechanical ratchet-type bender. Bend trade sizes 2 and larger on a power bender.

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

4.2.3 Bending intermediate metal conduit (IMC)

An IMC bender is the preferred bending tool for IMC. Limit hand bending to trade sizes $^1/_2$, $^3/_4$, 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 1 $^1/_4$ and 1 $^1/_2$ 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 electrical metallic tubing

Use a bender of the correct trade size designed for bending EMT. EMT trade sizes $^1/_2$, $^3/_4$, and 1 can be bent with hand benders because of the thinner pliable wall. Use a mechanical rachet-type bender for trade sizes 1$^1/_4$ and 1$^1/_2$. 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 $^1/_2$ or $^3/_4$ 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 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. Overbend the stub slightly beyond the intended position. Place handle back into bender and bend to desired vertical position.

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

(NOTE: If step-end is not down, the bender could get wedged by the bend.)

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 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.)

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 *"Raintight"* or *"Wet locations"* on the fitting or its smallest unit shipping container. "Raintight" fitting designs that require 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: "Raintight" or "Liquidtight" fittings are not necessarily suitable for use in applications where submersion in water is expected. "Raintight" fittings are not necessarily considered "Liquidtight." "Liquidtight" fittings are intended for use in typical wet locations but also in "wet" industrial environments which may contain machine oils and coolants.)

Rigid metal conduit 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 *"Raintight"* 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 "Raintight" are also "Concrete-tight".)

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 rigid metal conduit (RMC) 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.)

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 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: Listed fittings are tested under prescribed torque which represent normal, not excessive force. Performance is not enhanced, and can be reduced, by overtorquing the fitting's securement means.)

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 both screwdriver and wrench application options are offered, torque should be limited to that which can be applied by the screwdriver.

Compression (gland) type: Generally, most compression gland nuts achieve maximum securement after

Table 3: Expansion Characteristics of Rigid Metal Conduit (RMC)

Coefficient of Thermal Expansion = 6.5×10^{-6} in/in/°F

Temperature Change in Degrees F	Length Change in Inches per 100 feet of Steel Conduit	Temperature Change in Degrees F	Length Change in Inches per 100 feet of Steel Conduit	Temperature Change in Degrees F	Length Change in Inches per 100 feet of Steel Conduit	Temperature Change in Degrees F	Length Change in Inches per 100 feet of Steel Conduit
5	0.04	55	0.44	105	0.84	155	1.26
10	0.08	60	0.48	110	0.90	160	1.30
15	0.12	65	0.52	115	0.94	165	1.34
20	0.16	70	0.56	120	0.98	170	1.38
25	0.20	75	0.60	125	1.02	175	1.42
30	0.24	80	0.64	130	1.06	180	1.46
35	0.28	85	0.68	135	1.10	185	1.50
40	0.32	90	0.72	140	1.14	190	1.54
45	0.36	95	0.76	145	1.18	195	1.58
50	0.40	100	0.82	150	1.22	200	1.62

hand tightening and then wrench tightening one or two additional turns.

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.

4.3.3.2 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 handtight 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 assembly to a box or enclosure or a threadless coupling, RMC, IMC and EMT shall be supported at intervals required by the NEC, or more frequently, using raceway supports intended for the purpose 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 requirements based on ***minimum*** *spacing intervals given in the NEC. Closer support intervals than are required by the NEC are 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 insure that the threaded entry will accommodate a minimum of 3 full engaged threads.

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 $^1/_4$ turn using an appropriate tool.

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

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

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 Raceways

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

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

a) **Raceways 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 $^1/_2$ through 1 are permitted to be supported by nail-straps in wood framing members.

b) **Raceways 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) **Raceways 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. Where the conduit or tubing transitions to vertical, be sure to secure it to the stud and within three feet of the termination.

d) **Raceways suspended below ceilings or structural members such as beams, columns, or purlins, or in ceiling cavities:** These conduits 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 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. Where this system is wire, it shall be identified as conduit support. Conduit 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 raceways:** 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.

4.4.3 Raceway supports shall be installed only on conduit of the trade size indicated on the fitting or its smallest unit shipping container.

