

## ARTICLE

## 344 Rigid Metal Conduit (RMC)

**Part I. General**

**344.1 Scope.** This article covers the use, installation, and construction specifications for rigid metal conduit (RMC) and associated fittings.

**344.6 Listing Requirements.** RMC, factory elbows and couplings, and associated fittings shall be listed.

**Part II. Installation****344.10 Uses Permitted.****(A) Atmospheric Conditions and Occupancies.**

**(1) Galvanized Steel, Stainless Steel, and Red Brass RMC.** Galvanized steel, stainless steel, and red brass RMC shall be permitted under all atmospheric conditions and occupancies.

**Δ (2) Aluminum RMC.** Aluminum RMC shall be permitted to be installed where approved for the environment.

**(3) Ferrous Raceways and Fittings.** Ferrous raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors and in occupancies not subject to severe corrosive influences.

**(B) Corrosive Environments.**

**(1) Galvanized Steel, Stainless Steel, and Red Brass RMC, Elbows, Couplings, and Fittings.** Galvanized steel, stainless steel, and red brass RMC, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, in direct burial applications, or in areas subject to severe corrosive influences where protected by corrosion protection approved for the condition.

**(2) Supplementary Protection of Aluminum RMC.** Aluminum RMC shall be provided with approved supplementary corrosion protection where encased in concrete or in direct contact with the earth, or in direct burial applications where identified for the application.

Other documents, such as the Steel Tube Institute's 2015 *Guidelines for Installing Steel Conduit/Tubing*, and ANSI/NECA 101-2013, *Standard for Installing Steel Conduits (Rigid, IMC, EMT)*, should be consulted for approval guidance of corrosion-resistant materials or for requirements prior to the installation of nonferrous metal (aluminum) conduit in concrete, since chloride additives in the concrete mix can cause corrosion.

**(C) Cinder Fill.** Galvanized steel, stainless steel, and red brass RMC shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 50 mm (2 in.)

thick; where the conduit is not less than 450 mm (18 in.) under the fill; or where protected by corrosion protection approved for the condition.

Although cinder fill is not commonly used in modern construction, it is still encountered at older building sites. Cinders used as fill may contain sulfur and, when combined with moisture, form sulfuric acid, which can corrode metal raceways.

**(D) Wet Locations.** All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant materials.

Informational Note: See 300.6 for protection against corrosion.

**(E) Severe Physical Damage.** RMC shall be permitted to be installed where subject to severe physical damage.

**344.14 Dissimilar Metals.** Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Stainless steel and aluminum fittings and enclosures shall be permitted to be used with galvanized steel RMC, and galvanized steel fittings and enclosures shall be permitted to be used with aluminum RMC where not subject to severe corrosive influences. Stainless steel rigid conduit shall only be used with the following:

- (1) Stainless steel fittings
- (2) Stainless steel boxes and enclosures
- (3) Steel (galvanized, painted, powder or PVC coated, and so forth) boxes and enclosures when not subject to severe corrosive influences
- (4) Stainless steel, nonmetallic, or approved accessories

Aluminum rigid conduit can be used with steel fittings and enclosures, as can aluminum fittings and enclosures with steel rigid conduit. Tests show that the galvanic corrosion at steel and aluminum interfaces is minor compared to the natural corrosion on the combination of steel and steel or of aluminum and aluminum.

**344.20 Size.**

**(A) Minimum.** RMC smaller than metric designator 16 (trade size ½) shall not be used.

*Exception: Metric designator 12 (trade size ⅜) shall be permitted for enclosing the leads of motors as permitted in 430.245(B).*

**(B) Maximum.** RMC larger than metric designator 155 (trade size 6) shall not be used.

Informational Note: See 300.1(C) for the metric designators and trade sizes. These are for identification purposes only and do not relate to actual dimensions.

**344.22 Number of Conductors.** The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9.



Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

Table 4 of Chapter 9 provides the usable area within the selected conduit or tubing, and Table 5 provides the required area for each conductor. Examples using these tables to calculate a conduit or tubing size are provided in the commentary following Chapter 9, Notes to Tables, Note 6.

