

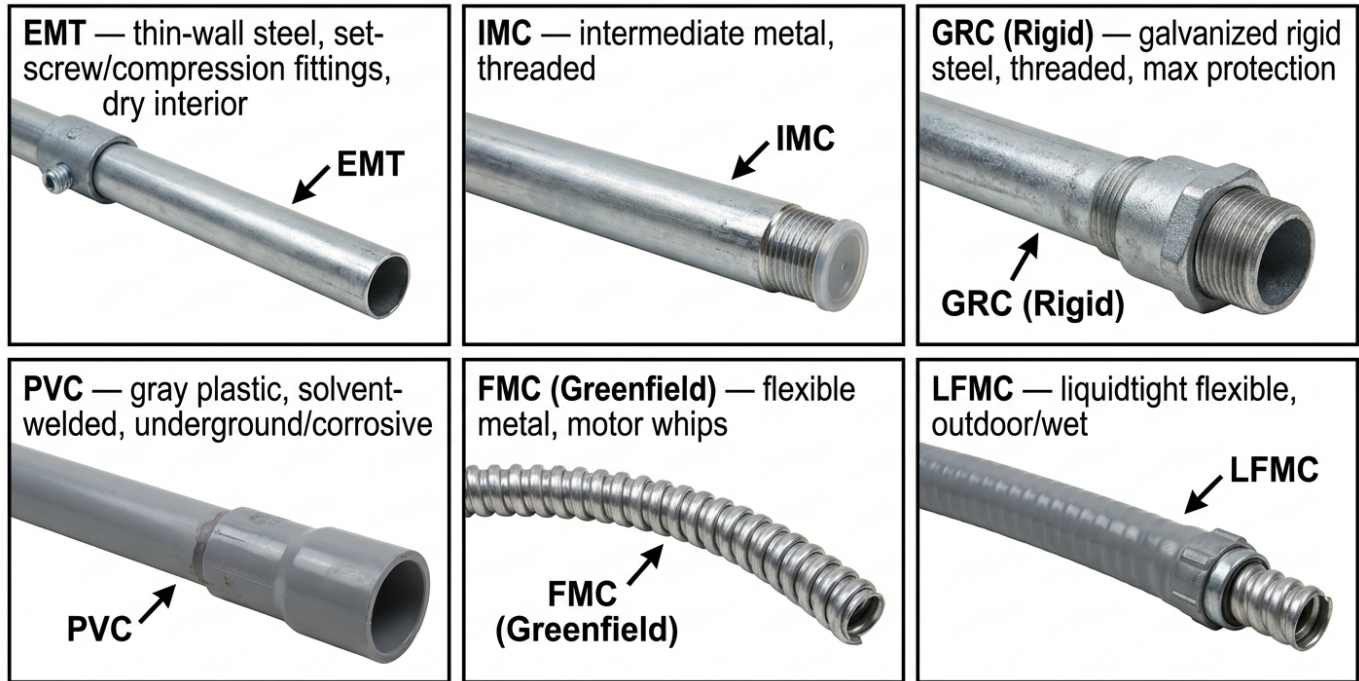
# Module 1.2 — Raceway & Conduit Systems

The raceway IS the wiring method. Types, then step by step: cut, ream, thread, join, bond, solvent-weld, terminate, fill, support, firestop, and allow for expansion.

**Why this module.** In a house the cable is the wiring method: you staple the cable and move on. In commercial work the **raceway is the wiring method**. The pipe routes and protects every conductor, and the wire goes in after. This module is the hands-on guide to the pipe: the types, then **step by step** how to cut, ream, thread, join, terminate, bond, fill, support, firestop, and allow for expansion, the way you will actually do it on the floor.

## Part A — Conduit & Tubing: Know Your Types

### COMMON COMMERCIAL CONDUIT & TUBING



The six everyday raceways. Choose by location, protection, and how it joins.

| Type                | Wall / what it is           | How it joins                                   | Where (NEC art.)                                     |
|---------------------|-----------------------------|------------------------------------------------|------------------------------------------------------|
| <b>EMT</b>          | Thin-wall steel tubing      | Set-screw or compression fittings (no threads) | Interior, the workhorse (358)                        |
| <b>IMC</b>          | Intermediate metal, thicker | Threaded                                       | Rigid-grade protection at less weight (342)          |
| <b>GRC/<br/>RMC</b> | Rigid steel, heaviest       | Threaded                                       | Maximum protection: exposed, hazardous, risers (344) |
| <b>PVC</b>          | Rigid plastic (Sch 40/80)   | Solvent-welded (glued)                         | Underground, slab, corrosive, wet (352)              |
| <b>FMC</b>          | Flexible metal              | Flex connectors                                | Whips to motors and fixtures, dry only (348)         |
| <b>LFMC</b>         | Liquidtight flexible metal  | Liquidtight connectors                         | Wet or outdoor flexible: rooftop HVAC (350)          |