4.5 Firestopping and Fire Blocking

4.5.1 Penetration of fire-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-rated assembly be sealed, to prevent smoke, gases, and flames from one area migrating

into another. *(NOTE: This is called firestopping.)* There are many listed penetration firestopping systems which can be used to seal openings; the listing instructions shall be strictly followed.

Most building codes permit openings around galvanized steel RMC, IMC, and EMT in 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.

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

RMC, IMC, and EMT are not required to have fire ratings because building codes define these galvanized steel raceways as noncombustible. Listed firestopping systems shall be used to fill the penetrations around metallic raceways.

4.5.2 Penetration of non-fire-rated assemblies

Openings in non-fire-rated assemblies are to be filled with noncombustible materials unless specified otherwise by the applicable building code or the project specification. *(NOTE: This is called fireblocking.)*

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 shall 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 raceways in a fire-rated enclosure (horizontal or vertical), embedding in concrete, using a listed wrap system for protection from fire (sometimes called Electrical Circuit Protection System or Thermal Barrier Protection for Electrical Components), and using conductors specifically rated to maintain the circuit.

(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 where conduit is installed in a fully sprinklered building. Local codes shall be consulted and the requirements of the applicable code must be followed.

4.6 Corrosion Protection

RMC, IMC and EMT sometimes require supplementary corrosion protection when installed in environments generally called "severely corrosive." Information on some indoor wet locations considered severely corrosive can be found in the NEC. See 4.6.1 for information on determining soil corrosivity. Specifics on installing conduit with a supplementary PVC coating applied at the factory are contained in Section 6. Other supplementary coatings are covered in 4.6.4.

4.6.1 Installed in soil

Where installed in contact with soil, RMC and IMC and associated fittings require supplementary corrosion protection if:

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

b) Local experience has confirmed that the soil is extremely corrosive.

(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.)

Electrical metallic tubing 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 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 it shall be provided by one of the following methods, and the authority having jurisdiction must pre-approve the method selected.

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

b) Paints approved for the purpose; one example is bitumastic paint. Paints shall be applied in two coats unless specifically approved for one coat.

c) Tape wraps approved for application. Wraps shall overlap and shall cover the entire surface of the conduit and all associated fittings.

4.7. Equipment Grounding Using Steel Conduit

4.7.1 Steel conduit as equipment grounding conductor

Rigid metal conduit, IMC and EMT are recognized by the NEC as equipment grounding conductors. Use of a supplemental equipment grounding conductor in the form of a *wire* in addition to the raceway is a design decision, except where the Code requires it for redundancy in some special installations.

Steel conduit is the main equipment grounding conductor regardless of whether a supplemental 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 fewer 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 Code requirements when properly designed and installed *(see Annex B).*

4.7.3 Maximum length of raceway

Equipment grounding conductors (which include steel conduit) and the connectors must be properly sized. EMT connectors shall not be used with IMC or rigid RMC. The installed length of any wiring method can also impact safe 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.

4.7.4 Clean threads

Threads must be clean to insure electrical continuity of the assembled raceway system. Leave the thread protec-

tors on the conduit until ready to use. Wipe field-cut threads with a clean cloth to remove excess oil.

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

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

1. Use listed fittings.
2. With 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, and shall be made electrically continuous by the use of equipment bonding jumpers.

5. Specific Installation Requirements

5.1 General

(NOTE: All requirements in this section are in addition to those of the NEC.)

a) All exposed raceways shall be run parallel or perpendicular to walls and ceilings.

b) A sufficient number of *home run* raceways 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 (suspended ceilings excepted), the minimum size of home run conduit and tubing shall be trade size $^3/_4$.

d) The minimum size for raceways in industrial occupancies shall be trade size $^3/_4$.

(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 RMC, IMC or EMT. EMT shall not be used for mast installations supporting the overhead drop.

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) Coat all exposed threads in wet or damp environments with a zinc-enriched paint or other suitable means of preventing corrosion.

i) Do not use raceways 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 raceway. *(NOTE: This is extremely important in alternating current (AC) applications.)*

l) The raceway 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 4.1 or 6.3 (PVC-coated conduit), as applicable.

n) Bending shall comply with 4.2.

o) Supports shall comply with 4.4.