To select the proper trade size of RMC, see the appropriate sub-table for Article 344, Rigid Metal Conduit (RMC), in Table 4 of Chapter 9. If the conductors are of the same wire size and insulation type, Tables C.9 and C.9(A) for RMC in Informative Annex C can be used instead of performing the calculations.

#### Δ 344.24 Bends.

**N (A) How Made.** Bends of RMC shall be so made that the conduit will not be damaged and so that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of any field bend to the centerline of the conduit shall not be less than indicated in Table 2, Chapter 9.

**N (B) Number in One Run.** The total degrees of bends in a conduit run shall not exceed 360 degrees between pull points.

Limiting the number of bends in a conduit run reduces pulling tension on conductors. It also helps ensure easy insertion or removal of conductors during later phases of construction when the conduit may be permanently enclosed by the finish of the building.

**344.28 Reaming and Threading.** All cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with a 1 in 16 taper ( $\frac{3}{4}$  in. taper per foot) shall be used. PVC-coated RMC shall be threaded in accordance with manufacturer's instructions to prevent damage to the exterior coating.

Informational Note No. 1: See ANSI/ASME B1.20.1-2013, *Standard for Pipe Threads, General Purpose (Inch)*.

Informational Note No. 2: See NECA 101-2013, *Standard for Installing Steel Conduits (RMC, IMC, EMT)*, for information on threading and clamping methods for RMC and PVC-coated RMC.

Conduit is cut using a saw or a roll cutter (pipe cutter). Crooked threads result from a die not started on the pipe squarely. After the cut is made, the conduit must be reamed. Proper reaming removes burrs from the interior of the cut conduit so that as wires and cables are pulled through the conduit, chafing of the insulation or cable jacket does not occur. Finally, the conduit is threaded. The number of threads is important. When determining the correct number of threads for a conduit end, the same number of threads should be cut on the conduit as are present on the factory (threaded) end of the conduit. Where excessive threads are cut on the conduit and threaded couplings are installed, the conduits within the coupling will butt, resulting in a weak mechanical joint and poor grounding continuity.

To avoid damage to the exterior coating on PVC-coated conduits, proper threading and clamping tools specifically designed for PVC-coated conduit must be used. Standard threading and clamping tools, which have not been modified, can cause damage to the coatings, therefore exposing the conduit to unintended corrosion and potential unsafe conditions. Manufacturer's instructions for threading and bending should also be followed, in order to prevent any additional damage.

**344.30 Securing and Supporting.** RMC shall be installed as a complete system in accordance with 300.18 and shall be securely fastened in place and supported in accordance with 344.30(A) and (B).

**(A) Securely Fastened.** RMC shall be secured in accordance with one of the following:

- (1) RMC shall be securely fastened within 900 mm (3 ft) of each outlet box, junction box, device box, cabinet, conduit body, or other conduit termination.
- (2) Fastening shall be permitted to be increased to a distance of 1.5 m (5 ft) where structural members do not readily permit fastening within 900 mm (3 ft).
- (3) Where approved, conduit shall not be required to be securely fastened within 900 mm (3 ft) of the service head for above-the-roof termination of a mast.

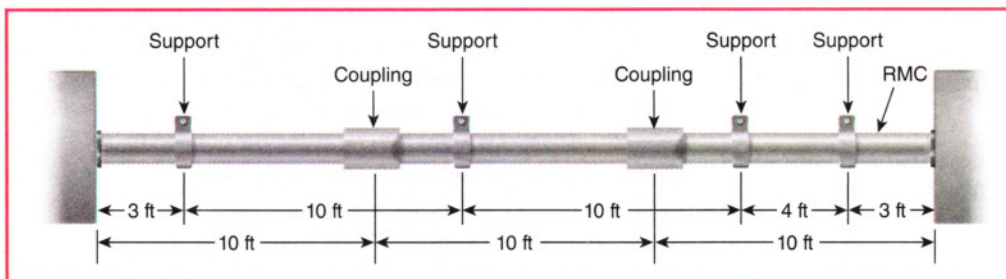
*Exception: For concealed work in finished buildings or pre-finished wall panels where such securing is impracticable, unbroken lengths (without coupling) of RMC shall be permitted to be fished.*

As illustrated in Exhibit 344.1, RMC is required to be securely fastened within 3 feet of outlet boxes, junction boxes, cabinets, conduit bodies, or other conduit terminations. Couplings are not considered conduit terminations. However, where structural support members do not permit fastening within 3 feet, secure fastening can be located up to 5 feet away. In addition, RMC is required to be supported at least every 10 feet unless permitted otherwise by 344.30(B).