### Where each one is allowed and where it is not (NEC 2026)

| Raceway                     | Permitted                                                                                                                                             | Not permitted                                                                                                                 |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <b>EMT</b> 358.10 / 358.12  | Exposed or concealed; dry, damp, and wet locations; in concrete or in contact with earth when protected against corrosion                             | Where subject to severe physical damage; to support luminaires or equipment (except conduit bodies no larger than the tubing) |
| <b>IMC / RMC</b> 342 / 344  | All the same locations. Both are threaded with a taper of 1 in 16. RMC may serve as the equipment grounding conductor (344.60)                        | —                                                                                                                             |
| <b>PVC</b> 352.10 / 352.12  | Concealed, in concrete, corrosive areas, wet locations, exposed, and direct-buried. Schedule 80 with listed fittings where subject to physical damage | Hazardous locations; supporting luminaires; physical damage unless Sch 80; ambient over 50°C (122°F) unless listed; theaters  |
| <b>FMC</b> 348.10 / 348.12  | Exposed and concealed                                                                                                                                 | Wet locations, hoistways, battery rooms, underground or in poured concrete, where subject to physical damage                  |
| <b>LFMC</b> 350.10 / 350.12 | Wet locations; in concrete when listed for direct burial                                                                                              | Where subject to physical damage                                                                                              |

- **Sizes.** EMT, IMC, RMC, and PVC come in ½ to 6 inch. ⅜-inch EMT is only for motor leads. FMC and LFMC come in ½ to 4 inch, and ⅜ inch is allowed only in whips 6 feet or shorter.
- **Metric names.** Drawings may use the metric designator: ½ = 16, ¾ = 21, 1 = 27, 1¼ = 35, 1½ = 41, 2 = 53, 2½ = 63, 3 = 78, 4 = 103 (NEC 2026 Table 300.19(B)).
- **Thread protector caps** on RMC and IMC are color-coded by size, which helps you grab the right stick off the rack (Steel Tube Institute installation guide).

- **Underground.** The inside of an underground raceway is a wet location (NEC 2026 300.7(B), 300.5(B) in 2023), so the wire inside must be wet-rated. Minimum cover depths are in Table 300.7(A) (Table 300.5 in 2023) and are covered in Module 1.8.

## Part B — STEP-BY-STEP: Cutting, Reaming & Threading

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### Cut and ream EMT

1. **Measure and mark.** Measure to the stop inside the fitting, not to the face of the box. Mark a thin line all the way around the tube so you can see it on every side of the saw.
2. **Hold it.** Clamp the tube in a trisland chain vise or a pipe vise so it cannot roll.
3. **Cut square** with a hacksaw (24 to 32 teeth per inch) or a portable band saw. Do **not** use a roll-type tubing cutter on EMT. The Steel Tube Institute says roll cutters leave a ridge that needs heavy reaming, which flares the wall and keeps fittings from going on.
4. **Ream the inside.** NEC 2026 358.28(A): "All cut ends of EMT shall be reamed or otherwise finished to remove rough edges." Use a conduit reamer (for example Klein 85091) or a drill-driven reamer. Pliers heads work if you are careful not to flare the end. File off the outside burr so the fitting slides on.
5. **Never thread EMT.** 358.28(B): "EMT shall not be threaded."
6. **Dry-fit.** The tube must bottom out on the stop inside the fitting.

**Why reaming is non-negotiable.** The most common cause of insulation damage on a pull is an unreamed cut. Run your finger inside every cut end before the wire goes in.

### Cut, ream, and thread rigid (RMC) or IMC

Steps follow the Steel Tube Institute guide and the RIDGID 700 power drive manual.

1. **Cut** with a wheel cutter (for example RIDGID 2-A), turning it all the way around and tightening about a quarter turn each revolution, or with a band saw. Keep the cut square.
2. **Ream before you thread.** Use a flute reamer. The Steel Tube Institute warns that "reaming the conduit after threading will stretch or flare the end."
3. **Set up the die.** Use a die head sized for the conduit (for example a RIDGID 12-R on a 700 power drive for  $\frac{1}{8}$  to 2 inch). Dies must be sharp and in their numbered slots, 1 through 4. Check the head setting on a factory-threaded nipple.
4. **1 inch and larger:** use the support arm, or brace a 14-inch pipe wrench against the torque arm, so the drive cannot spin you. No glove on the hand that pushes the die-head cover plate.
5. **Start square.** Push the cover plate with your palm. After about two threads the dies feed themselves.
6. **Flood the dies with thread-cutting oil.** The guide says "there is no such thing as too much oil at the die head."

7. **Stop at the right length.** Stop when the pipe end is even with the edge of the dies. Thread one thread short of the end of the chaser so the conduit does not butt inside the coupling.
8. **Back the die off,** then wire-brush and wipe the threads.
9. **Check the thread.** With a ring gauge, the pipe end should be flush with the gauge face, plus or minus one turn. Without a gauge, a new fitting should go on **4 to 5 turns hand-tight** on 2-inch and smaller pipe (RIDGID manual).
10. **Make up the joint** hand-tight, then wrench-tight. Wrench-tightening should not go more than **three more threads**, and never use a cheater bar on the wrench.
11. **Coat field-cut threads** with a conductive corrosion-protection compound. Field threads have lost their zinc coating, and NEC 2026 300.8(A) (300.6(A) in 2023) requires corrosion protection.

| Conduit size | Pipe wrench | Conduit size | Pipe wrench |
|--------------|-------------|--------------|-------------|
| ½ in.        | 12 in.      | 2 to 2½ in.  | 24 in.      |
| ¾ to 1¼ in.  | 14 in.      | 3 to 4 in.   | 36 in.      |
| 1½ in.       | 18 in.      |              |             |

Steel Tube Institute, Guidelines for Installing Steel Conduit/Tubing, Table 2.

