Electrical Level 1

Raceways and Fittings 26108-14

Objectives

When trainees have completed this session, they should be able to do the following:

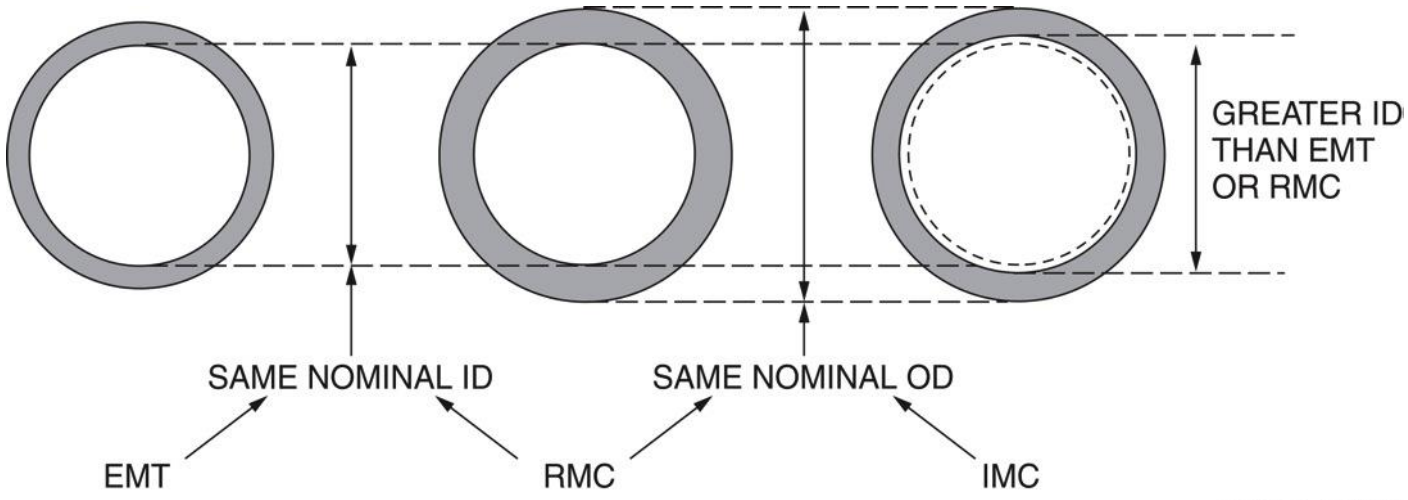
1. Identify and select various types and sizes of raceways and fittings for a given application.
2. Identify various methods used to fabricate (join) and install raceway systems.
3. Identify uses permitted for selected raceways.
4. Demonstrate how to install a flexible raceway system.
5. Terminate a selected raceway system.
6. Identify the appropriate conduit body for a given application.

Performance Tasks

1. Identify and select various types and sizes of raceways, fittings, and fasteners for a given application.
2. Demonstrate how to install a flexible raceway system.
3. Terminate a selected raceway system.
4. Identify the appropriate conduit body for a given application.

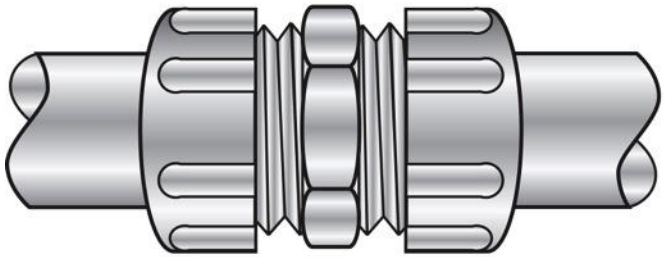
Introduction; Raceways; Conduit

- A raceway is an electrical channel or conduit used to house electrical wiring. Raceway must be installed, grounded, and bonded per the *NEC*®.
- Metal conduit is a circular raceway that can be used as a path to ground.
- EMT, RMC, and IMC can all be used as conduit.

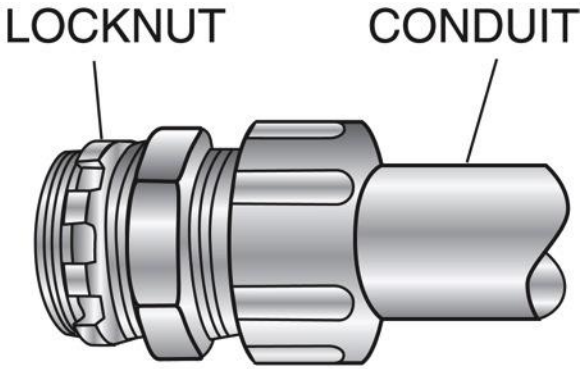


Compression Fittings

- EMT is too thin for threading and requires the use of setscrew or compression fittings.
- Fittings must be matched to the application.



COUPLING



CONNECTOR

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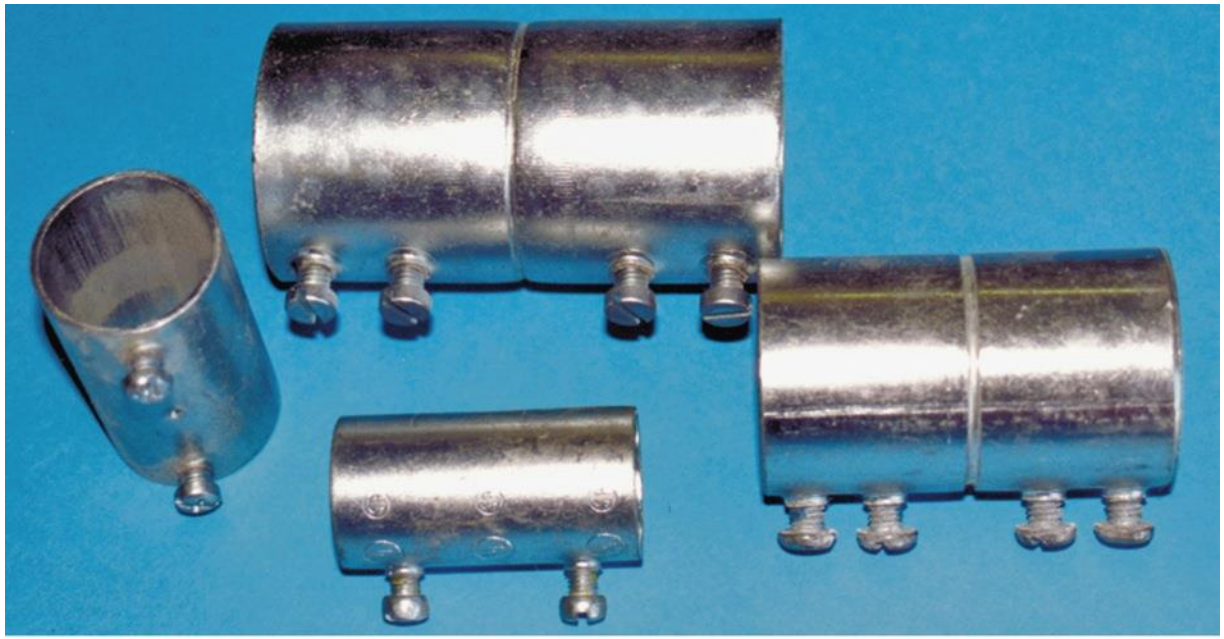
Setscrew Fittings

- Compression fittings are used in wet locations.
- Setscrew fittings are used in dry locations.



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(A) RIGID METAL CONDUIT (RMC)

(B) PLASTIC-COATED RMC

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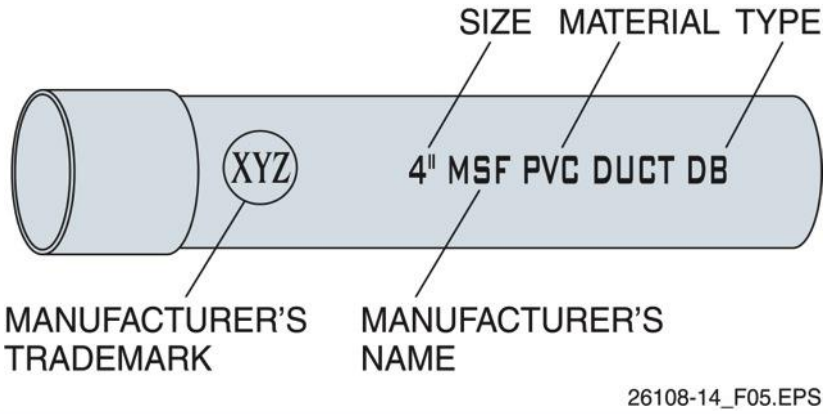
Rigid Metal Conduit

- RMC requires the use of threaded fittings and is available in steel or aluminum. Plastic-coated RMC provides corrosion protection.
- IMC has a thinner wall than RMC and is lighter and less expensive, but its use is restricted in some jurisdictions. Check local codes.

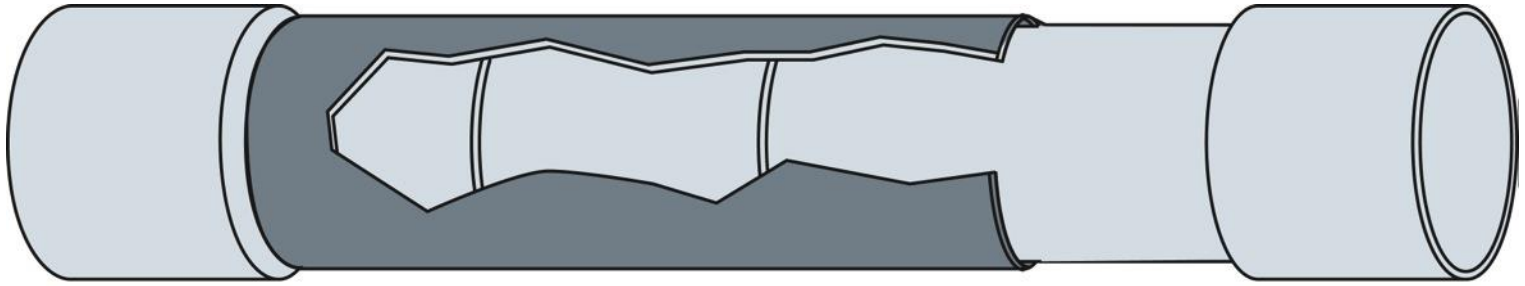
Rigid Polyvinyl Chloride Conduit

- PVC does not corrode and is easier to handle than metal conduit, but is subject to expansion/contraction due to temperature changes and cannot be used as an equipment grounding conductor.
- PVC is available in two types: Type 1 or EB (thin wall), and Type 2 or DB (thick wall). Schedule 40 DB is heavy duty and Schedule 80 DB is extra heavy duty.



PVC Expansion Coupling

- Expansion couplings must be installed per the *NEC*® to prevent damage due to temperature changes.
- PVC must be supported within 3' of terminations and then every 3' to 8', depending on the size of the conduit.
- HDPE is rigid nonmetallic conduit listed for underground use.



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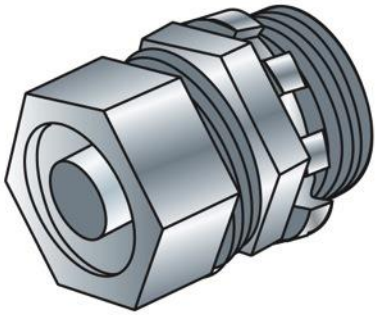
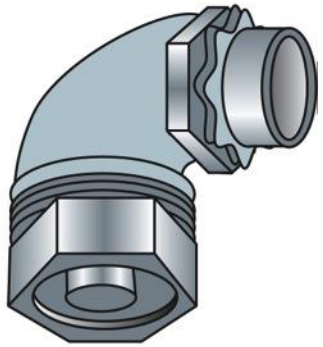
Liquidtight Flexible Nonmetallic Conduit

- Liquidtight flexible nonmetallic conduit (LFNC) is sunlight resistant and available in several types for use in wet locations.
- Compression connectors are used with LFNC.



STRAIGHT CONNECTOR

45° CONNECTOR



90° CONNECTOR

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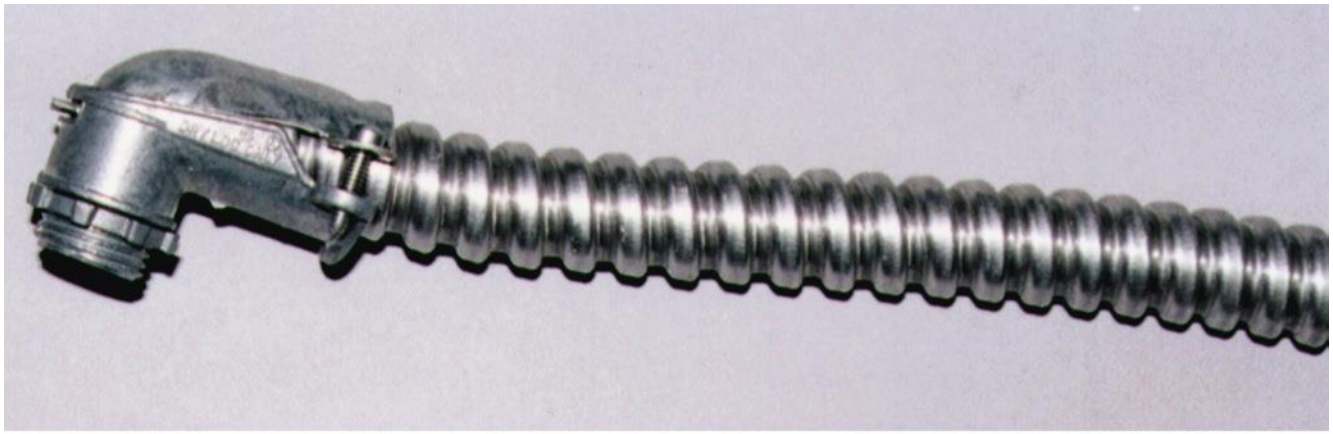
Flexible Metal Conduit

- Flexible nonmetallic conduit (flex) is often used in applications subject to vibration, such as in motor connections.
- A flexible conduit connector is used to make a flex-to-box connection.



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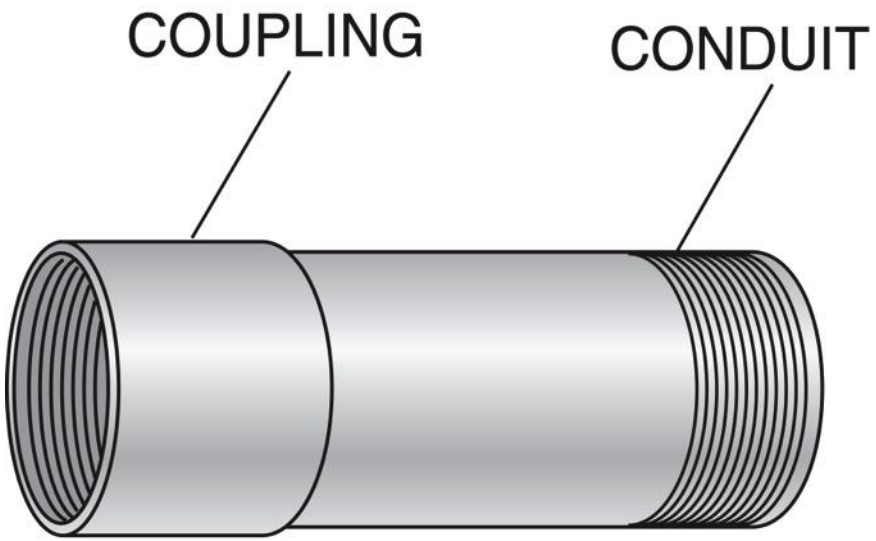
Next Sessions…

Metal Conduit Fittings

Metal Conduit Fittings

- The type of fitting selected depends on the type of conduit, its location, and the installation method.
- Couplings are fittings that are threaded inside to join two pieces of conduit.