5.2 Raceways Installed in Concrete

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

b) Conduit 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 or after the concrete pour.)

c) Refer to 4.6.2 for supplementary corrosion protection requirements where steel raceways transition from concrete to earth.

d) Conduit shall be supported to prevent damage prior to and during the concrete pour. When nonmetallic conduits 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, mark the stub in some manner to indicate a supplemental equipment grounding conductor is needed 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.)

e) See 4.3.2 for requirements regarding taping of joints in concrete.

5.3 Communication Circuits

a) Raceways for low voltage or communications circuits shall terminate in boxes, enclosures, or wireways, except as permitted in 5.3(c).

b) If vacant 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 such raceways and provisions are to be made to prevent debris from entering the conduit.

5.4 Underground Services

a) It is recommended that IMC or RMC be used to bring underground service conductors out of the ground to the meter or disconnect.

b) Where underground service raceways 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 from entering the building.)

5.5 Verification of Installation

All metal raceway systems shall be electrically 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.
2. A PVC coating over listed galvanized steel conduit. This is a supplementary coating intended for added protection in severely corrosive locations.
3. A primary PVC coating over a supplementary coating of zinc. This is also intended for severely corrosive locations.

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.)

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 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 rigid metal conduit as follows.

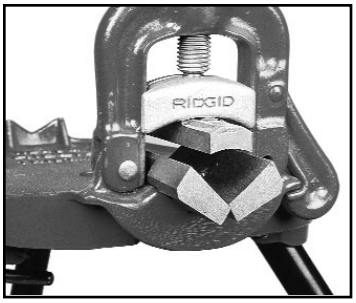

Figure 14: Manfacturer's adapters used with pipe vise to protect PVC-Coated conduit.
(Courtesy of ROBROY Industries Conduit Division)

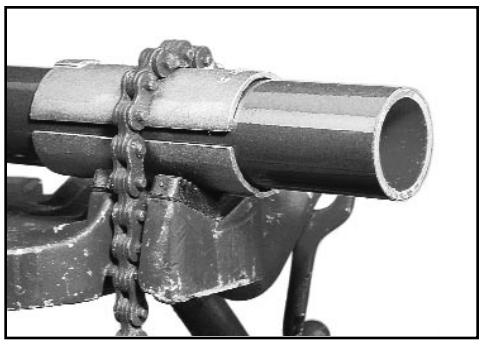

Figure 15: Field-fabricated half shell clamps used with chain vise to protect PVC-coated conduit.
(Courtesy of ROBROY Industries Conduit Division)

Figure 16: Using a utility knife to "pencil-cut" PVC coating before threading conduit.
(Courtesy of ROBROY Industries Conduit Division)

6.2.1 Clamping sleeves made from rigid metal conduit (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 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.

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.)

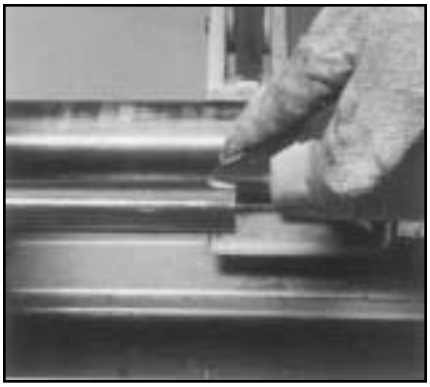

Figure 17: Before threading PVC-coated conduit, make a series of cuts along the axis of the conduit with a utility knife. (Courtesy of ROBROY Industries Conduit Division)

Figure 18: Using a reamer to remove rough edges of cut PVC-coated conduit. (Courtesy of ROBROY Industries Conduit Division)

Figure 19: To avoid damaging the PVC coating, use an EMT shoe one trade size larger than the conduit being bent. (Courtesy of ROBROY Industries Conduit Division)

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. To avoid this and permit removal of PVC in small pieces, make a series of longitudinal cuts in the PVC coating (i.e., along the conduit) in the area to be threaded. The thread protector can be used as a length guide *(see Figure 17)*.