## Bad threads and what caused them

| What you see                       | Likely cause                                 |
|------------------------------------|----------------------------------------------|
| Torn or ragged threads             | Dull dies, not enough oil, or thin-wall pipe |
| Crooked threads                    | Die head or pipe cut not square              |
| Threads that won't start a fitting | Dies in the wrong slots                      |

## Cut flex (FMC and LFMC)

1. Cut with a hacksaw at an angle across one ribbon of the spiral, then twist the two pieces in opposite directions to separate them. A rotary flex cutter (for example Greenlee 1940) makes a cleaner cut.
2. Trim the sharp end. Ream LFMC inside and outside (350.28).

## Part B — mistakes to avoid

- A roll cutter on EMT. Use a saw.
- Reaming rigid after threading. Ream first.
- Running the die dry. Oil, oil, oil.
- Bare field threads left uncoated. They rust inside a year.

## Part C — STEP-BY-STEP: Joining & Terminating

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### Set-screw EMT connector or coupling

1. Slide the fitting onto the reamed tube until it bottoms on the stop.
2. Tighten each set screw until it bottoms firmly on the tube. Snug and solid, not stripped.
3. Set-screw fittings are for dry locations. They count as concrete-tight only when taped. In wet locations use a fitting listed for wet locations (NEC 2026 358.42).

### Compression EMT connector or coupling

1. Back off the compression nut. Slide the fitting on until the tube bottoms against the internal shoulder.
2. Tighten the nut with **two wrenches**, one on the body and one on the nut, until the gland ring grips the tube.
3. If the carton says the fitting needs a sealing ring for wet locations, use the ring named on the carton. Fittings now say "Wet Locations" instead of "raintight."

### Landing a connector in a box

1. Push the connector through the knockout and run the **locknut** on from the inside.
2. Tighten until the locknut teeth bite into bare metal. Scrape off paint first: NEC 2026 250.96(A) requires nonconductive coatings to be removed at contact surfaces. The locknut is part of the ground path.
3. Where the raceway carries conductors **4 AWG and larger**, protect them with an insulating bushing or a fitting with a smoothly rounded insulating surface (NEC 2026 300.6(G), 300.4(G) in 2023).

#### **NEC 2026 250.97 — bonding over 250 volts to ground (277/480 V work)**

On circuits over 250 V to ground, the raceway's electrical continuity must be ensured by one of the service bonding methods in 250.92(B), such as a **bonding bushing with a jumper** or a bonding locknut. **Exception:** if there are no oversized, concentric, or eccentric knockouts (or the box is listed for bonding with them), an EMT connector with a shoulder that seats tight against the box and one locknut inside is permitted. In practice: on 480 V work, any time you land on a concentric knockout or use reducing washers, put on a bonding bushing and a jumper.

### Threaded rigid or IMC connection

1. Thread the conduit fully into the **coupling** or into a threaded box hub, hand-tight then wrench-tight.
2. **Two fixed ends that cannot turn:** use a **three-piece union** (for example an Appleton UNF or UNY) or an Erickson coupling. **Never use a running thread.** NEC 2026 344.42(B) and 342.42(B): "Running threads shall not be used on conduit for connection at couplings."

A running thread is a long thread cut so a coupling can be run all the way back onto one pipe; it weakens the conduit and works loose.

3. **Into a non-threaded knockout:** one locknut outside and one inside (344.29), then a bushing (344.46). Use a bonding bushing where 250.97 applies.
4. **At a service:** locknuts and bushings alone are not enough to bond the raceway (NEC 2026 250.92(B)). Use threaded hubs made up wrenchtight, bonding bushings with jumpers, or another listed method.

## Solvent-weld PVC

The five steps are from the Carlon (ABB) cement instructions, with details from a city utility specification.

1. **Cut square** with a fine-tooth saw or a ratchet PVC cutter ( $\frac{1}{2}$  to  $1\frac{1}{4}$  inch). Use a miter box on 2 to 6 inch.
  2. **Deburr** and round the inside edge of the cut end.
  3. **Clean** the inside of the socket and the outside of the pipe end of dirt and moisture. Dry-fit: the pipe should go no more than halfway into the socket dry.
  4. **Apply a uniform coat of cement** to the pipe end and push it to the bottom of the socket, rotating it a quarter turn. Hold it 15 seconds (1 minute in extreme cold) so it does not push back out.
  5. **Let it set** before you disturb it, about 10 minutes, and at least 5 minutes before handling. Use gray regular-grade cement in normal weather and an all-weather quick-set cement in the cold. Follow the label on the can. Throw out cement older than 12 months, and don't use plastic-bristle brushes.
- PVC is field-bent only with a heater made for it (hot box or heat blanket), never with a torch, and never tighter than the minimum radius (352.24(A)).
  - At a box, PVC ends in a listed adapter or bushing (352.46). Ventilate when you use cement, and keep flames away.