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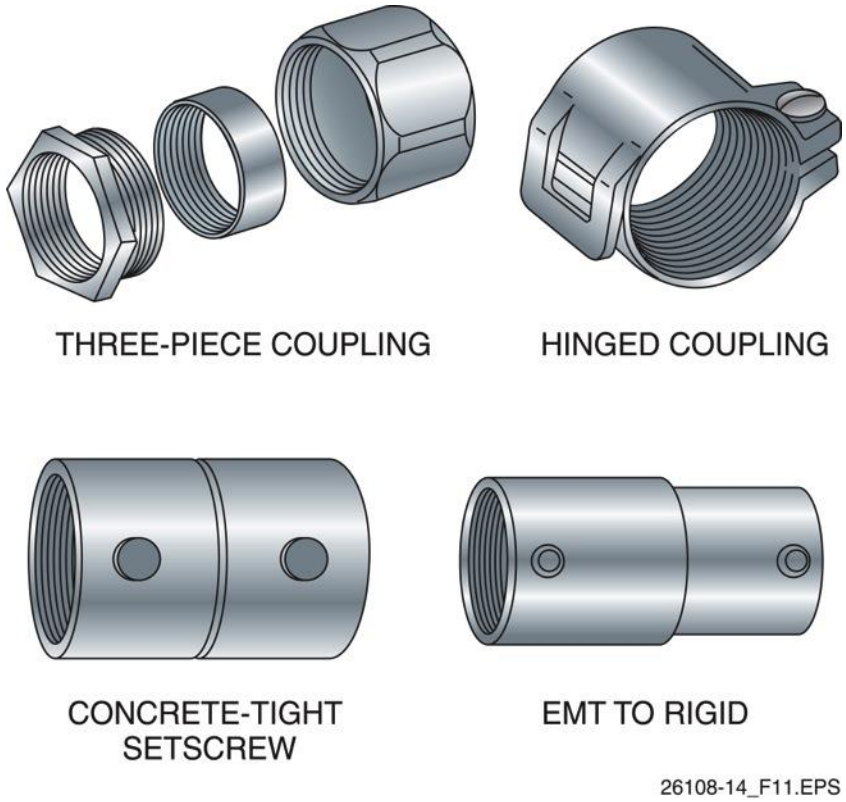
Metal Conduit Couplings

Couplings are available in various types for different types of conduit and applications.



Conduit Bodies

- Conduit bodies, also called condulets, can be used at junctions or pull points. They are more expensive than couplings, but may be required in exposed or outdoor locations or to change the type or size of raceway.
- The maximum number of conductors permitted in a conduit body is found using ***NEC Table 314.16(B)***.

Table 1 Volume Required per Conductor
[Data from ***NEC Table 314.16(B)***]

Size of Conductor	Free Space Within Box for Each Conductor
No. 18	1.5 cubic inches
No. 16	1.75 cubic inches
No. 14	2.0 cubic inches
No. 12	2.25 cubic inches
No. 10	2.5 cubic inches
No. 8	3.0 cubic inches
No. 6	5.0 cubic inches

Type C Conduit Bodies

- A Type C conduit body is a straight fitting with a screw-on cover for conductor access.
- Type C conduit bodies are used to provide a pull point in a long run or one with bends totaling more than 360°.

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Type L Conduit Bodies

- A Type L conduit body is an elbow fitting that provides a 90° change in direction.
- Various types of Type L conduit bodies are available to provide access to the conductors from the top, either side, or both sides.

TYPE LL TYPE LB TYPE LR

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TYPE LB

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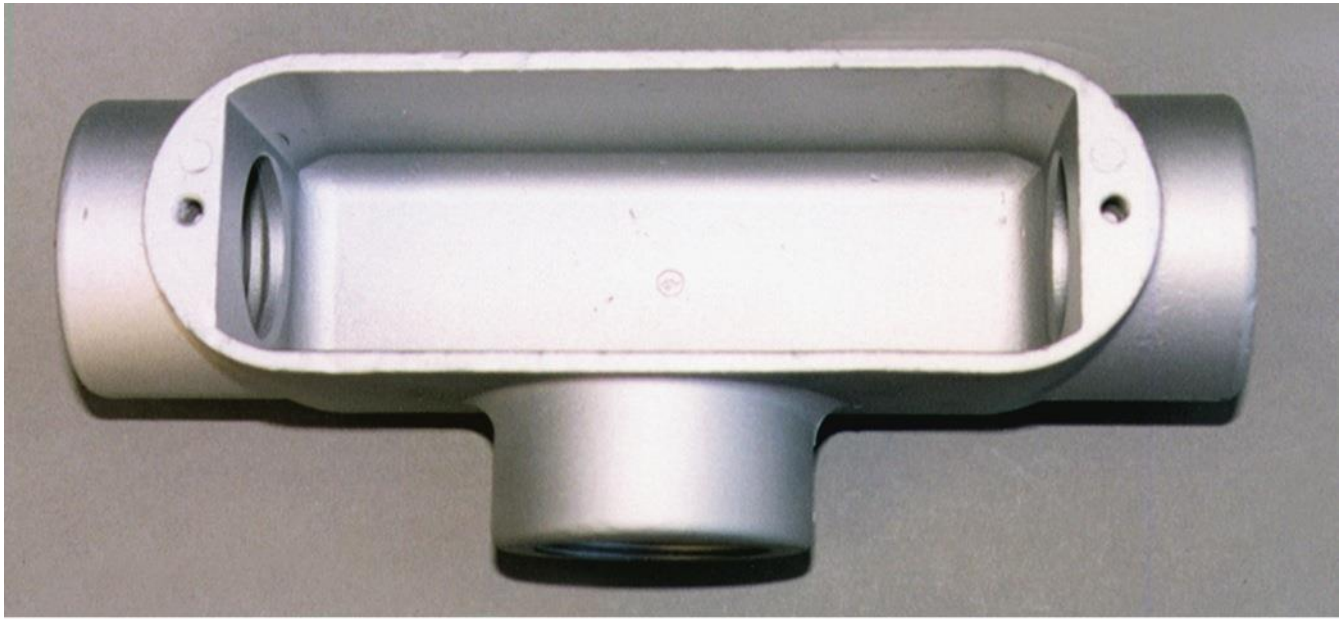
Type T Conduit Bodies

Type T conduit bodies provide a junction point between three intersecting conduits.



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Type X Conduit Bodies

Type X conduit bodies provide a junction point for four intersecting conduits.

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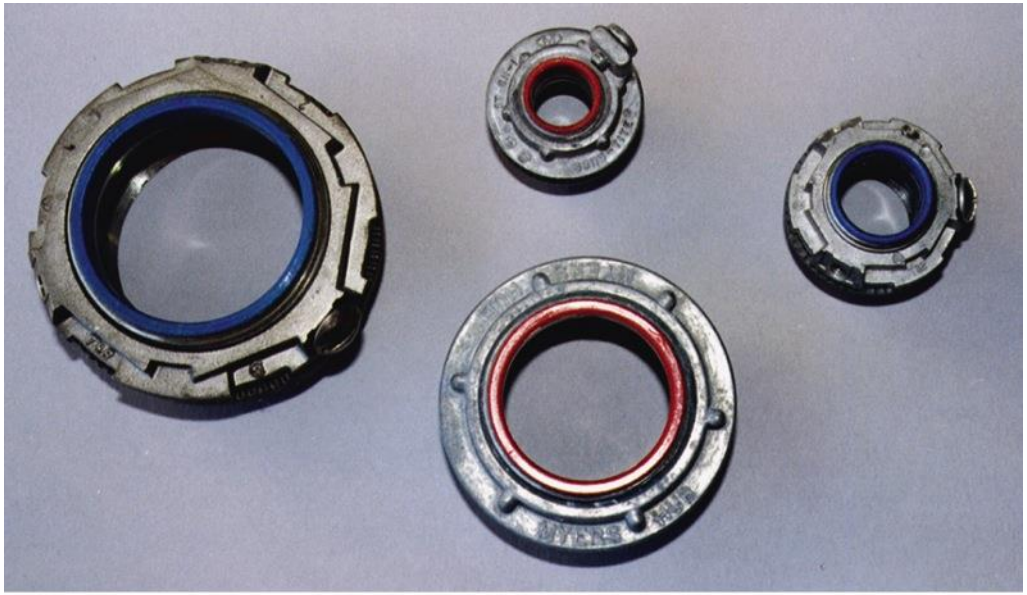
Threaded Weatherproof Hub

Threaded waterproof hubs are used for conduit entering a box in a wet location.



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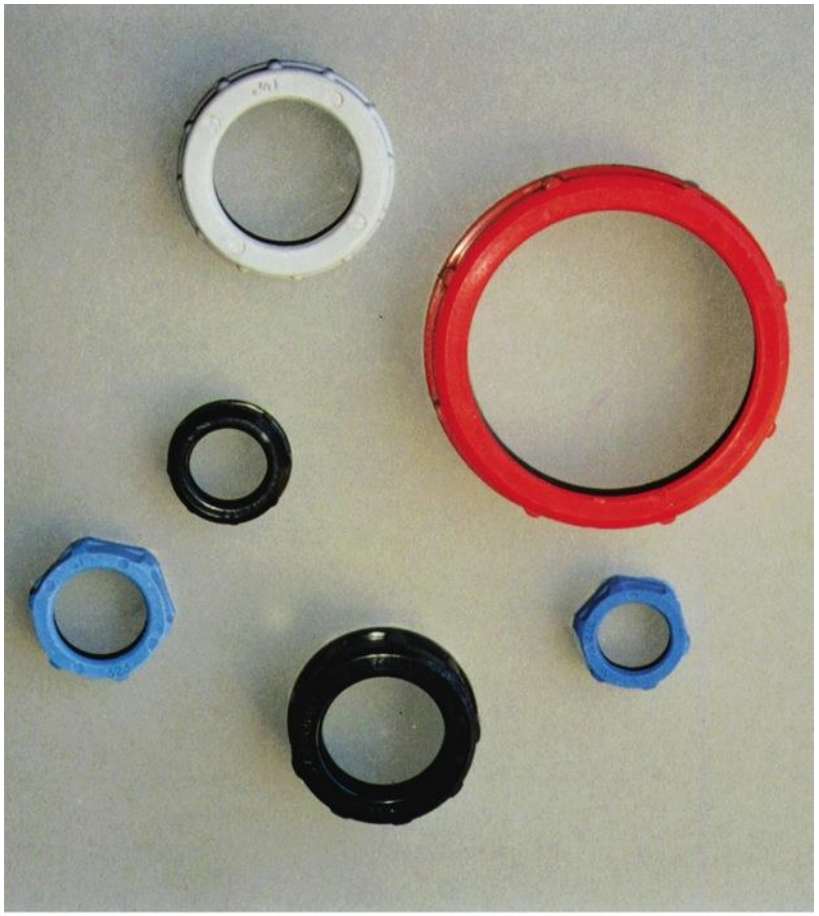

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Insulating Bushings

Insulating bushings are used to protect conductors from being damaged by threaded conduit entering a sheet metal enclosure.

Grounding Insulating Bushings

Grounded insulating bushings both protect conductors and allow for the connection of an equipment grounding conductor.

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Offset Nipples

Offset nipples are used to make quick offset connections between two pieces of equipment in close proximity.

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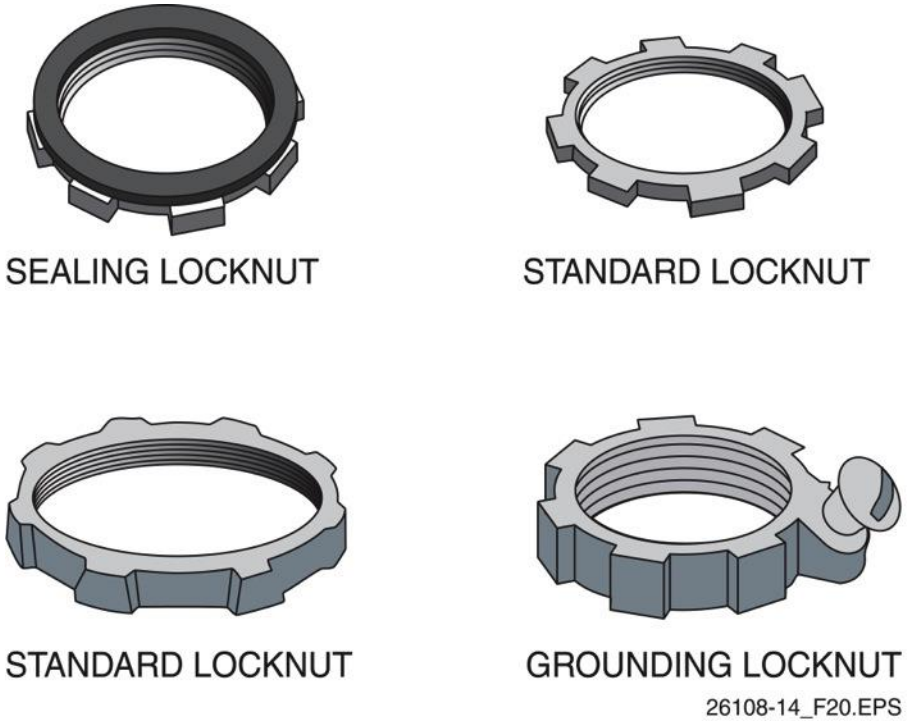
Performance Task

Have the trainees identify the appropriate conduit body for a given application.

Making a Conduit-to-Box Connection

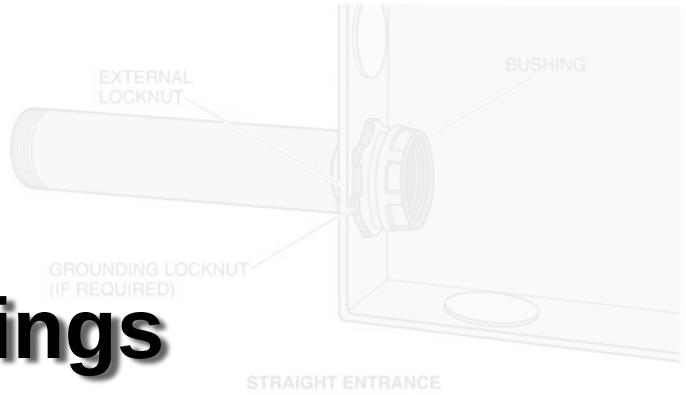
Locknuts are used on the inside and outside walls between a box and a conduit connection. A grounding locknut is used for the connection of a bonding wire.



Next Session…

Conduit-to-Box Connections

- A good conduit-to-box connection requires the use of both internal and external locknuts and a protective bushing.
- An offset or kick may be required so that the conduit enters straight into the box.



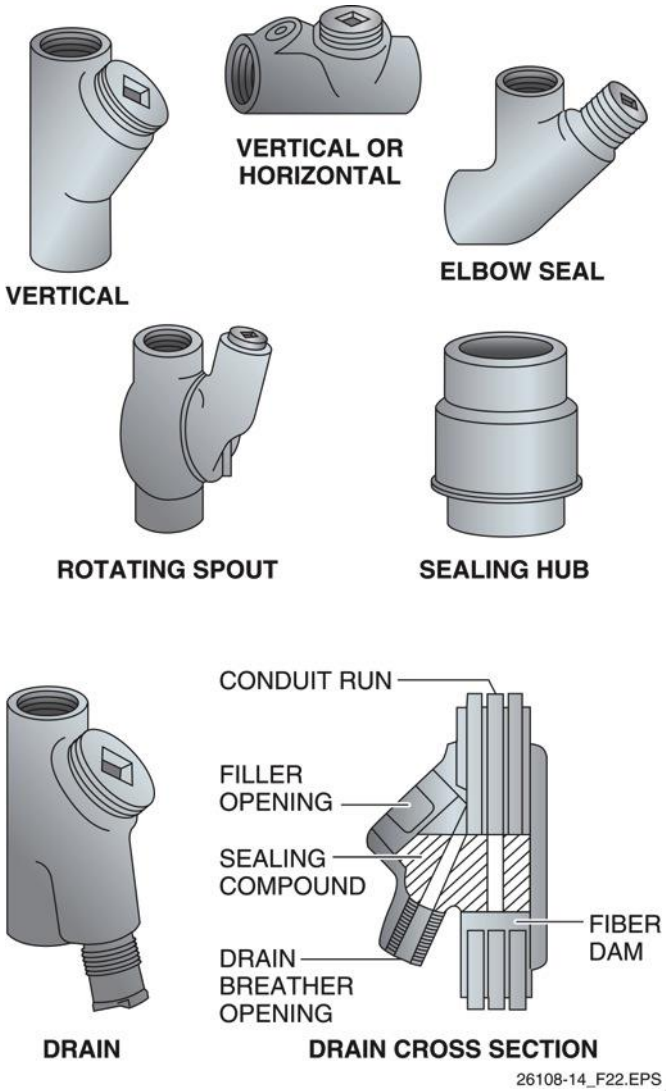
Sealing Fittings

Performance Task

This session will conclude with trainees terminating a selected raceway system.