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

6.3.4 Thread protection

A conductive rust resistant coating shall be applied to field-cut threads to protect against corrosion. Zinc-rich paint is the most protective but a number of conductive coatings are available.

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 $^3/_4$ PVC-coated conduit, use a trade size 1 EMT bender.

6.4.2 Electric bending

a) A bender made specifically to bend PVC-coated conduit is preferred. Otherwise, for trade sizes ½ through 1 $^1/_2$, use an electric bender with EMT shoes one size larger than the PVC-coated conduit *(see Figure 19)*.

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. *Sleeves shall not be cut off or split.* Trimming is permitted where the length of the sleeve exceeds the available space. In cases where two sleeves meet, each sleeve is permitted to be trimmed equally so the two sleeves butt.

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 4.7. When expansion joints are used in PVC-coated conduit systems, it is recommended that an external bonding jumper be used. Generally, this will require removing a portion of the PVC coating from the conduit where the jumper will be attached, installing the jumper, 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.

(Annexes are not a part of the standard)

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.
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 strength by minimizing the number of threads outside the coupling or fitting.

Threading is one of the most severe operations in machining. 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 metal to be 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° (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 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.

SQUEALING DURING CUTTING:

(1) Improper cutting fluid

(2) Poor cutting fluid flow.

CHATTERED THREADS:

Dies are getting worn out and are dull.

Annex B: Grounding

The key to a reliable electrical system is a grounded system with all materials properly selected for the application and installed in accordance with the recommended installation guidelines, the product "Listing," and a recognized electrical code.

(NOTE: There are exceptions for unique installations in which an ungrounded system with reliable ground-fault detectors and assured maintenance are acceptable.)

The most important element of all electrical systems is to assure the system is grounded and that equipment grounding is provided; yet it remains one of the least understood and the most error prone part of any electrical system.

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 ll
- 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 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 on grounding, along with later research on how steel conduit shields against electromagnetic fields, sponsored by the Steel Tube Institute, is now available in a software analysis program (for the WINDOWS operating system) called **GEMI**, **G**rounding and **E**lectro**M**agnetic **I**nterference. Although the techniques established by Soares *Grounding Electrical Distribution Systems for Safety* have provided the industry with good primary design guidance, these new computer and analytical means have made advancements possible.

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), copper or aluminum conductors.

GEMI software is available from the Steel Tube Institute of North America (STI). See Annex C.

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 publications may also provide useful information:

National Fire Protection Association
One Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000 tel
(617) 770-3500 fax
www.nfpa.org

NFPA 70-1999, *National Electrical Code* (ANSI)

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209
(703) 841-3200 tel
(703) 841-3300 fax
www.nema.org

NEMA FB 1-1993, *Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies* (ANSI)

Steel Tube Institute of North America
8500 Station Street, Suite 270
Mentor, OH 44060
(440) 974-6990 tel
(440) 974-6994 fax
www. steeltubeinstitute.org

Modeling and Evaluation of Conduit Systems for Harmonics and Electrimagnetic Fields

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

GEMI (Grounding and ElectroMagnetic Interference) Analysis Software

Other *National Electrical Installation Standards*™ published by NECA:

National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 215-4504 tel
(301) 215-4500 fax
www.neca-neis.org

NECA 1-2000, *Practices for Good Workmanship in Electrical Construction* (ANSI)

NECA 100-1999, *Symbols for Electrical Construction Drawings* (ANSI)

NECA/FOA 301-1997, *Standard for Installing and Testing Fiber Optic Cables*

NECA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards* (ANSI)

NECA 402-2000, *Recommended Practice for Installing and Maintaining Motor Control Centers*

NECA/EGSA 404-2000, *Recommended Practice for Installing Generator Sets* (ANSI)

NECA/IESNA 500-1998, *Recommended Practice for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 501-2000, *Recommended Practice for Installing Exterior Lighting* (ANSI)

NECA/IESNA 502-1999, *Recommended Practice for Installing Industrial Lighting Systems* (ANSI)

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Standards & Safety
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