## Flexible whips (FMC and LFMC)

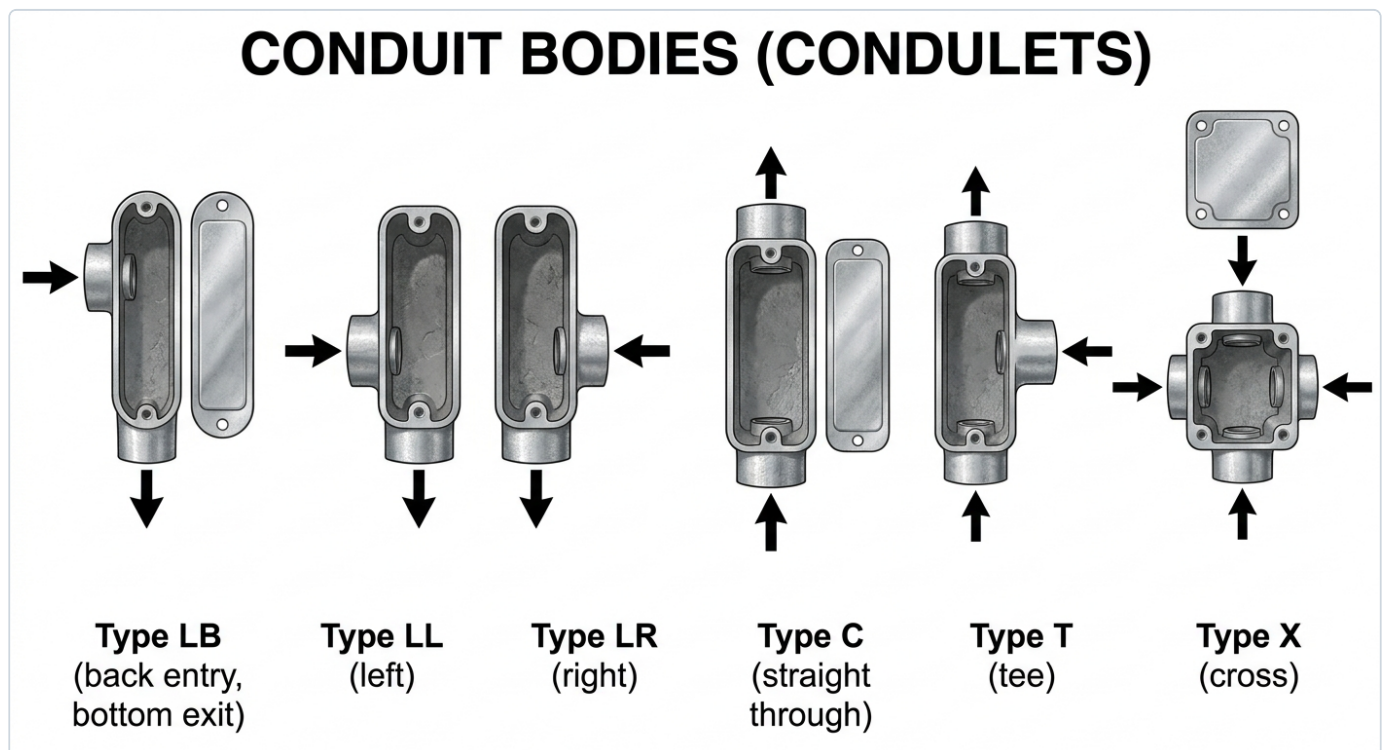
1. Cut and trim (Part B). Make up the connector. For LFMC, use a **liquidtight** connector with its sealing ring toward the wet side.
2. Angle connectors may not be concealed in the wall (348.42, 350.42).
3. Land in the box with a locknut and bushing.
4. **Pull a wire equipment grounding conductor in every motor and HVAC whip.** The flex itself counts as a ground path only within strict limits (NEC 2026 250.118(A)(6) for LFMC): listed fittings,  $\frac{3}{8}$  to  $\frac{1}{2}$  inch only on circuits of 20 A or less,  $\frac{3}{4}$  to  $1\frac{1}{4}$  inch only on 60 A or less, no more than 6 feet total of flex in the fault path, and a wire ground wherever the flex is there for vibration or movement. A motor whip is there for vibration, so it always gets a wire.

5. Expansion fittings and telescoping sections of metal raceway need a bonding jumper across them (NEC 2026 250.98).

### Part C — inspection

- Every fitting tight. Locknuts biting bare metal.
- Bushings on 4 AWG and larger. Bonding bushings with jumpers on concentric knockouts over 250 V to ground.
- No running threads. Unions where two fixed ends meet.
- Wet-location fittings in wet locations. Wire ground in every flex whip.

### Part D — Conduit Bodies (condulets)



LB/LL/LR/C/T/X — for turns, pulls, and access on rigid runs.

- **LB** = back in, bottom out (through a wall, then drop down) • **LL/LR** = out to the left or right • **C** = straight pull • **T** = tee • **X** = cross. A conduit body in the middle of a run is a pull point, so it resets the 360-degree bend count.
- **6 AWG and smaller:** the body's cross-section must be at least twice that of the largest conduit attached, and it holds no more conductors than that conduit is allowed (NEC 2026 314.16(C)(1)).
- **4 AWG and larger:** the body must meet the pull-box rules in 314.28: 8 times the conduit size for a straight pull (C body), 6 times for an angle (LB, LL, LR). Ordinary bodies are too small. Use a **mogul** body (also called Form 8) and measure it.
- **Short-radius bodies** (capped elbows, service-entrance elbows) are pull points only. No splices (314.16(C)(3)).

- A conduit body no larger than the raceway may hang on a single EMT, IMC, RMC, or PVC run (314.23(E) exception). The cover must stay accessible (314.29).

**Splices only if marked (NEC 2026 314.16(C)(2)):** a conduit body may contain splices, taps, or devices only if it is durably marked with its cubic-inch volume and the fill is within that volume. Otherwise it is a pull point only.