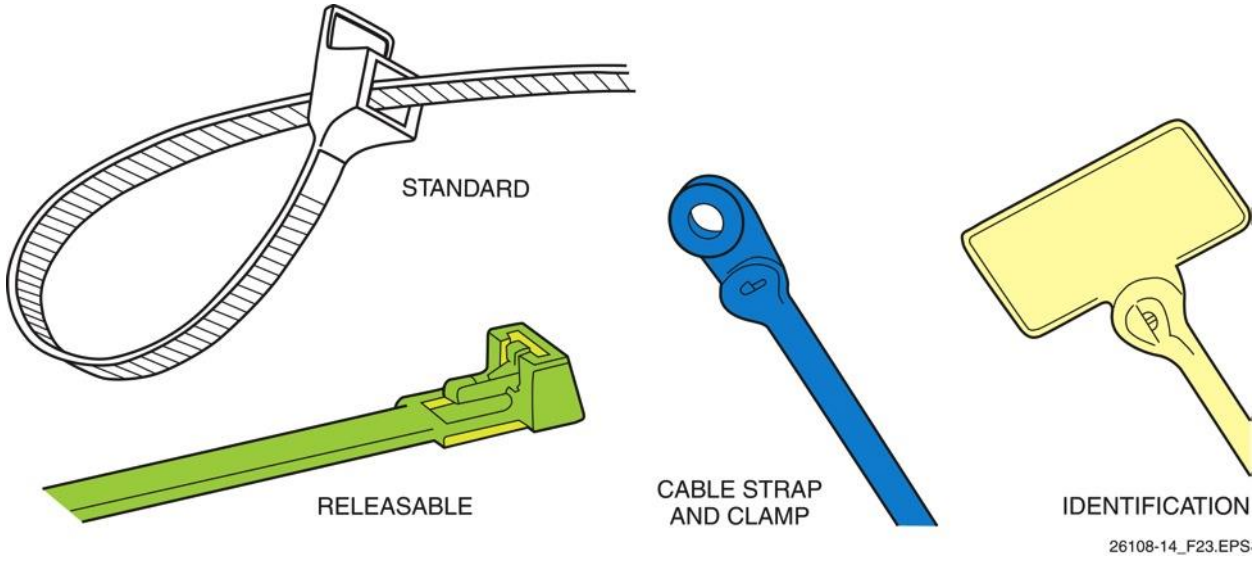
Sealing Fittings

- A variety of sealing fittings are used in hazardous location to minimize the passage of dangerous gases and vapors through the conduit system.
- Sealing fittings are also used to make connections between hazardous (classified) and nonhazardous (unclassified) locations.



Fasteners and Anchors

- Many types of fasteners are used to attach conduit to a building structure. The type of fastener selected depends on whether the conduit is connected to wood, concrete, or metal.
- Tie wraps are used to bundle and identify cable.



Screws

- Screws are made in a variety of sizes, shapes, and head types. Always use a screwdriver or power driver with the proper tip to match the screw being driven.
- Wood screws are used to fasten electrical boxes or panels to wooden framing members. Choose a screw long enough so that at least two-thirds of the screw length will enter the wooden member.

Lag Screws and Shields

- Lag screws and shields are used in applications that require greater holding power.
- The length of the lag screw should equal the thickness of the component to be fastened plus the length of the lag shield.

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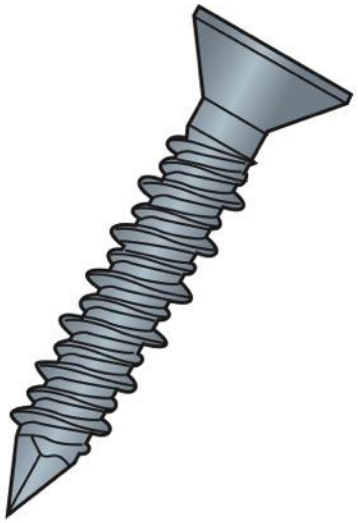
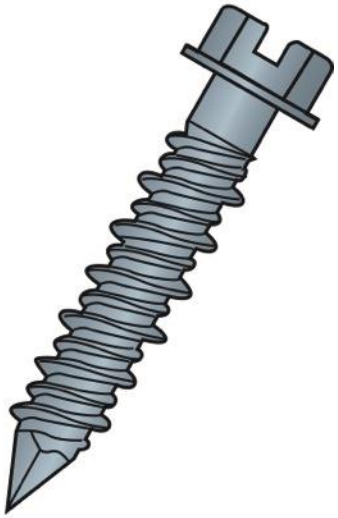
Concrete/Masonry Screws

Concrete/masonry screws are driven into predrilled holes in concrete using a rotary hammer fitted with a carbide drill bit.



PHILLIPS FLAT HEAD



HEX WASHER HEAD

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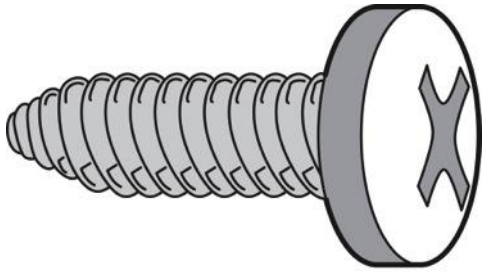
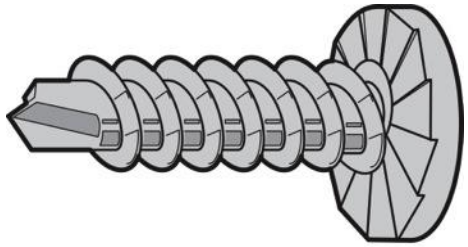
Thread-Forming and Thread-Cutting Screws

Thread-forming screws eliminate the need to tap a hole before installing the screw. They must be installed per the manufacturer's instructions.



STANDARD THREAD-FORMING SCREW



SELF-DRILLING SCREW

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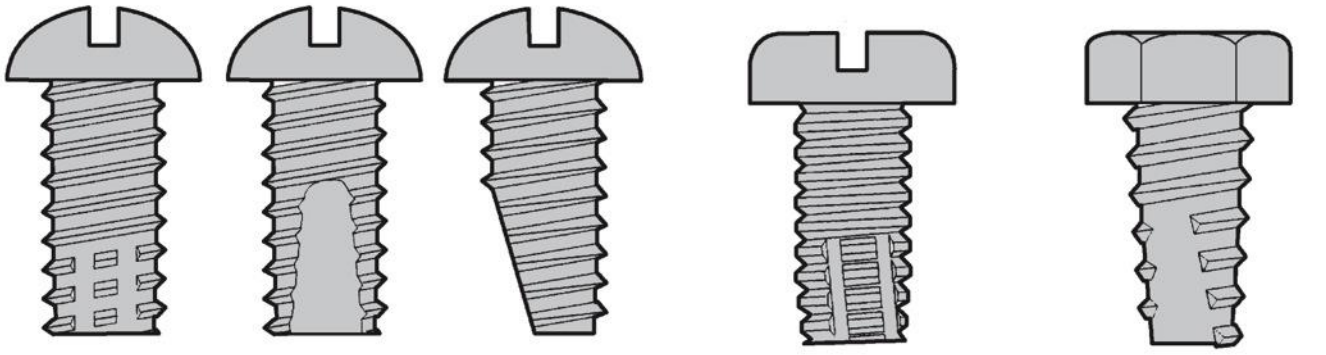
Thread-Cutting Screws

Thread-cutting screws can be used to join metal components that are softer than the hardened steel of the screw.



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7.2.4

Can you name an electrical application for self-drilling screws?

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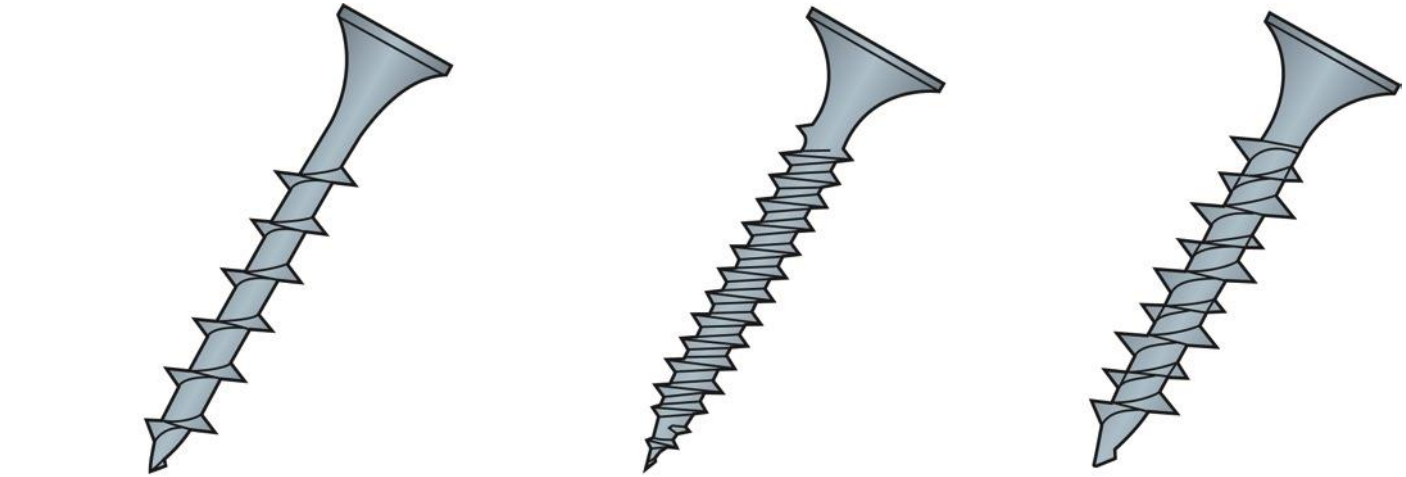
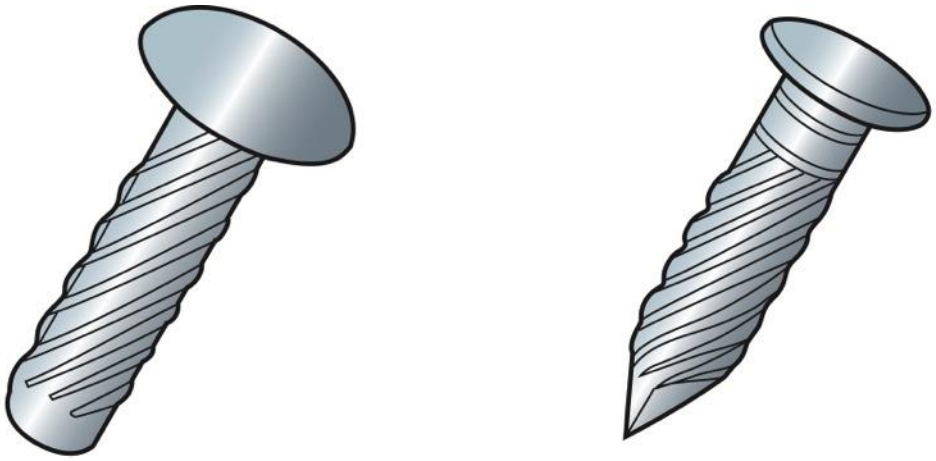
Drywall Screws

- Drywall screws are used to hold wallboard tight to a stud.
- They have a bugle-shaped head with a Phillips or Robertson shape to prevent damage to the wall surface during installation.



Drive Screws

- Drive screws are installed by hammering the screw into a drilled or punched hole of the proper size.
- Drive screws are commonly used on motor nameplates.



TYPE U DRIVE SCREW

TYPE 21 DRIVE SCREW

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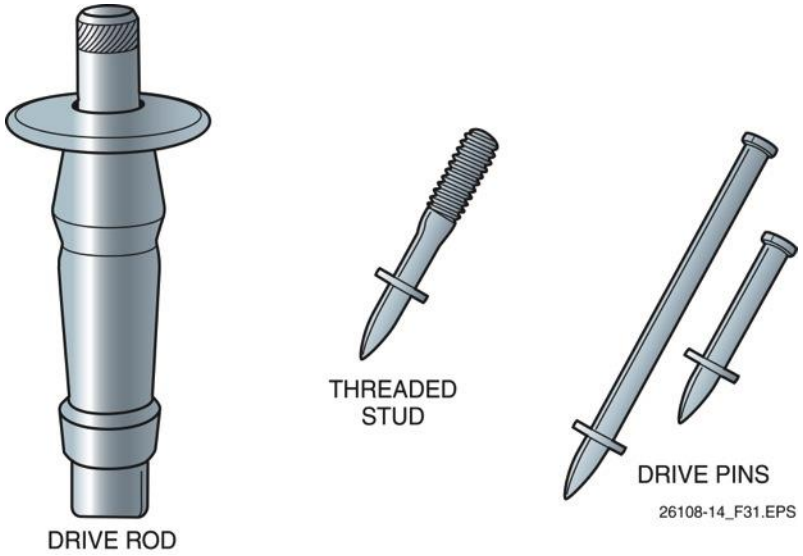
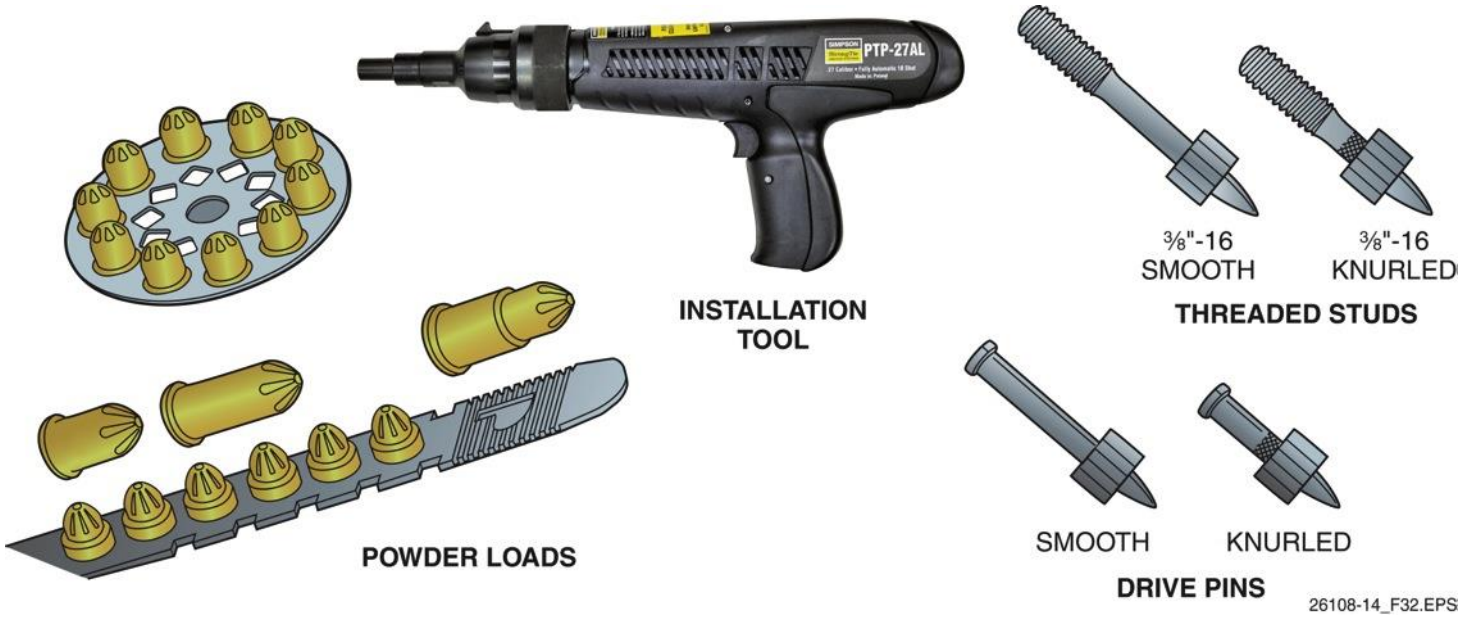
Hammer-Driven Pins and Studs

- Hammer-driven pins or threaded studs are used to fasten wood or steel to concrete without the need to predrill holes.
- The pin is inserted in the tool, positioned against the surface to be fastened, and struck using an engineer's hammer.

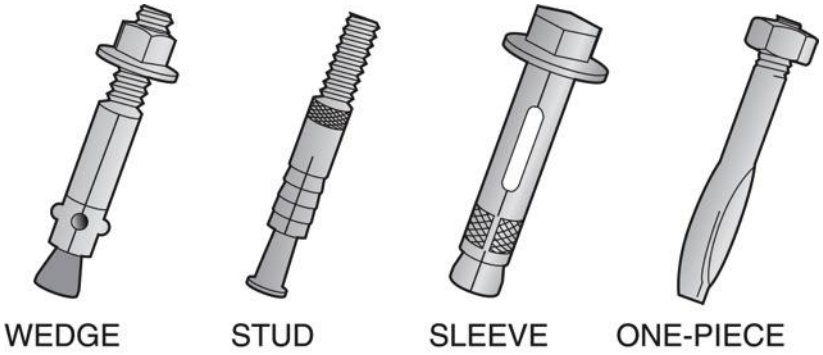


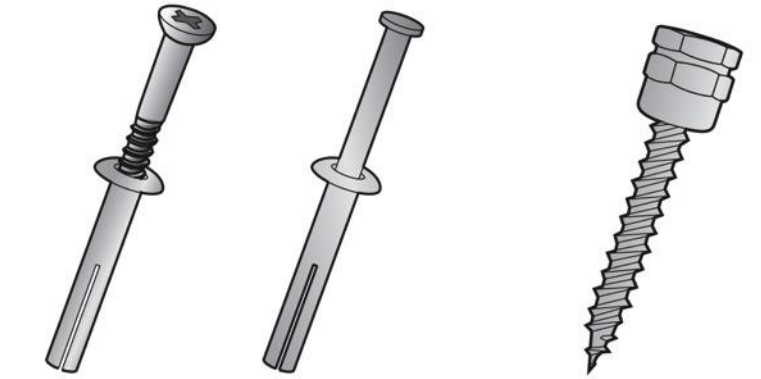
Powder-Actuated Tools and Fasteners

- Powder-actuated fasteners use a gunpowder charge to drive fasteners into masonry or steel.
- The use of a powder-actuated tool requires special training and an operator's license.