**Δ (B) Supports.** RMC shall be supported in accordance with one of the following:

- (1) Conduit shall be supported at intervals not exceeding 3 m (10 ft).
- (2) The distance between supports for straight runs of conduit shall be permitted in accordance with Table 344.30(B), provided the conduit is made up with threaded couplings and supports that prevent transmission of stresses to termination where conduit is deflected between supports.
- (3) Exposed vertical risers from industrial machinery or fixed equipment shall be permitted to be supported at intervals not exceeding 6 m (20 ft) if the conduit is made up with threaded couplings, the conduit is supported and securely fastened at the top and bottom of the riser, and no other means of intermediate support is readily available.





**EXHIBIT 344.1** Minimum support required for RMC.

**TABLE 344.30(B)** Supports for Rigid Metal Conduit

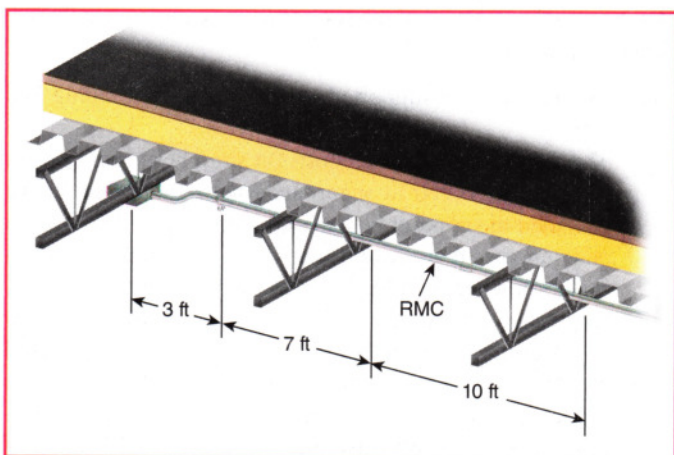
Conduit Size		Maximum Distance Between Rigid Metal Conduit Supports	
Metric Designator	Trade Size	m	ft
16–21	1/2–3/4	3.0	10
27	1	3.7	12
35–41	1 1/4–1 1/2	4.3	14
53–63	2–2 1/2	4.9	16
78 and larger	3 and larger	6.1	20

- (4) Horizontal runs of RMC supported by openings through framing members at intervals not exceeding 3 m (10 ft) and securely fastened within 900 mm (3 ft) of termination points shall be permitted.

Lengths of RMC are permitted to be supported (but not necessarily secured) by framing members at 10-foot intervals, provided the RMC is secured and supported at least 3 feet from the box or enclosure. Installations where the RMC is installed through bar joists are just one example, as illustrated in Exhibit 344.2.

### 344.42 Couplings and Connectors.

(A) **Threadless.** Threadless couplings and connectors used with conduit shall be made tight. Where buried in masonry or concrete,



**EXHIBIT 344.2** An example of RMC supported by framing members and securely fastened 3 feet from the box.

they shall be the concrete tight type. Where installed in wet locations, they shall comply with 314.15. Threadless couplings and connectors shall not be used on threaded conduit ends unless listed for the purpose.

Exhibit 344.3 illustrates two different conduit fittings: a threadless conduit coupling and a threadless conduit connector. Threadless fittings might be suitable for other applications, such as in raintight or concretetight applications, provided the product itself, or the product packaging, is marked as such.

In general, threadless fittings are not intended for use over threads, because the fitting will not seat properly. The threaded end of the conduit should be cut off and the conduit reamed before installation.