## Part E — Boxes & the Fill Math

# COMMERCIAL ELECTRICAL BOXES



4-inch square (1900) box



4-11/16 inch square box



octagon ceiling box



handy (utility) box



masonry box



FS cast box



FD cast box



screw-cover pull/junction box

Steel and cast boxes — match the box to the device, the wall, and the environment.

| Box (inches)   | Volume (in <sup>3</sup> ) | Box (inches)        | Volume (in <sup>3</sup> ) |
|----------------|---------------------------|---------------------|---------------------------|
| 4 × 1¼ square  | 18.0                      | 4-11/16 × 1¼ square | 25.5                      |
| 4 × 1½ square  | 21.0                      | 4-11/16 × 1½ square | 29.5                      |
| 4 × 2⅞ square  | 30.3                      | 4-11/16 × 2⅞ square | 42.0                      |
| 4 × 1½ octagon | 15.5                      | 3 × 2 × 2½ device   | 12.5                      |

| Wire size                      | #14  | #12  | #10  | #8   | #6   |
|--------------------------------|------|------|------|------|------|
| Volume each (in <sup>3</sup> ) | 2.00 | 2.25 | 2.50 | 3.00 | 5.00 |

NEC 2026 Table 314.16(A) and Table 314.16(B)(4).

### Step by step: box fill (NEC 2026 314.16(B))

1. Count each insulated conductor that enters the box and is spliced or terminated there as **1**.

2. Count a conductor that passes straight through without a splice as **1**. An unbroken loop long enough to be cut into two free ends counts as **2**. A pigtail that starts and ends inside the box counts **0**.
3. Count all internal cable clamps together as **1**. Connectors that clamp outside the box count **0**.
4. Count each fixture stud or hickey as **1**.
5. Count each device yoke (a receptacle or switch) as **2**, at the size of the largest conductor landed on it.
6. Count up to four equipment grounding conductors together as **1**. Each one past four adds  $\frac{1}{4}$ .
7. Multiply each count by the volume for its wire size and add them up. The total must not exceed the box volume.
8. Leave at least 6 inches of free conductor at every box, with 3 inches sticking out past the opening when the opening is under 8 inches (NEC 2026 300.16, 300.14 in 2023).

**Worked example 1.** A  $4 \times 1\frac{1}{2}$  square box ( $21.0 \text{ in}^3$ ) with two 12-2 MC cables and one duplex receptacle, using connectors that clamp outside the box. Conductors:  $4 \times 2.25 = 9.00$ . Grounds:  $1 \times 2.25 = 2.25$ . Receptacle yoke:  $2 \times 2.25 = 4.50$ . Total **15.75 in<sup>3</sup>**, which fits a 21.0 or an 18.0 box. Add a third 12-2 passing through: two more conductors add 4.50, for **20.25 in<sup>3</sup>**. That still fits the 21.0 box but fails the 18.0 box.

### **Pull and junction box sizing — NEC 2026 314.28(A)**

**Straight pull:** box length at least **8 ×** the largest raceway. **Angle or U pull:** distance from the entry to the opposite wall at least **6 ×** the largest raceway, plus the diameters of the other raceways in the same row. Raceways holding the same conductors must enter at least **6 ×** the larger raceway apart. Over 6 feet in any dimension, the conductors inside must be supported (314.28(B)).

- **Worked example 2.** An angle pull with one 2-inch and one 1-inch conduit in the same row:  $6 \times 2 + 1 = \mathbf{13 \text{ inches}}$  each way. The two ends of the 2-inch run must enter at least 12 inches apart.
- **Worked example 3.** A straight pull with a 3-inch conduit:  $8 \times 3 = \mathbf{24\text{-inch}}$  box length minimum.

### **Mounting boxes (NEC 2026 314.23)**

- Surface boxes must be "rigidly and securely fastened." Screws through the box must sit within  $\frac{1}{4}$  inch of the back or ends, with the threads guarded from the wires.
- Boxes above a suspended ceiling ( $100 \text{ in}^3$  or less) mount to framing or to dedicated support wires secured at both ends.
- A box hung only from conduit ( $100 \text{ in}^3$  or less) needs two threaded conduits made up wrenchtight, each secured within 3 feet of the box. If all entries are on one side, or the box holds a device or luminaire, that distance is 18 inches.

- In a noncombustible wall, a flush box may be set back no more than  $\frac{1}{4}$  inch from the finished surface (314.20). Gaps around the box edge may be no more than  $\frac{1}{8}$  inch (314.21). Every unused opening gets closed (110.12(A)).