Mechanical Anchors





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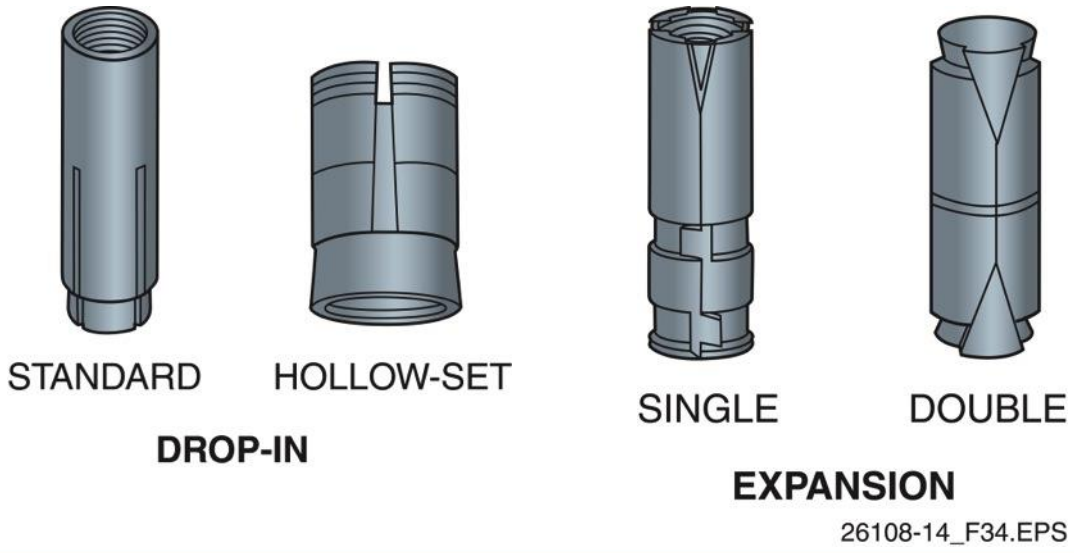
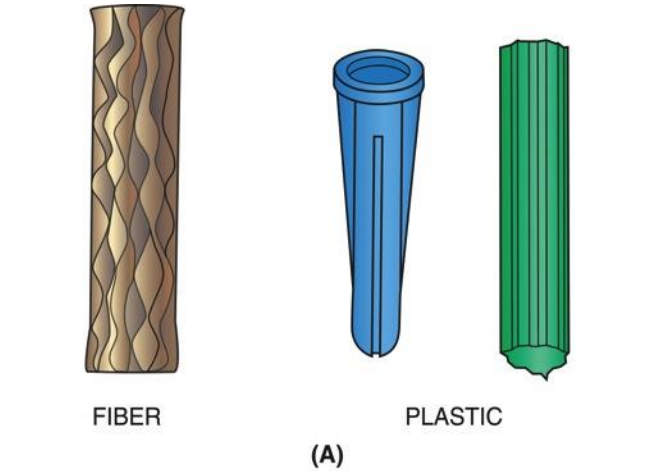
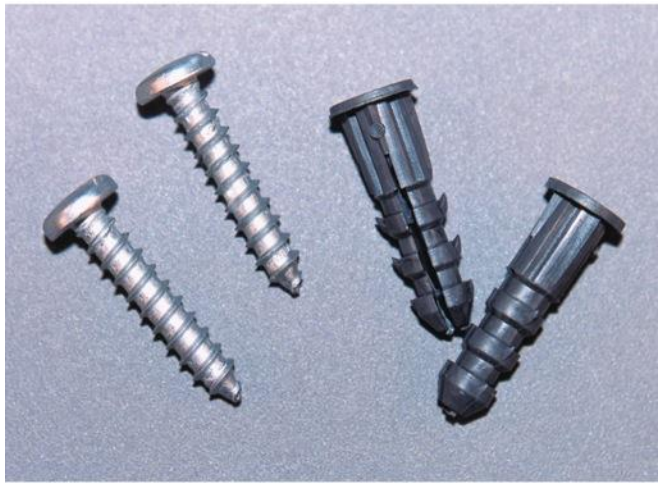
- Mechanical anchors provide additional holding power in applications that would not hold with a standard fastener.
- Common anchor types include one-step anchors, bolt anchors, screw anchors, self-drilling anchors, and hollow-wall anchors.
- One-step anchors are installed in a single operation.

Bolt Anchors

- Bolt anchors are used in conjunction with threaded machine bolts or screws.
- Two common types of bolt anchors are drop-in and expansion anchors. Double expansion anchors provide additional holding power when the strength of the concrete or masonry is in question.

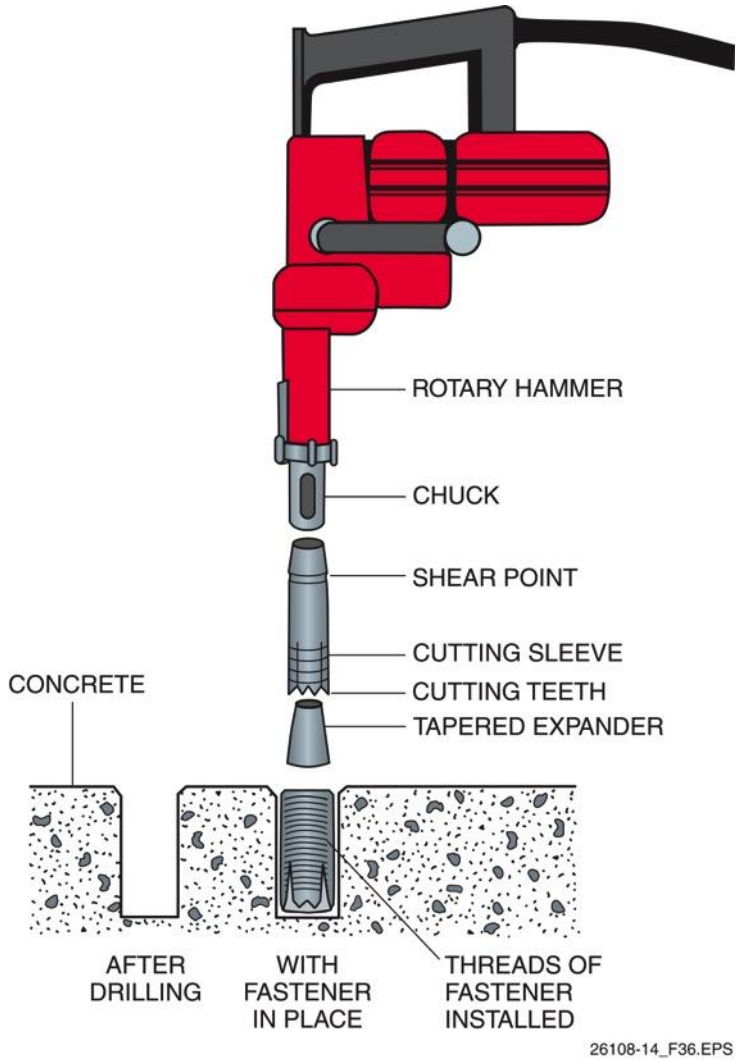






Screw Anchors

- Screw anchors are used with sheet metal, wood, or lag screws.
- Common screw anchors are made of fiberglass or plastic. The anchor must be matched to the size and type of screw.

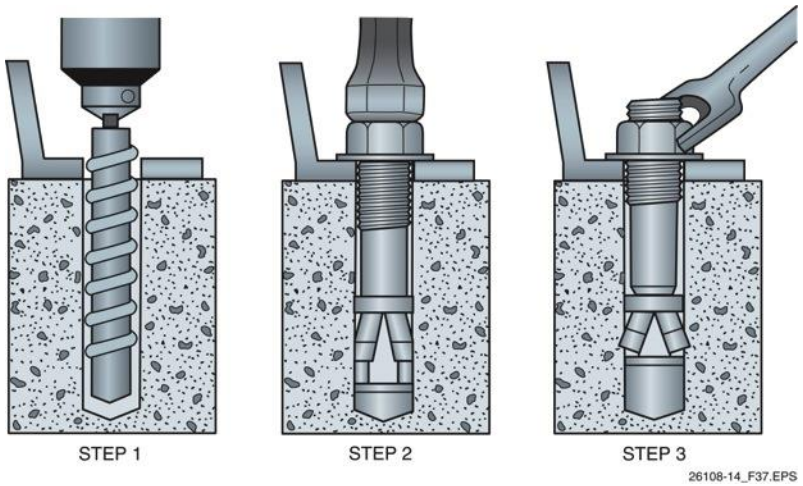


Self-Drilling Anchors

- Self-drilling anchors are used in concrete.
- The cutting sleeve is used as a drill bit and then driven back in the hole to become part of the fastener.

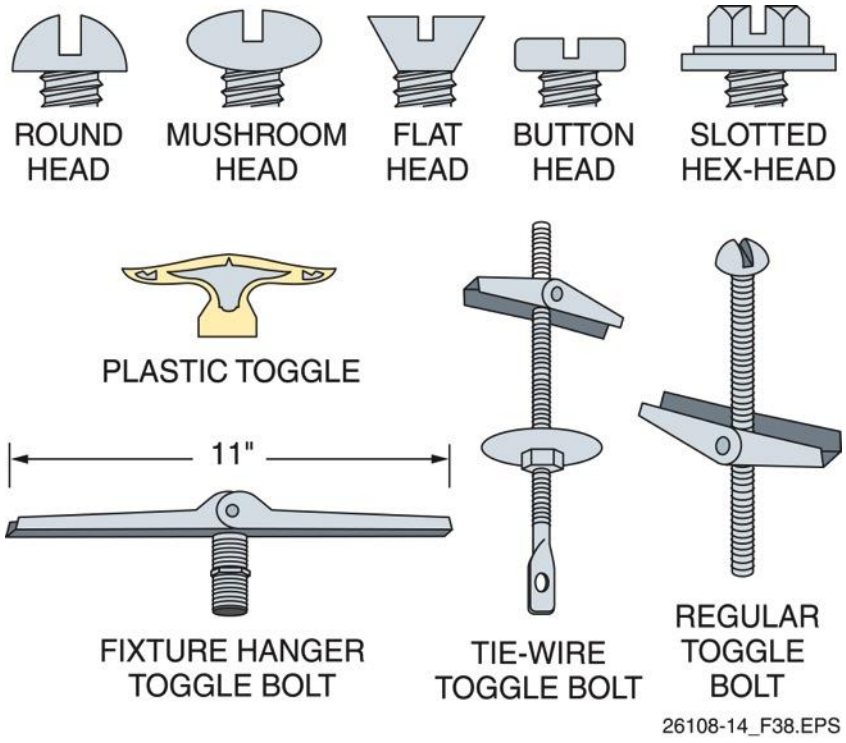
Guidelines for Drilling Anchor Holes in Hardened Concrete or Masonry

- When drilling anchor holes in concrete or masonry, drill the bolt hole the same size as the fastener.
- Drive the anchor bolt into the hole using a hammer.
- Add a washer and nut and tighten with a wrench until it is secure.



Hollow-Wall Anchors

- Hollow-wall anchors are used in hollow materials such as wallboard, plaster, block, and structural steel.
- Toggle bolts are used in a predrilled hole and then tightened to draw the wings of the fastener against the back of the surface.



Sleeve-Type, Wallboard, and Metal Drive-In Anchors

- Other types of anchors include sleeve-type, wallboard, and metal drive-in anchors.
- Sleeve-type anchors are either tapped into a predrilled hole or driven in with a hammer. Wallboard anchors are self-drilling, while metal drive-in anchors are hammered into place.

Sleeve-Type Drive Anchors

What happens when you remove the screw when a sleeve-type drive anchor is in place?

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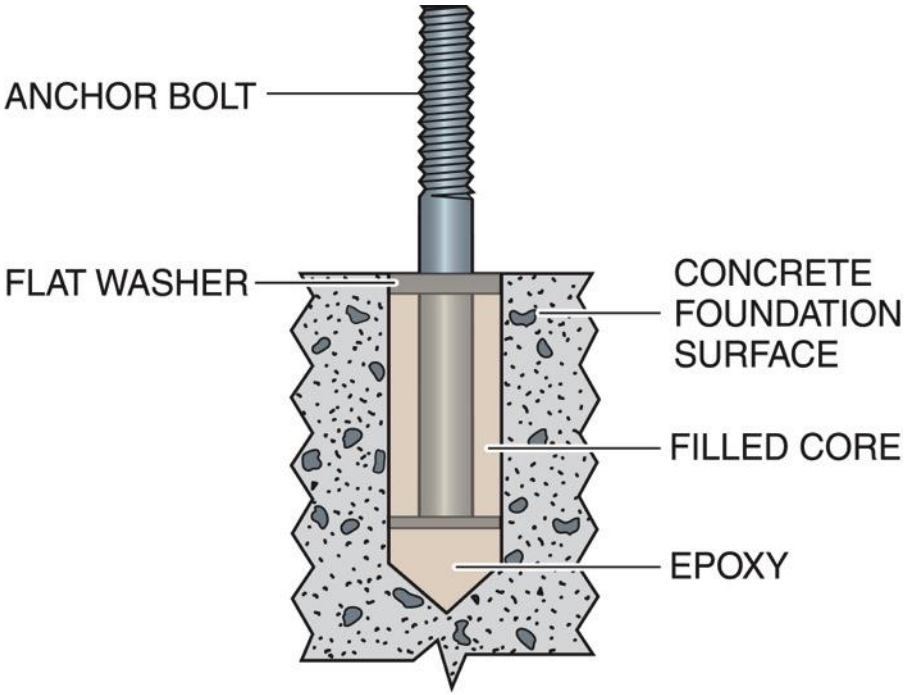
Ceiling Installations

26108-14_SA09.EPS

In the dormitory question discussed earlier, which of these fasteners could have been used to safely secure the emergency lights?

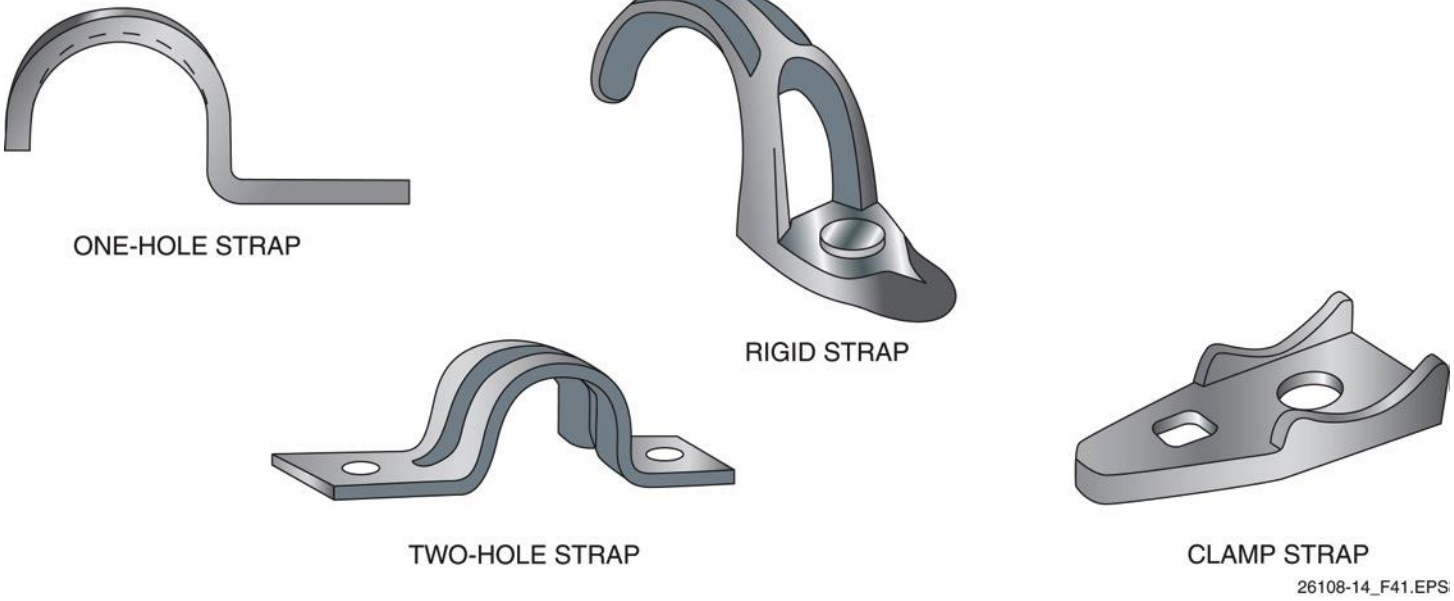
Epoxy Anchoring Systems

- Epoxy anchoring systems use a two-part epoxy that is installed using a tool similar to a caulking gun.
- To use these anchors, a hole is predrilled and cleaned, then the hole is filled halfway with epoxy. The fastener is then inserted and allowed to harden before tightening.