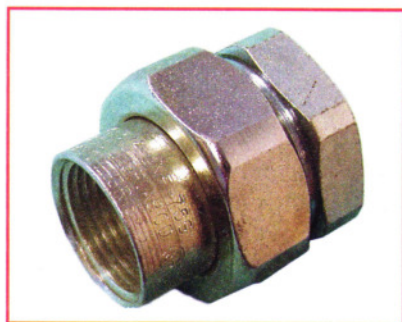
Exhibit 344.4 illustrates a three-piece threaded coupling (the electrical equivalent of a pipe union), which is used to join two lengths of conduit where turning either length is impossible, such as in underground or concrete slab construction. Another fitting for joining conduit is a bolted split coupling.

(B) **Running Threads.** Running threads shall not be used on conduit for connection at couplings.



**EXHIBIT 344.3** An example of RMC threadless connector (bottom) and a threadless coupling (top). (Courtesy of Eaton, Crouse-Hinds Division)





**EXHIBIT 344.4** A three-piece (union-type) coupling. (Courtesy of Appleton™, Emerson Electric Co.)

**344.46 Bushings.** Where a conduit enters a box, fitting, or other enclosure, a bushing shall be provided to protect the wires from abrasion unless the box, fitting, or enclosure is designed to provide such protection.

Informational Note: See 300.4(G) for the protection of conductors sizes 4 AWG and larger at bushings.

**344.56 Splices and Taps.** Splices and taps shall be made in accordance with 300.15.

**344.60 Grounding.** RMC shall be permitted as an equipment grounding conductor.

### Part III. Construction Specifications

**344.100 Construction.** RMC shall be made of one of the following:

- (1) Steel with protective coatings
- (2) Aluminum
- (3) Red brass
- (4) Stainless steel

**344.120 Marking.** Each length shall be clearly and durably identified in every 3 m (10 ft) as required in the first sentence of 110.21(A). Nonferrous conduit of corrosion-resistant material shall have suitable markings.

#### ARTICLE

## 348

### Flexible Metal Conduit (FMC)

#### Part I. General

**348.1 Scope.** This article covers the use, installation, and construction specifications for flexible metal conduit (FMC) and associated fittings.

**348.2 Reconditioned Equipment.** FMC shall not be reconditioned.

**348.6 Listing Requirements.** FMC and associated fittings shall be listed.

#### Part II. Installation

**348.10 Uses Permitted.** FMC shall be permitted to be used in exposed and concealed locations.

FMC ½ inch and larger may be installed in unlimited lengths, provided an equipment grounding conductor (EGC) is installed with the circuit conductors.

#### See also

**250.118(A)(5)** and **348.60(A)** for specific requirements related to the use of FMC as an EGC

**348.12 Uses Not Permitted.** FMC shall not be used in the following:

- (1) In wet locations
- (2) In hoistways, other than as permitted in 620.21(A)(1)
- (3) In storage battery rooms
- (4) In any hazardous (classified) location except as permitted by other articles in this Code
- (5) Where exposed to materials having a deteriorating effect on the installed conductors, such as oil or gasoline
- (6) Underground or embedded in poured concrete or aggregate
- (7) Where subject to physical damage

#### 348.20 Size.

**(A) Minimum.** FMC less than metric designator 16 (trade size ½) shall not be used unless permitted in 348.20(A)(1) through (A)(5) for metric designator 12 (trade size ¾).

- (1) For enclosing the leads of motors as permitted in 430.245(B)
- (2) In lengths not in excess of 1.8 m (6 ft) for any of the following uses:
  - a. For utilization equipment
  - b. As part of a listed assembly
  - c. For tap connections to luminaires as permitted in 410.117(C)

Trade size ¾ FMC is permitted to be used as the manufactured or field-installed metal raceway (1½ feet to 6 feet in length) to enclose tap conductors between the outlet box and the terminal housing of recessed luminaires. FMC is also permitted to be used as a 6-foot luminaire whip from an outlet box to a luminaire.

- (3) For manufactured wiring systems as permitted in 604.100(A)

A smaller minimum size for manufactured wiring systems is permitted [see Exception No. 3 to 604.100(A)(2)] because conductors assembled under factory-controlled conditions are not as prone to physical damage.

- (4) In hoistways as permitted in 620.21(A)(1)
- (5) As part of a listed assembly to connect wired luminaire sections as permitted in 410.137(C)