## Part F — Filling the Pipe (Ch. 9, Table 1)

| Conductors in raceway | Max fill |
|-----------------------|----------|
| 1                     | 53%      |
| 2                     | 31%      |
| 3 or more             | 40%      |

Use **Annex C** to look it up directly when all the conductors are the same size. Use Tables 4 and 5 when sizes are mixed. Overfill jams the pull, overheats the wire, and forces derating.

| EMT size            | 40% fill area (in <sup>2</sup> ) | 60% (nipple) area (in <sup>2</sup> ) |
|---------------------|----------------------------------|--------------------------------------|
| $\frac{1}{2}$ in.   | 0.122                            | 0.182                                |
| $\frac{3}{4}$ in.   | 0.213                            | 0.320                                |
| 1 in.               | 0.346                            | 0.519                                |
| 1 $\frac{1}{4}$ in. | 0.598                            | 0.897                                |
| 1 $\frac{1}{2}$ in. | 0.814                            | 1.221                                |
| 2 in.               | 1.342                            | 2.013                                |
| 2 $\frac{1}{2}$ in. | 2.343                            | 3.515                                |
| 3 in.               | 3.538                            | 5.307                                |
| 4 in.               | 5.901                            | 8.852                                |

| THHN/THWN-2 | Area (in <sup>2</sup> ) | THHN/THWN-2 | Area (in <sup>2</sup> ) |
|-------------|-------------------------|-------------|-------------------------|
| #14         | 0.0097                  | 1/0         | 0.1855                  |
| #12         | 0.0133                  | 2/0         | 0.2223                  |
| #10         | 0.0211                  | 3/0         | 0.2679                  |
| #8          | 0.0366                  | 4/0         | 0.3237                  |
| #6          | 0.0507                  | 250 kcmil   | 0.3970                  |
| #4          | 0.0824                  | 350 kcmil   | 0.5242                  |
| #2          | 0.1158                  | 500 kcmil   | 0.7073                  |

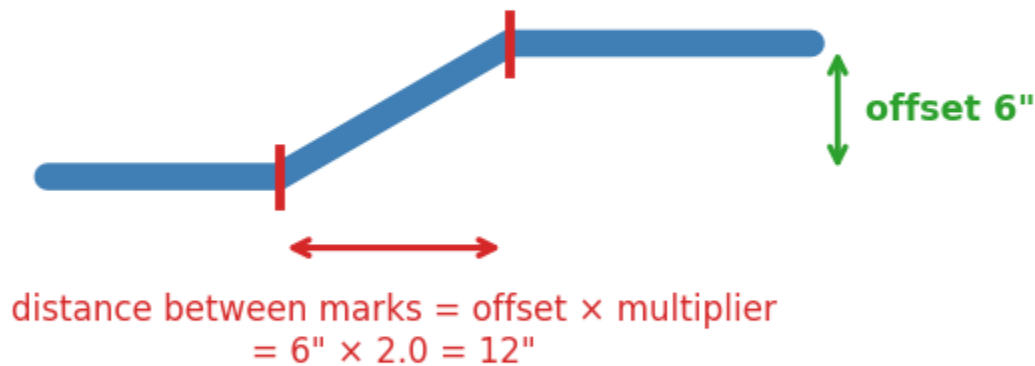
NEC 2026 Chapter 9, Table 4 (EMT) and Table 5 (THHN/THWN-2).

## Step by step: conduit fill with mixed sizes

1. List every conductor in the pipe, including the equipment grounding conductor. Grounds count at their actual area (Chapter 9, Note 3).
  2. Look up each conductor's area in Table 5 and add them up.
  3. Pick the smallest conduit whose 40 percent column is at least that total.
  4. For a nipple 24 inches or shorter, you may use the 60 percent column, with no ampacity adjustment (Note 4).
  5. Check for jamming when three conductors share a pipe. If the conduit's inside diameter divided by one conductor's outside diameter falls between 2.8 and 3.2, the wires can wedge in a bend. Go up a size.
- **Worked example 4.** Three #12 THHN plus a #12 ground in ½-inch EMT:  $4 \times 0.0133 = 0.053$  in<sup>2</sup>, under 0.122. OK. The most #12 THHN that fit are  $0.122 \div 0.0133 = 9.17$ , so **9**.
  - **Worked example 5.** Four 500 kcmil THHN =  $4 \times 0.7073 = 2.829$  in<sup>2</sup>. 2½-inch EMT (2.343) fails; 3-inch EMT (3.538) passes. Add a 1/0 ground:  $2.829 + 0.1855 = 3.015$ , still a 3-inch.
  - **Worked example 6, the jam check.** Three 500 kcmil (0.949 inch across) in 2½-inch EMT (2.731-inch inside):  $2.731 \div 0.949 = \mathbf{2.88}$ , inside the jam range. In 3-inch EMT (3.356): 3.54, clear.
  - **Worked example 7, a nipple.** A 20-inch ½-inch EMT nipple at 60 percent:  $0.182 \div 0.0133 = 13.7$ , so **13** #12 THHN.

## Part G — Bending (Overview → Module 1.2B)

### OFFSET BEND (30° shown)



|                   |                  |                   |                |                 |                |
|-------------------|------------------|-------------------|----------------|-----------------|----------------|
| <b>MULTIPLIER</b> | <b>10°×6.0</b>   | <b>22½°×2.6</b>   | <b>30°×2.0</b> | <b>45°×1.4</b>  | <b>60°×1.2</b> |
| <b>SHRINK/in:</b> | <b>10°=1/16"</b> | <b>22½°=3/16"</b> | <b>30°=¼"</b>  | <b>45°=3/8"</b> | <b>60°=½"</b>  |

The offset — the bend you make most. Full method and tables in the Bending Masterclass.