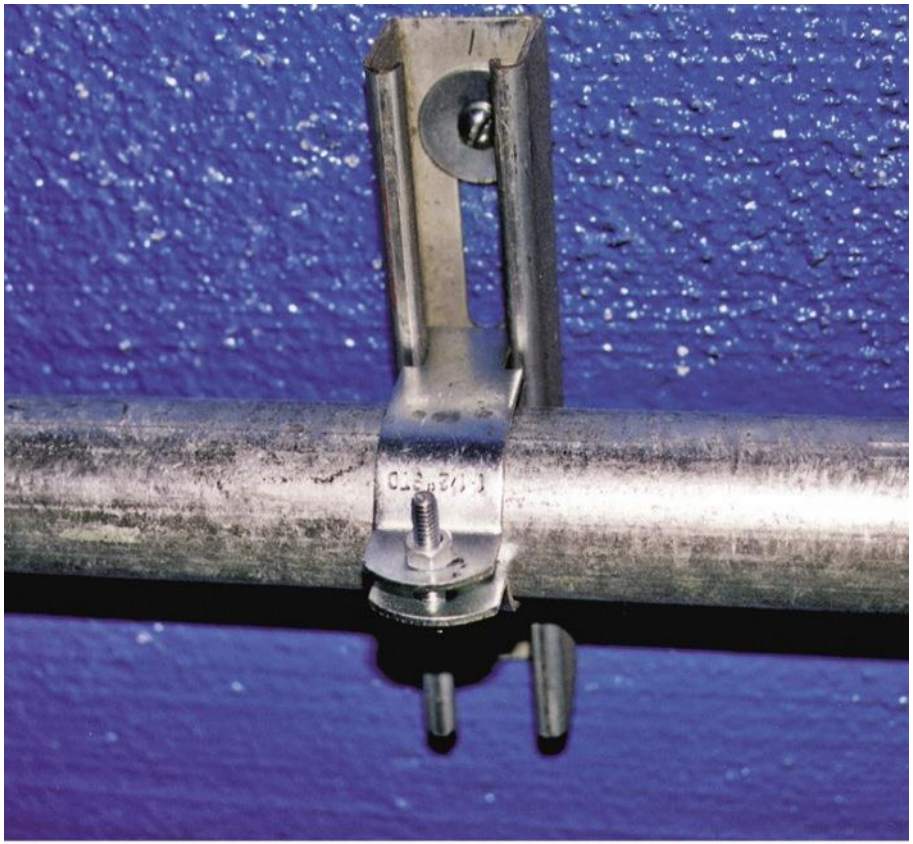


Raceway Supports

- Raceway supports must be installed properly into sound structural members.
- Straps are often used to support conduit against a surface.



Standoff Supports



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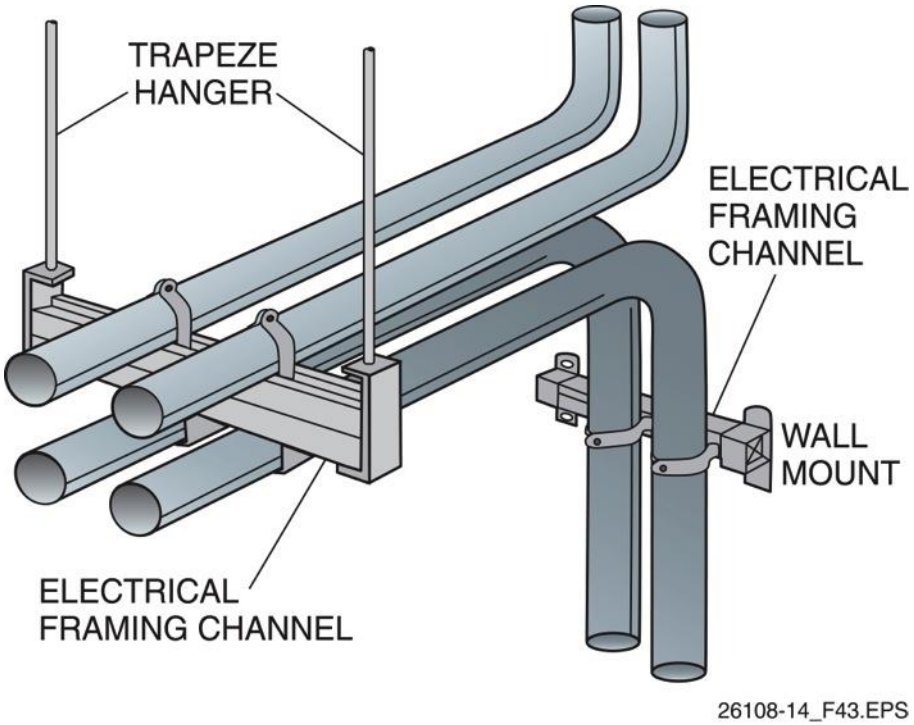
Standoff supports are used to support conduit away from the structure.

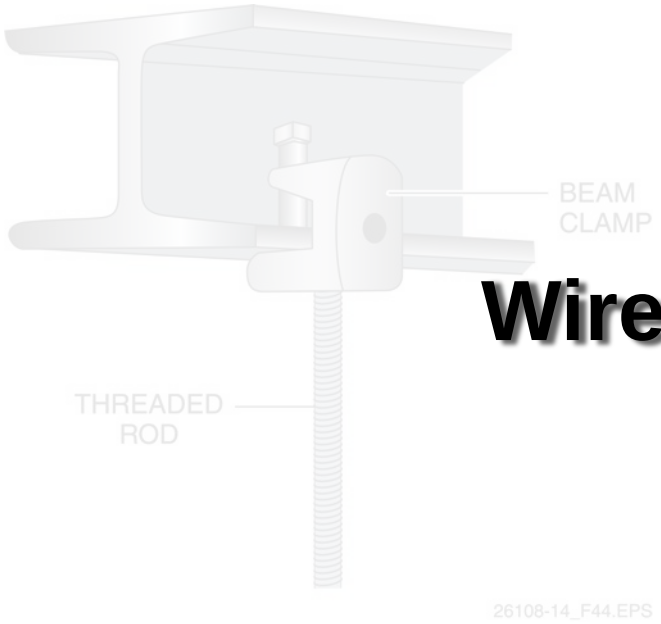
Electrical Framing Channels



- Electrical framing channels are used with conduit clamps to support conduit from a ceiling, wall, or other surface.
- Trapeze hangers are used with framing channels to support overhead conduit.

Next Session…

Beam Clamps



26108-14_F44.EPS

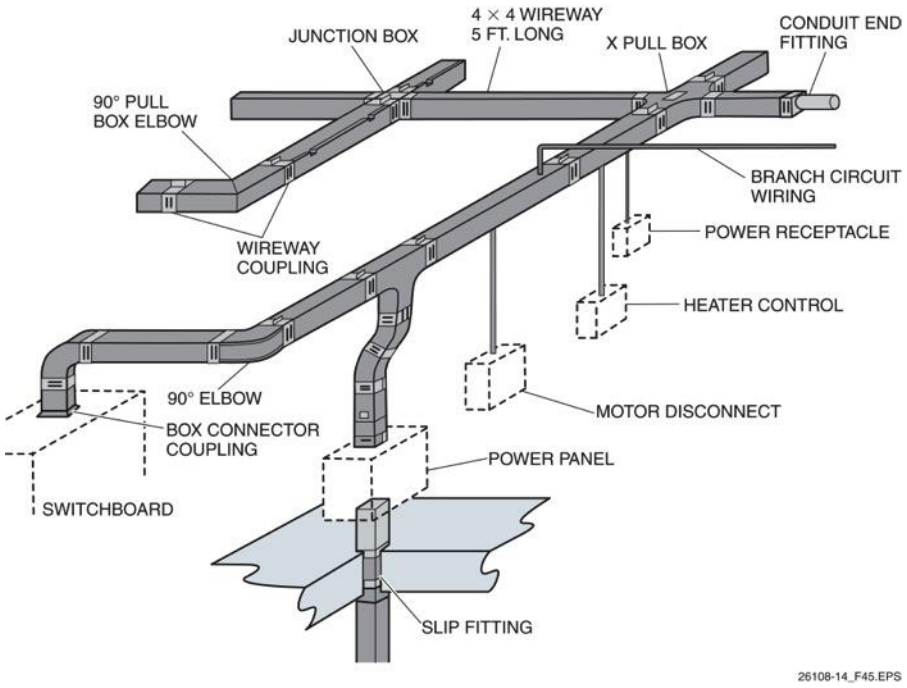
Beam clamps are used with suspended hangers. e end is attached to the beam and the other to a hanger.

Wireways

Performance Task

This session will conclude with trainees identifying and selecting various types and sizes of raceways, fittings, and fasteners for a given application.

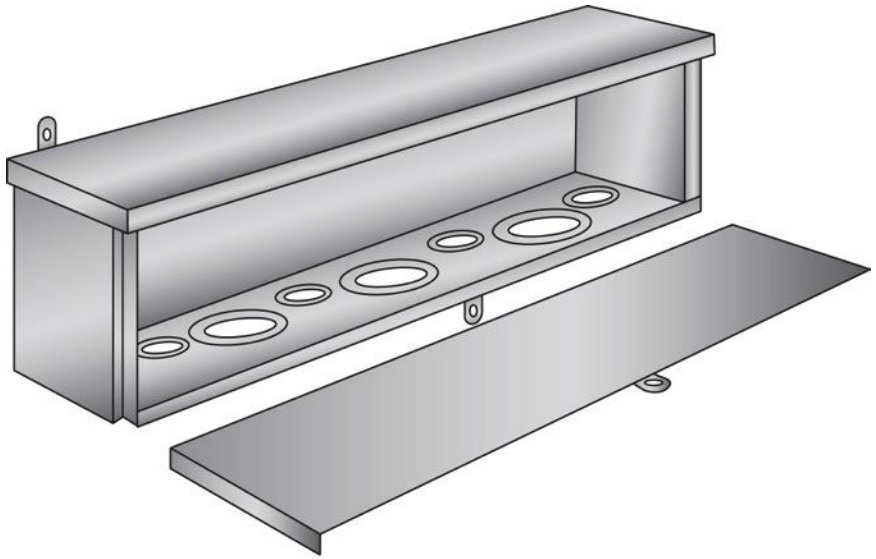
Wireways



- Wireways are sheet metal troughs with removable covers for access to the conductors.
- Auxiliary gutters are similar to wireways, but are part of larger assemblies such as switchboards or distribution equipment.

Types of Wireways

- Duct-type wireways are available with hinged covers to lay in the conductors or as a screw-cover trough.
- Troughs provide access from the side rather than the top. Raintight troughs are used where exposed to moisture.



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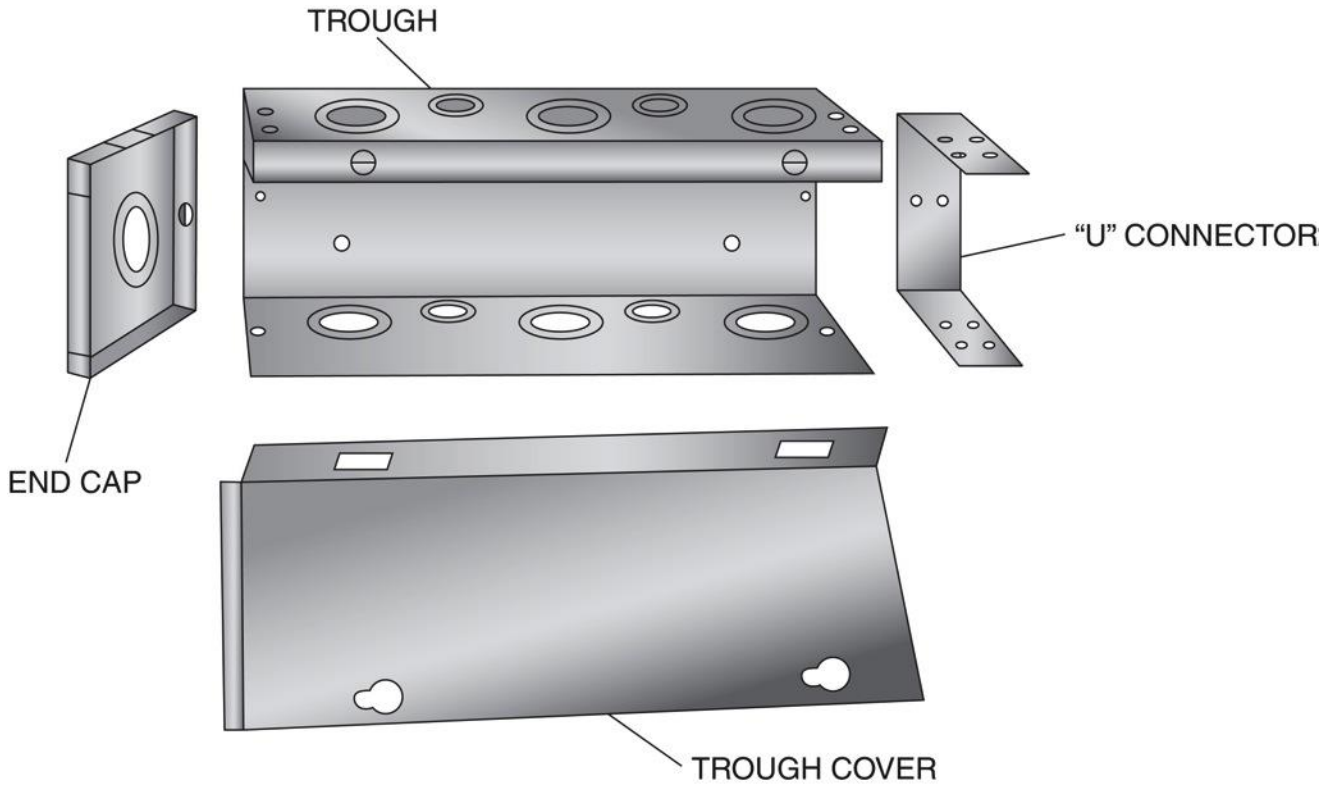
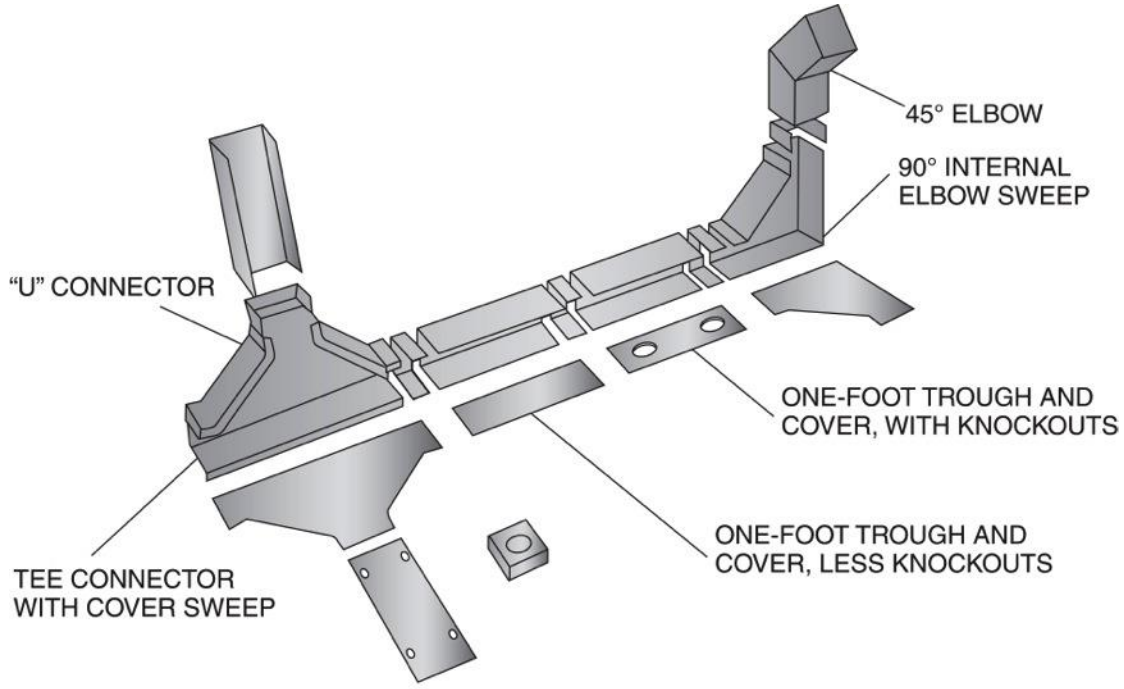
Trough

Troughs contain knockouts similar to junction boxes.