**Two rules:** the total of all bends between pull points may not exceed **360 degrees** (NEC 2026 358.24(B) for EMT, 344.24(B) RMC, 342.24(B) IMC, 352.24(B) PVC, 348.24(B) FMC, 350.24(B) LFMC; this was 358.26 and its siblings in 2023). And never bend tighter than the **minimum radius** in Chapter 9, Table 2.

| Size                                            | ½ | ¾  | 1  | 1¼ | 1½ | 2  | 2½  | 3  | 4  |
|-------------------------------------------------|---|----|----|----|----|----|-----|----|----|
| Min. radius, one-shot or full-shoe bender (in.) | 4 | 4½ | 5¾ | 7¼ | 8¾ | 9½ | 10½ | 13 | 16 |

- **Which bender:** a hand bender for ½ to 1 inch EMT, IMC, or RMC (rigid fits the EMT shoe one size larger). A ratchet bender for 1¼ to 1½ inch. A power bender for 2 inch and up.
- Never put a threaded end in the bender shoe. It crushes the threads.
- On a hydraulic bender: set it level, put the lever in return before starting the pump, and make sure the pins pass the ball lock.

## Part H — STEP-BY-STEP: Supporting & Securing

| Raceway                              | Secure within ... of each box or termination   | Maximum spacing                                                                                                            |
|--------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <b>EMT</b> 358.30                    | 3 ft (5 ft where the structure prevents it)    | 10 ft                                                                                                                      |
| <b>IMC</b> 342.30                    | 3 ft (5 ft where the structure prevents it)    | 10 ft, or the Table 344.30(B) spacing with threaded couplings                                                              |
| <b>RMC</b> 344.30                    | 3 ft (5 ft where the structure prevents it)    | Table 344.30(B): ½–¾ in. 10 ft; 1 in. 12 ft; 1¼–1½ in. 14 ft; 2–2½ in. 16 ft; 3 in. and up 20 ft                           |
| <b>PVC</b> 352.30                    | 3 ft, fastened so it can move with temperature | Table 352.30(B): ½–1 in. 3 ft; 1¼–2 in. 5 ft; 2½–3 in. 6 ft; 3½–5 in. 7 ft; 6 in. 8 ft                                     |
| <b>FMC / LFMC</b><br>348.30 / 350.30 | 12 in.                                         | 4½ ft. Where flexibility is needed at the end, up to 3 ft (½–1¼ in.), 4 ft (1½–2 in.), or 5 ft (2½ in. and up) unsupported |

### Step by step

1. **Lay out the route** from the drawings with a chalk line. Run banked conduits together so the bends stay parallel.
2. **Pick the attachment** for the structure: beam clamps on steel, deck hangers, purlin clips, a strut trapeze on ⅜-inch rod (Module 1.1), or anchors in concrete. Never wood plugs in masonry.
3. **Strap within 3 feet** of every box, conduit body, and termination (12 inches for flex), then at the spacing in the table. Framing holes 10 feet or less apart count as support for EMT and rigid, but you still secure it at the box.
4. **Strut clamps** carry the conduit on a trapeze. Single straps go on walls: one-hole straps with machine or sheet-metal screws on metal, expansion anchors in masonry.
5. **Single overhead runs** can hang from rod or wire clips listed for the purpose. A raceway may not support another raceway (NEC 2026 300.13, 300.11 in 2023). Ceiling grid wires may not support wiring. Dedicated support wires above a ceiling must be marked and secured at both ends.
6. **PVC must slide.** Use loose or nonmetallic straps so the pipe can move as it heats and cools. Clamp the barrel of an expansion fitting tight and let the pipe slide.
7. **Wet locations:** use corrosion-resistant straps and hardware.
8. **Complete the raceway before pulling wire** (NEC 2026 300.20(A), 300.18(A) in 2023). Do not weld to raceway.

## Firestopping through rated walls and floors

NEC 2026 300.23 (300.21 in 2023): "Openings around electrical penetrations into or through fire-resistant-rated walls, partitions, floors, or ceilings shall be firestopped using approved methods."

1. Find out the wall or floor rating from the architectural drawings. Rated walls are often marked with a colored line or hatch.
2. Pick a UL-listed firestop system that matches the assembly (for example a system for steel conduit through a gypsum wall, or through concrete). The system sheet tells you the allowed gap around the pipe and the sealant.
3. Support the conduit rigidly on both sides of the wall.
4. Pack and caulk exactly as the system sheet shows. A typical sheet calls for intumescent caulk filling the gap, with a bead at the point where the pipe touches the opening.
5. Label each penetration with the system number.
6. Boxes on opposite sides of a rated wall are usually kept 24 inches apart (300.23 Informational Note).

## Expansion fittings

PVC grows and shrinks a lot with temperature. NEC 2026 352.44 requires expansion fittings where the change between fixed points will be  $\frac{1}{4}$  inch or more. Steel moves about one-fifth as much as PVC, and aluminum about two-fifths (NEC 2026 300.9(B) Informational Note, 300.7(B) in 2023).

| Temperature change                | 20°F | 50°F | 80°F | 100°F | 120°F | 140°F | 160°F |
|-----------------------------------|------|------|------|-------|-------|-------|-------|
| PVC length change, in. per 100 ft | 0.81 | 2.03 | 3.24 | 4.06  | 4.87  | 5.68  | 6.49  |

NEC 2026 Table 352.44.