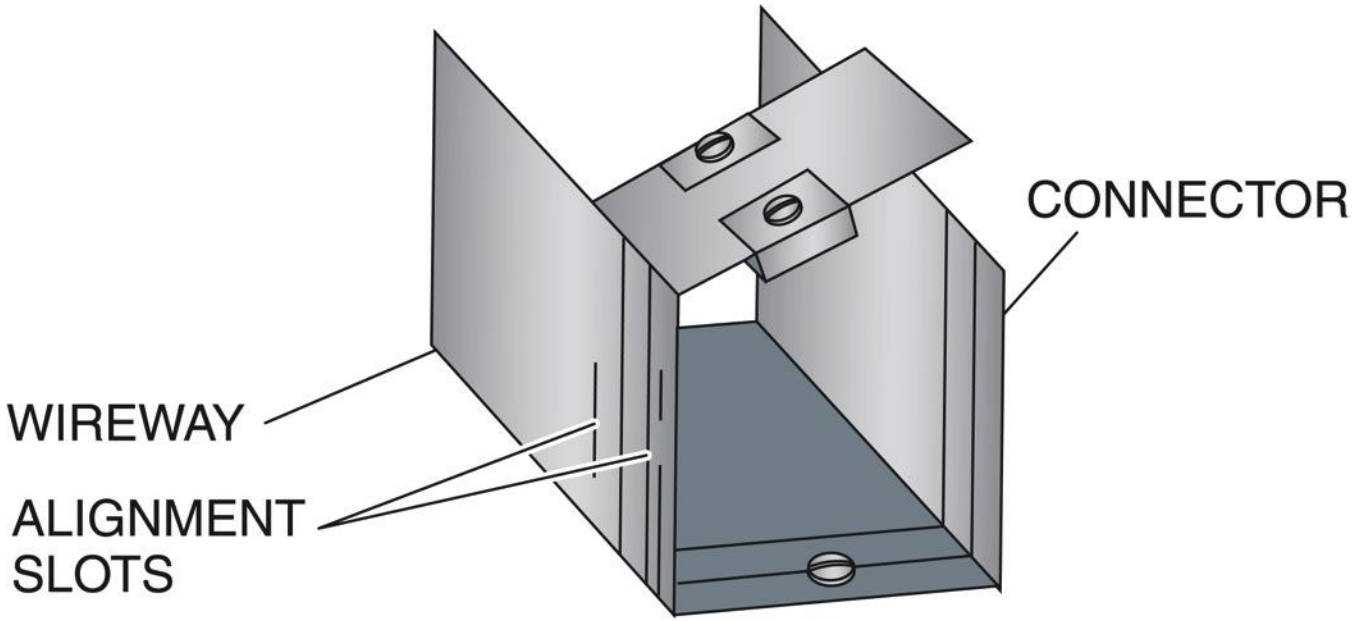
Wireway Sections

- A variety of fittings are available to create wireway systems.
- The fittings are attached to the duct using slip-on connectors.



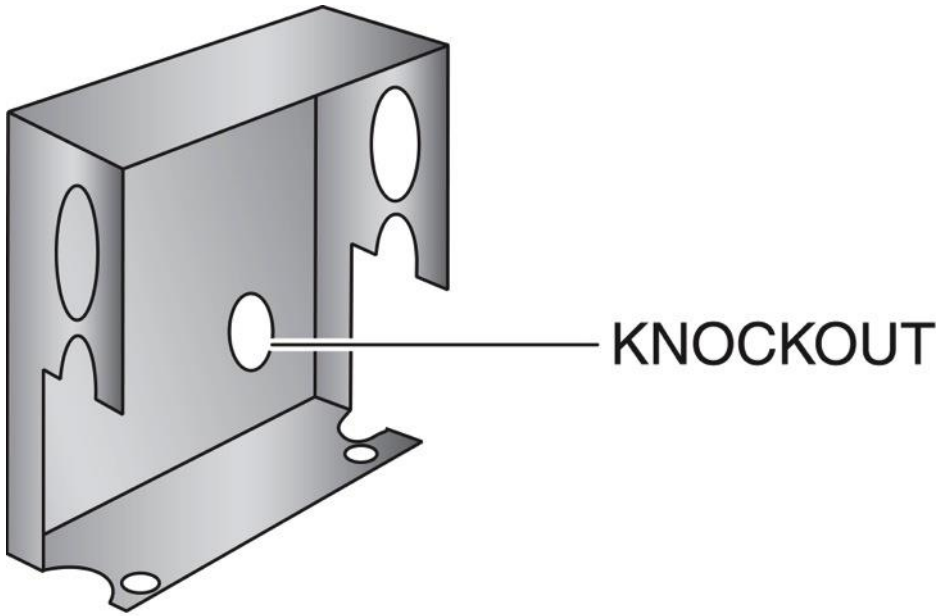
Connectors

Connectors are held to the wireway section using small bolts and nuts. A friction hinge holds the wireway cover open for access.



End Plates

- Wireways are finished using end plates.
- Knockouts allow the conductors to extend beyond the end plate.



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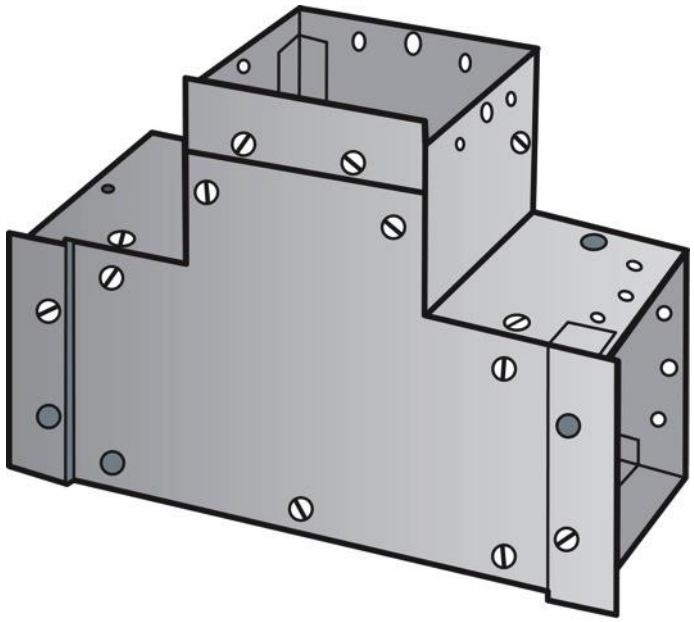
Tees

Tee connections are used where conductors must branch in different directions. The sides are removable for access to splices and taps.



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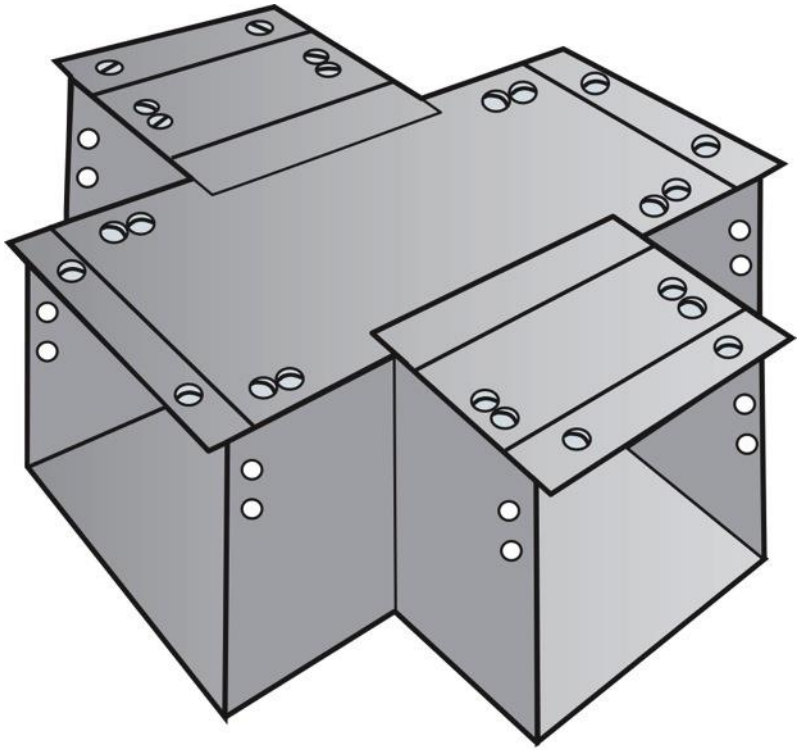
Crosses

Crosses are used to provide an intersection with four openings.



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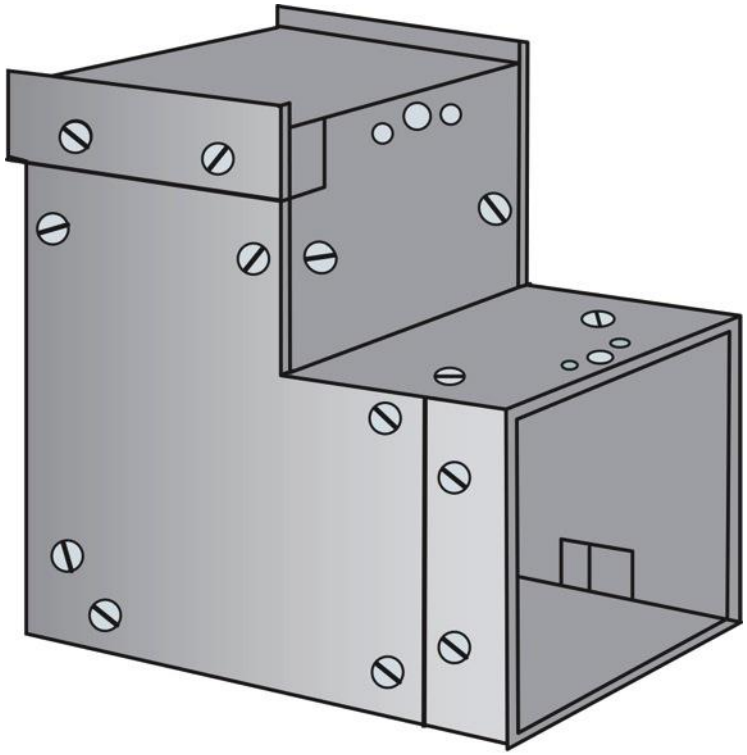
Elbows

- Elbows are available in angles of 22½˚, 45˚, and 90˚. The inside corners are rounded to prevent conductor damage.
- Telescopic (slip) fittings are used to attach wireway sections and are similar to a conduit nipple.



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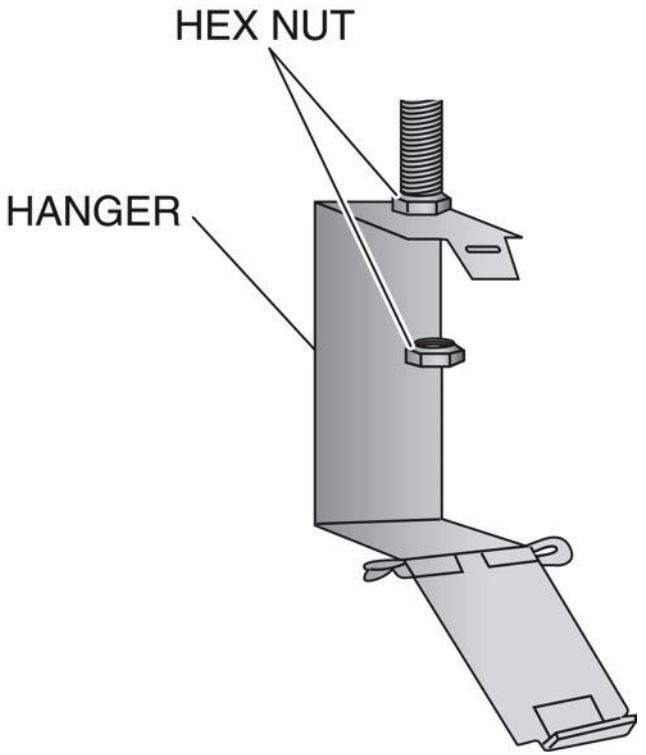
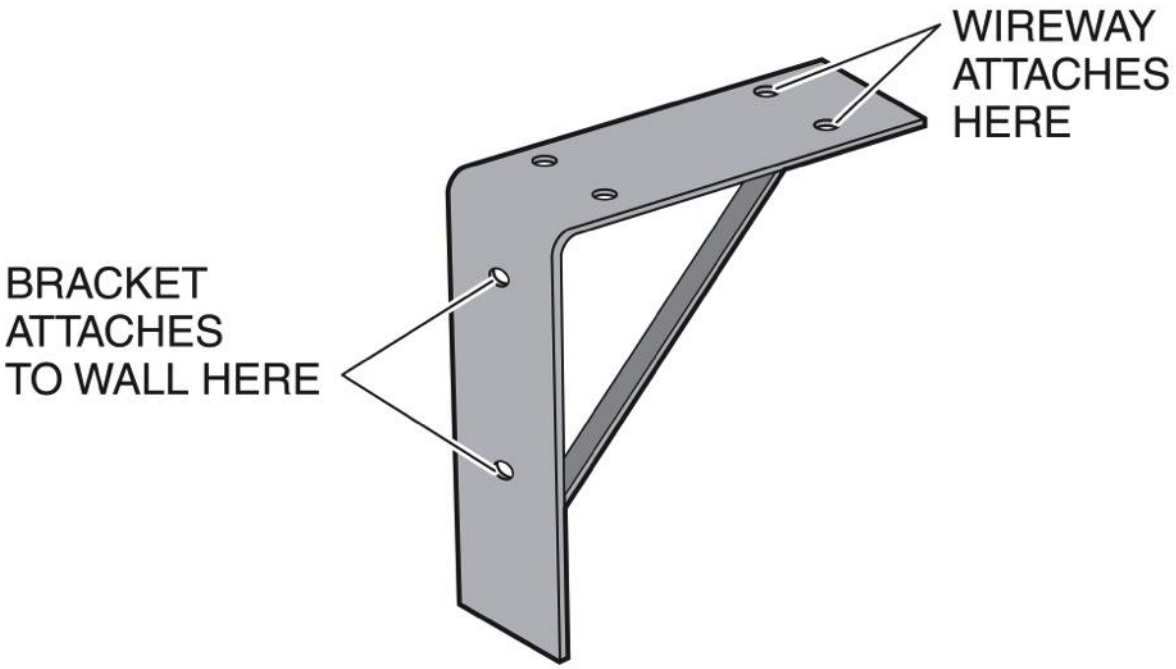
Wireway Supports

- Horizontal wireways must be supported at each end and every 5' thereafter.
- Wireways should be direct-mounted whenever possible; otherwise, suspended hangers may be used.



Gusset Brackets

Gusset brackets are used for wall mounting of wireways. The wireway rests on the bracket and is attached using screws or bolts.



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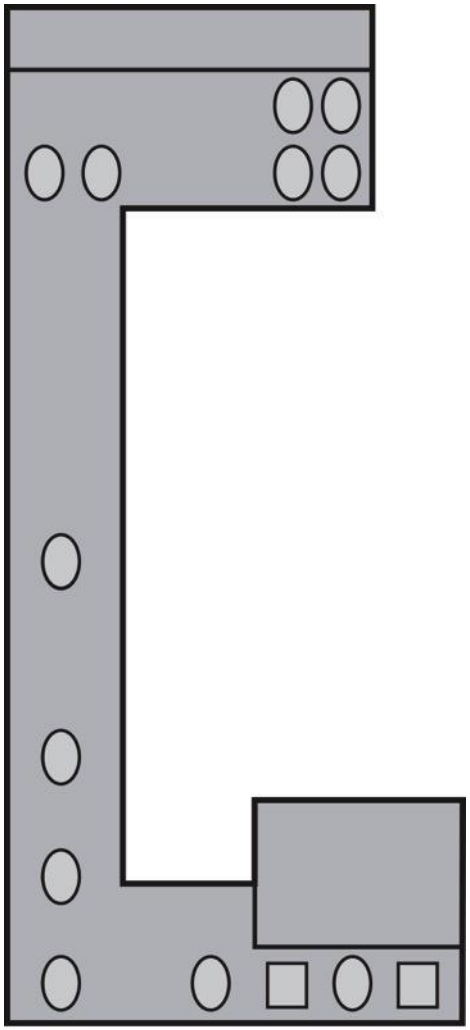


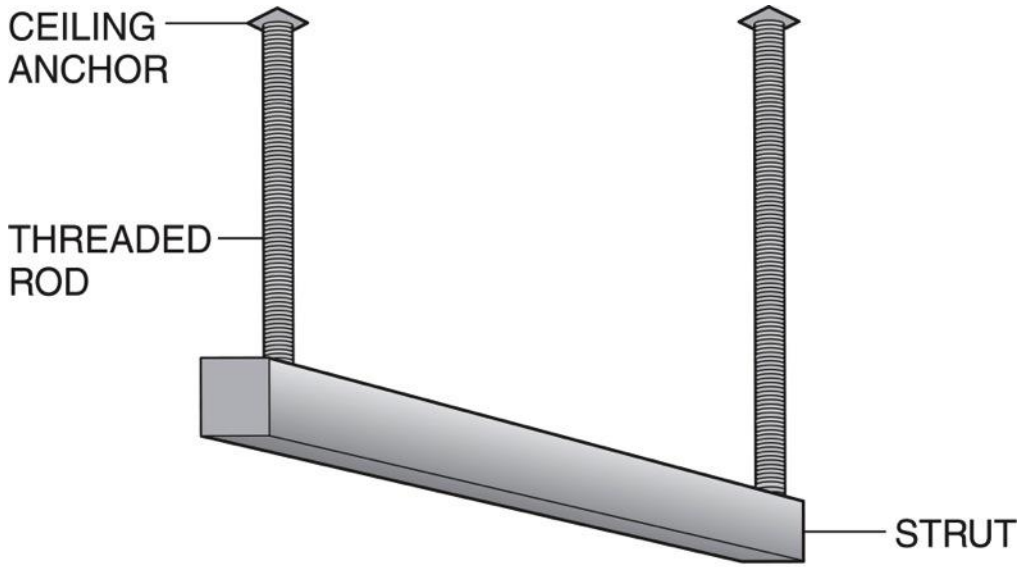
26108-14_F56.EPS

Standard Hangers

Standard hangers are made in two pieces that can be combined in different ways for different installation requirements.