1. Find the temperature swing: coldest to hottest the pipe will see. Carlon adds 30°F for pipe in direct sun.
  2. Read the change per 100 feet from the table and multiply by the run length in hundreds of feet.
  3. Divide by the travel of one fitting (Carlon's E945 has 4 inches of travel for  $\frac{1}{2}$  to  $1\frac{1}{2}$  inch, 8 inches for 2 to 6 inch). Round up to get the number of fittings.
  4. Set the piston opening for today's temperature: opening = travel  $\times$  (max temp – install temp)  $\div$  temperature swing.
  5. Anchor the barrel near each box, anchor the middle of the run, and let the rest slide. On a vertical run, put the fitting at the top with the barrel down.
- **Worked example 8.** 120 feet of 1-inch PVC on a sunny wall, 10°F to 100°F plus 30°F for sun = a 120°F swing. Change =  $4.87 \times 1.2 = \mathbf{5.84 \text{ inches}}$ . One E945 gives 4 inches, so you need **two**. Installing at 70°F: opening =  $4 \times (130 - 70) \div 120 = \mathbf{2.0 \text{ inches}}$ .

- **Worked example 9.** The same 120 feet in EMT with a 100°F swing:  $4.06 \times 1.2 \times 0.20 =$  **0.97 inch**. Across a roof between fixed boxes, use an expansion coupling made for EMT with a bonding jumper (250.98).
- **Worked example 10.** 60 feet of EMT between two boxes: straps at 3, 13, 23, 33, 43, 53, and 57 feet, which is **7 straps** minimum.

**Safety while you install.** Before you open live gear to land a raceway, put it in an electrically safe work condition with lockout (NFPA 70E Article 120, OSHA 1910.333). When you push a fish tape into a panel, push from the panel toward the first box so the tape stays off the bus, and blanket any live bus. On a threader, support arm on 1 inch and up, no glove on the die-head hand, and wipe up oil spills. PVC cement: ventilate and no flames.

## Part H — inspection checklist (the whole raceway)

- Every cut end reamed. Every fitting tight. Locknuts on bare metal.
- Bushings on 4 AWG and larger (300.6(G)). Bonding bushings where 250.97 applies.
- Straps within 3 feet (12 inches for flex) and at the right spacing.
- No more than 360 degrees of bends between pull points.
- Expansion fittings set to the right opening, barrels anchored, PVC free to slide.
- Every rated penetration firestopped and labeled.
- Metal raceway "metallically joined together into a continuous electrical conductor" (NEC 2026 300.12). All conductors of a circuit in the same metal raceway (300.22(A), 300.20(A) in 2023).
- Work done "in a professional and skillful manner" (NEC 2026 110.12).

### NEC 2026 Checkpoints (2023 number in parentheses where it moved)

- **358 EMT • 342 IMC • 344 RMC • 352 PVC • 348 FMC • 350 LFMC.**
- **358.24(B)** (358.26) 360° bends • **358.28** reaming, no threads on EMT • **344.42(B)** no running threads.
- **300.6(G)** (300.4(G)) bushings • **300.7** (300.5) underground • **300.8(A)** (300.6(A)) corrosion • **300.13** (300.11) support.
- **300.9(B)** (300.7(B)) expansion fittings • **300.16** (300.14) free conductor • **300.20** (300.18) complete raceway • **300.23** (300.21) firestopping.
- **250.92(B), 250.96(A), 250.97, 250.98, 250.118(A)(6)** bonding and flex as ground.
- **314.16, 314.23, 314.28** box fill, support, pull boxes • **Ch. 9 Tables 1, 2, 4, 5 / Annex C • 352.44** PVC expansion.

## Hands-On Field Exercise

- **Cut, ream, and make up** EMT with a set-screw connector into a box (locknut on bare metal); then do it again with a compression connector and two wrenches.
- **Thread** a stick of ½-inch rigid with cutting oil. Check it with the hand-tight-turns test, coat the threads, and make it up into a hub.
- Join two fixed rigid ends with a **three-piece union**.

- **Solvent-weld** a PVC coupling (cut, deburr, clean, cement, quarter-turn, hold) and set an expansion fitting's piston for today's temperature.
- Calculate **box fill** for a 4-inch square box with two 12-2 MC and a receptacle. Size a pull box for a straight pull of 2-inch conduit (16 inches minimum).
- Size an EMT for four 500 kcmil plus a ground, and run the jam check.
- Strap a run to 358.30 (within 3 feet, every 10 feet) and count the straps first.

#### Sources used in this module (public documents)

- NFPA 70, National Electrical Code 2026 (free read-only access at [nfpa.org](https://www.nfpa.org)): Articles 250, 300, 314, 342, 344, 348, 350, 352, 358; Chapter 9; Annex C.
- Steel Tube Institute, Guidelines for Installing Steel Conduit/Tubing (companion to NECA 101): [steeltubeinstitute.org](https://steeltubeinstitute.org)
- RIDGID 700 Power Drive Operator's Manual.
- Carlon (ABB) Cements, Primers and Sealers, and Expansion Fittings for PVC Conduit: [carlonsales.com](https://carlonsales.com)
- City of Anaheim, Solvent Cement Joining of PVC Conduit: [anaheim.net](https://anaheim.net)
- NAVEDTRA 14026 Construction Electrician Basic and NAVEDTRA 14027 Construction Electrician Intermediate, Chapter 5.
- nVent CADDY Fixing, Fastening & Support Products catalog.
- OSHA 29 CFR 1926.405 and 1910.333: [osha.gov](https://www.osha.gov)

Next: Module 1.2B — Conduit Bending Masterclass, then Module 1.3 — Conductors, Pulling & Terminations.