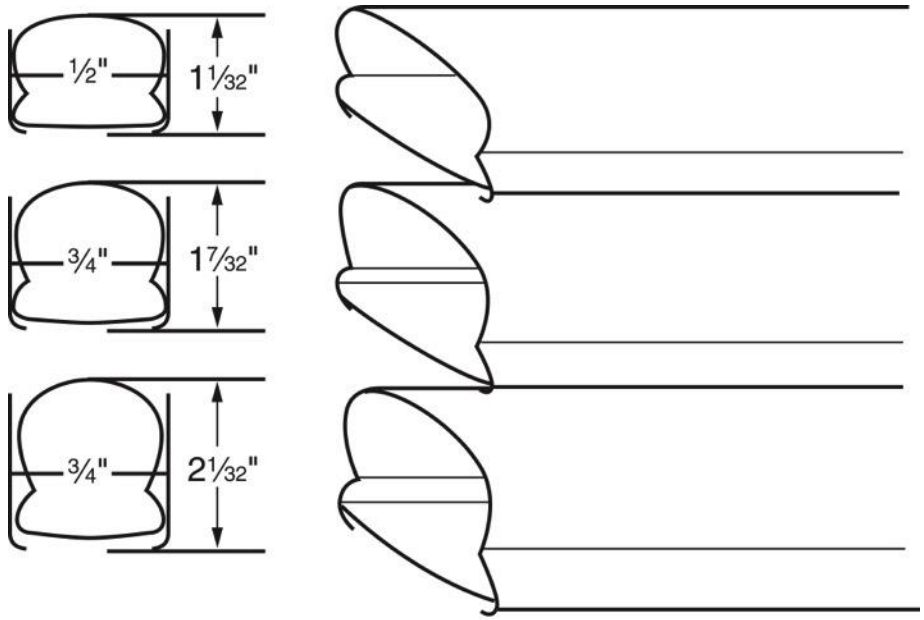
Wireway Hangers

- Wireway hangers are used to support larger wireways.
- A wireway hanger consists of a piece of strut mounted on threaded rods attached to a ceiling, beam, or other structural member.



Other Types of Raceways

- Surface metal and nonmetallic raceways are used indoors in dry locations.
- Smaller raceways are used to extend power conductors from one point to another.



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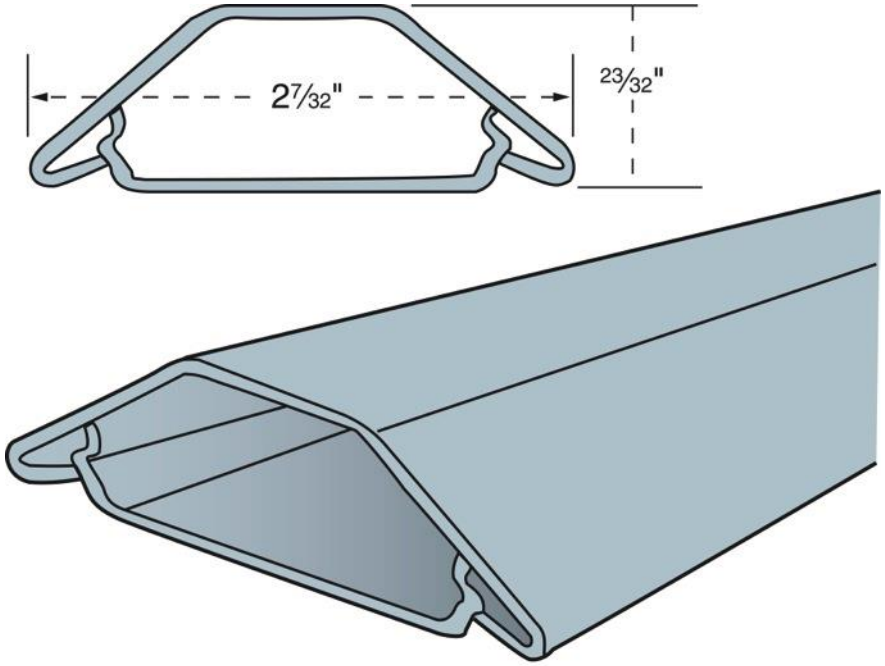
Pancake Raceway

Pancake raceways have a low profile and are used to extend power, lighting, telephone, or signal wire across the surface of a floor.



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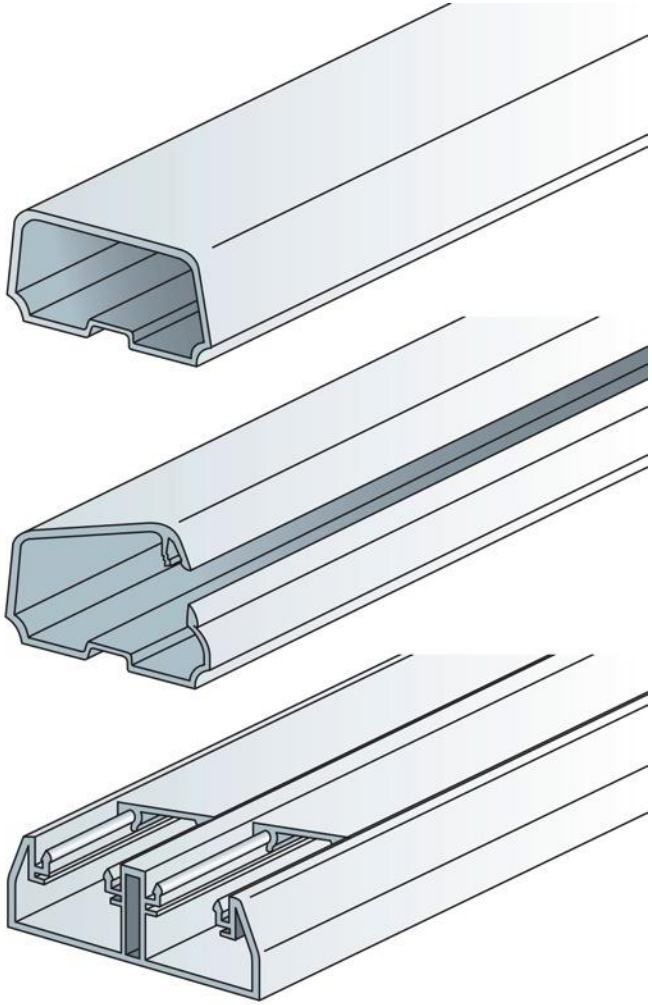
Examples of Surface Raceway

Twinduct or triple-duct raceways include partitions to separate power and control wiring.



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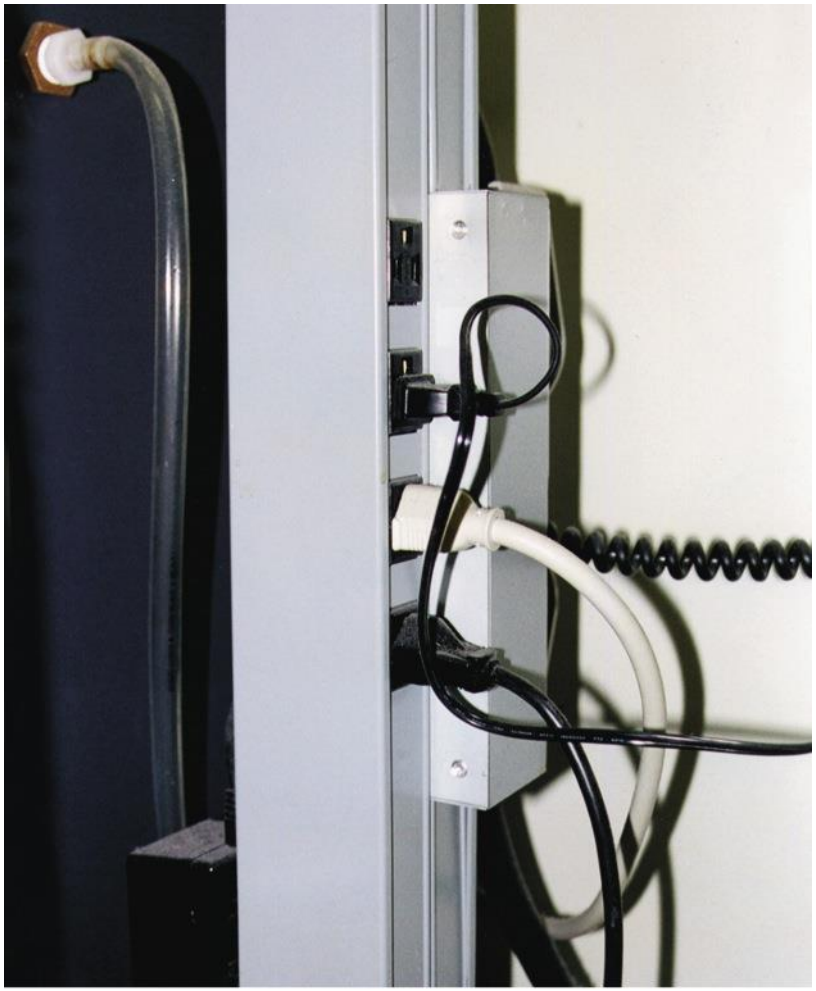
Multi-Outlet Assemblies

Multi-outlet assemblies hold receptacles and other devices within the raceway.

26108-14_F61.EPS

Pole Systems

Power poles are used to provide power in office cubicles and similar locations.



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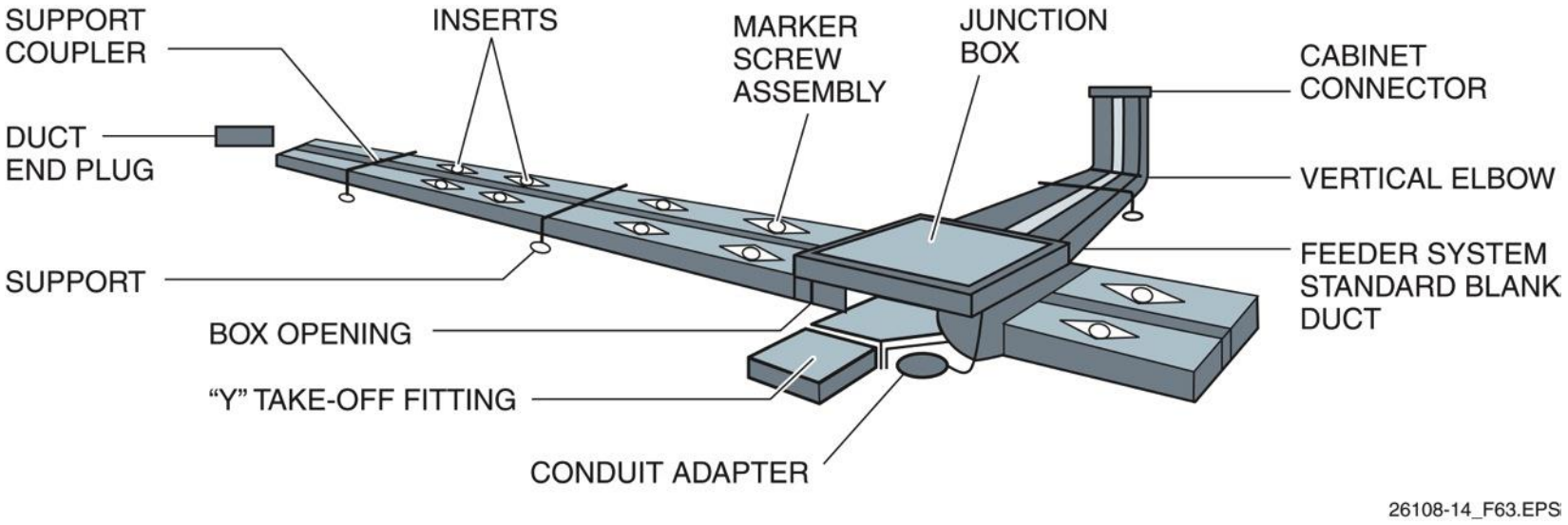
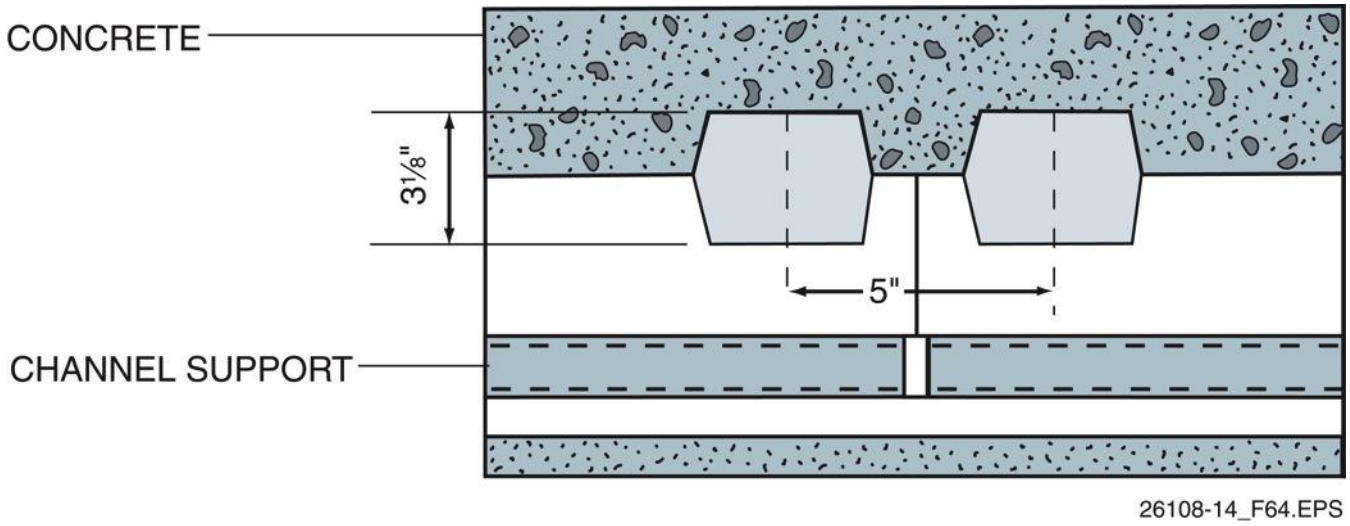
Underfloor Systems



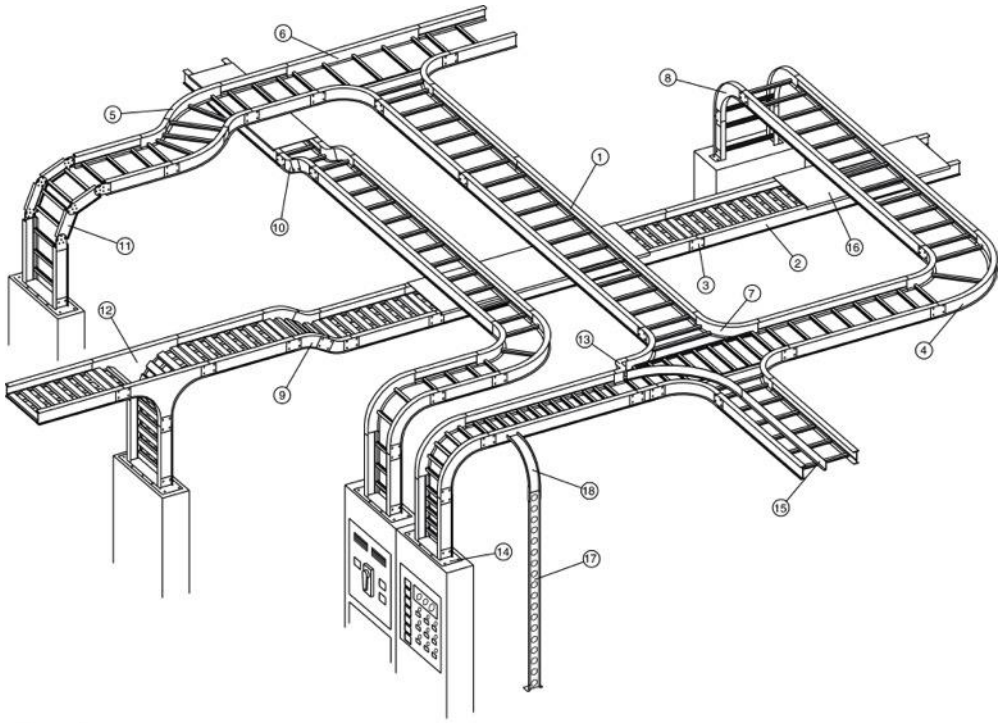
- Underfloor raceways are used to provide lighting, power, and signal wiring to cabinets and consoles.
- The inserts can be removed for outlet installation where desired.

Cellular Metal Floor Raceways; Cellular Concrete Floor Raceways



- Cellular metal raceways can be used to route wiring in steel-frame buildings.
- Junction boxes are installed in cellular concrete floor raceways to provide access to the conductors.

10.0.0 – 10.1.0



Legend

1. LADDER TYPE CABLE TRAY
2. VENTILATED TROUGH TYPE CABLE TRAY
3. STRAIGHT SPLICE PLATE
4. 90° HORIZONTAL BEND, LADDER TYPE CABLE TRAY
5. 45° HORIZONTAL BEND, LADDER TYPE CABLE TRAY
6. HORIZONTAL TEE, LADDER TYPE CABLE TRAY
7. HORIZONTAL CROSS, LADDER TYPE CABLE TRAY
8. 90° VERTICAL OUTSIDE BEND, LADDER TYPE CABLE TRAY
9. 45° VERTICAL OUTSIDE BEND, VENTILATED TYPE CABLE TRAY
10. 30° VERTICAL INSIDE BEND, LADDER TYPE CABLE TRAY
11. VERTICAL BEND SEGMENT (VBS)
12. VERTICAL TEE DOWN, VENTILATED TROUGH TYPE CABLE TRAY
13. LEFT HAND REDUCER, LADDER TYPE CABLE TRAY
14. FRAME TYPE BOX CONNECTOR
15. BARRIER STRIP STRAIGHT SECTION
16. SOLID FLANGED TRAY COVER
17. VENTILATED CHANNEL STRAIGHT SECTION
18. CHANNEL CABLE TRAY, 90° VERTICAL OUTSIDE BEND

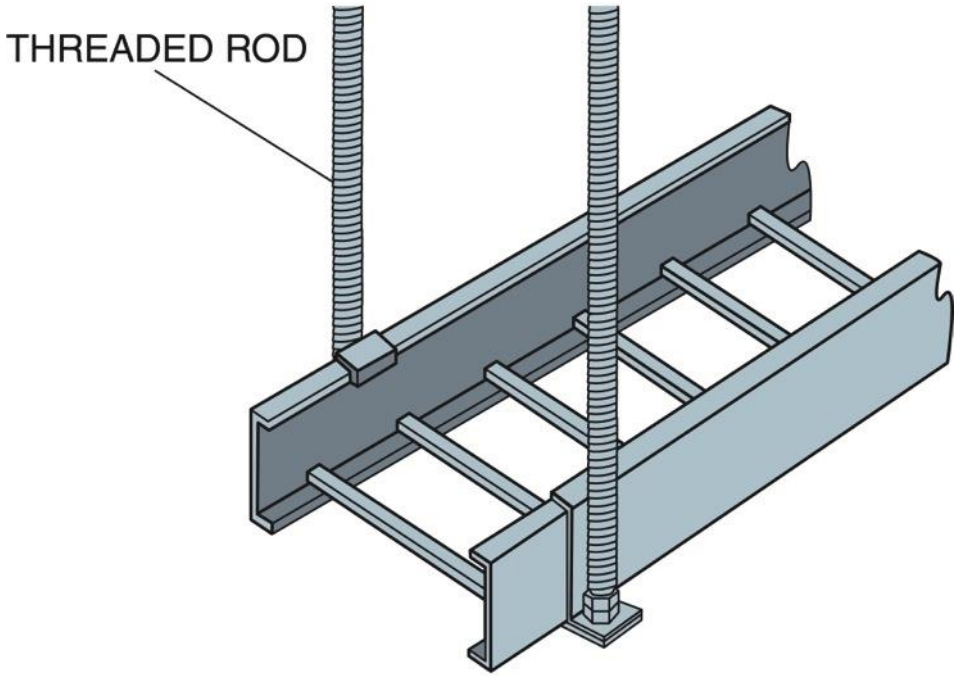
26108-14_F65.EPS

Cable Trays

- Cable trays provide open access in applications with frequent cable changes.
- A variety of fittings are available to provide changes in tray direction and/or dimension.

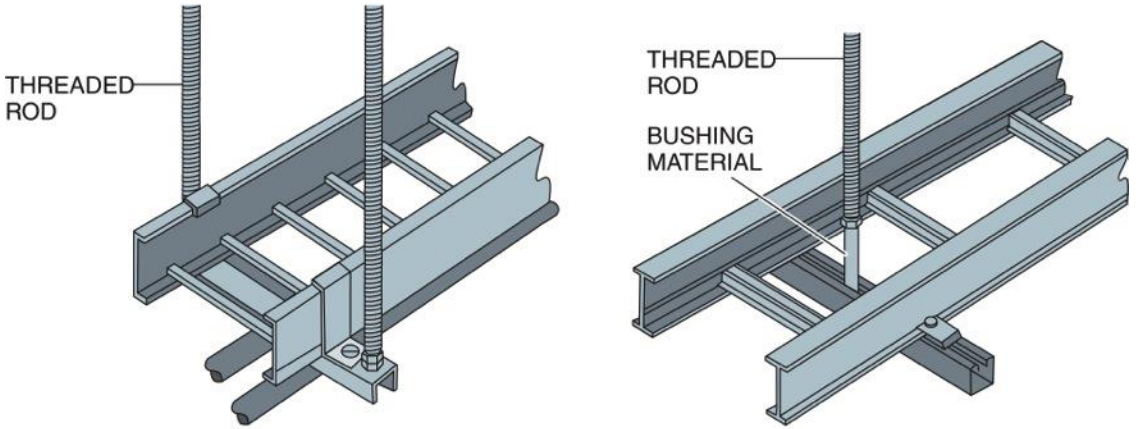
Cable Tray Supports

- Cable trays are typically supported in one of five ways: direct rod suspension, trapeze mounting, center hung, wall mounting, and pipe rack mounting.
- Direct rod suspension uses threaded rod and hanger clamps.

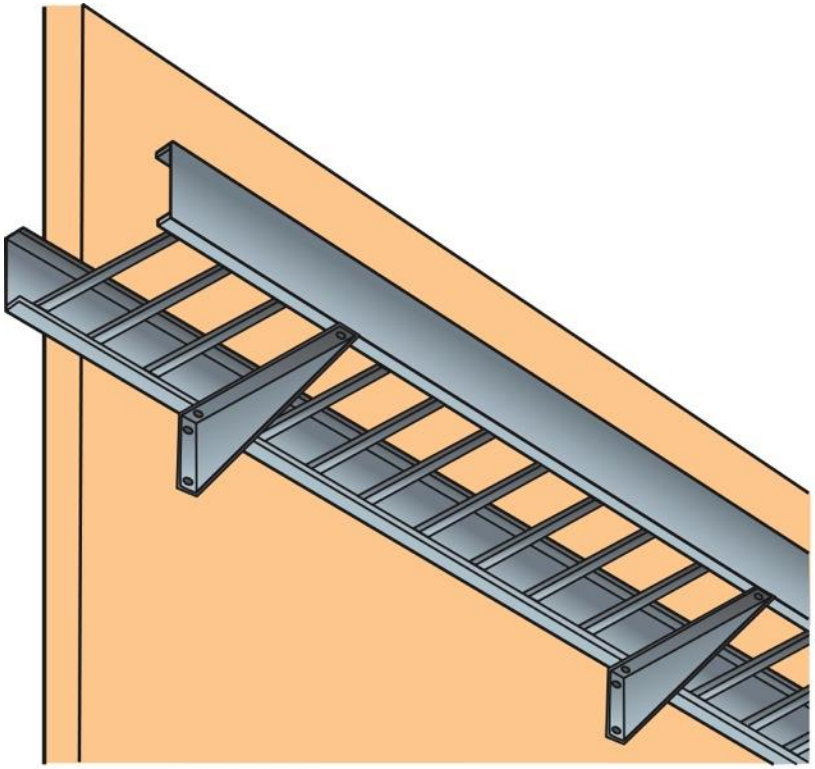


Trapeze Mounting and Center Hung Support

- Trapeze mounting is similar to direct rod suspension but uses a steel channel or strut similar to a trapeze.
- A center-hung cable tray uses a center rod and allows the cable to be easily dropped in or pulled out.



Wall Mounting; Pipe Rack Mounting; Storing Raceways; Handling Raceways



26108-14_F68.EPS

- Wall mounting uses structural supports mounted directly to the wall. It is typically found in tunnels and other underground locations with long cable runs between components.
- Pipe racks are often used to connect equipment outdoors in industrial facilities.
- Raceway components must be stored and handled carefully to prevent damage.

Ducting

Duct banks are used to safely route power underground rather than overhead.

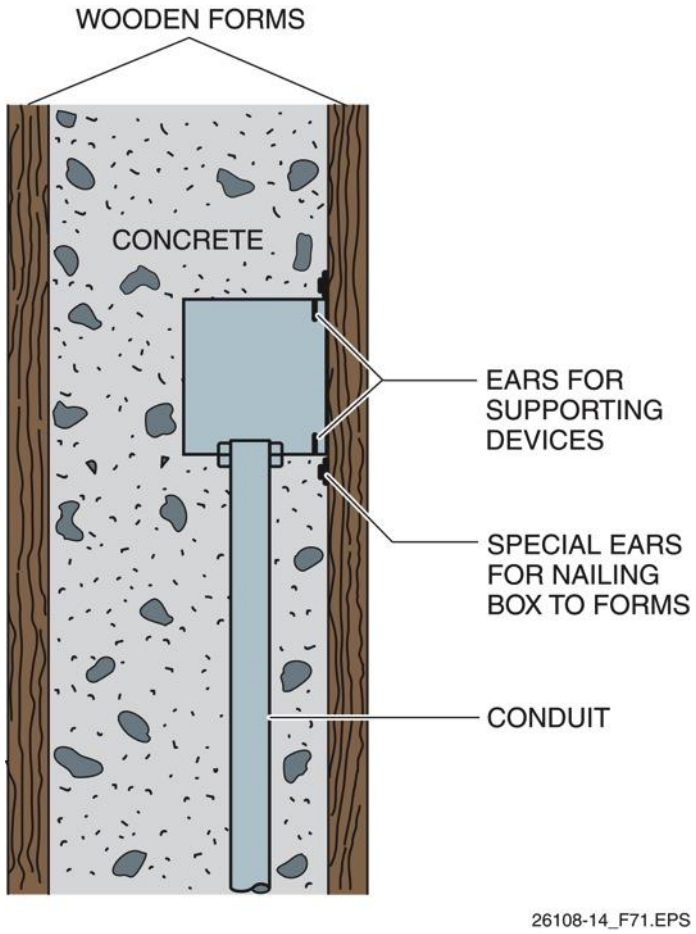
26108-14_F69.EPS

Next Sessions…

Construction Methods

- Manholes are set at intervals to provide access to underground duct runs. They are often located at intersections to provide access to cables in four directions.
- Underground duct lines can be made of fiber, tile, rigid metal or nonmetallic conduit, or poured concrete.
- Monolithic concrete is poured at the job site.
- Cable-in-duct is supplied with the conductors preinstalled.

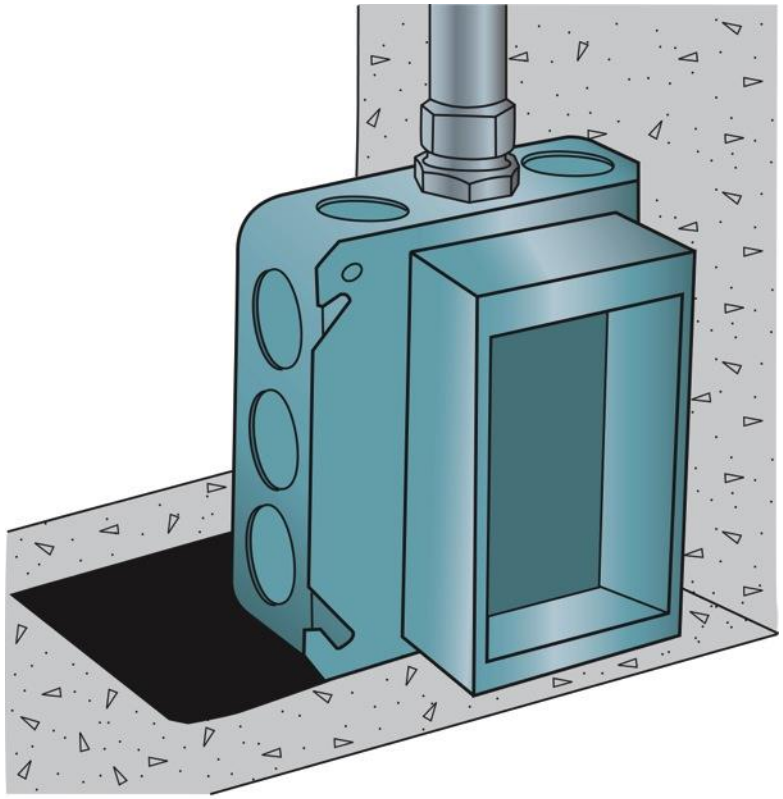
Construction Methods



- Raceway installation methods vary by the type of construction.
- Concrete boxes are nailed to wooden forms for embedding in the concrete when it is poured.

Box with Raised Ring

- When installing boxes flush in masonry construction, the electrician should work closely with the mason laying the blocks. The boxes are made up when the blocks reach the outlet elevation.
- Smaller boxes may require extension rings to bring them flush with the masonry surface.



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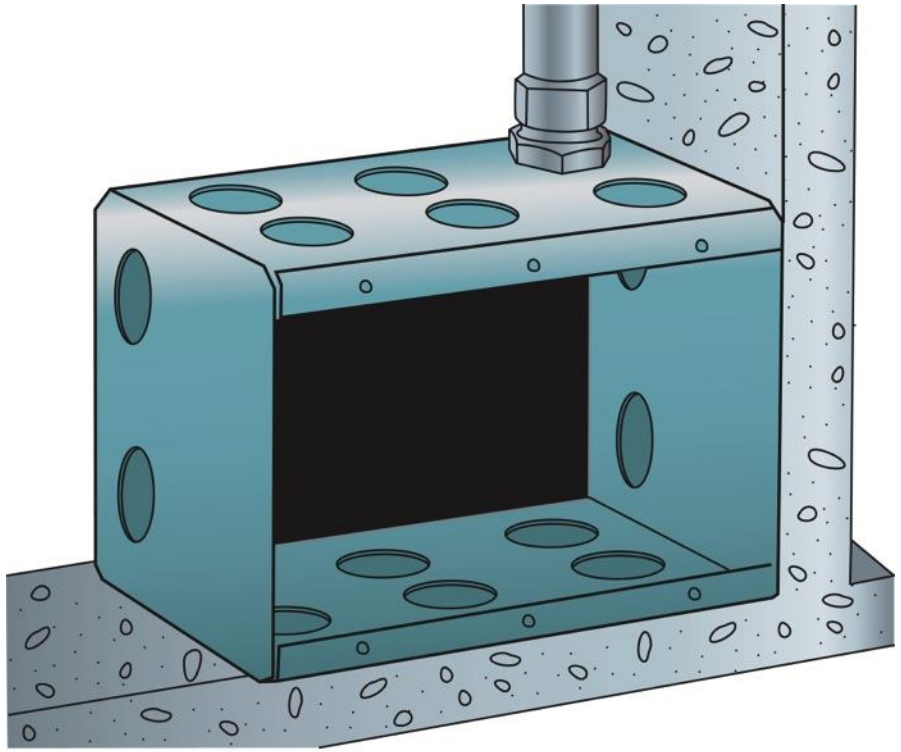
Three-Gang Concrete Box

Larger boxes do not require extension rings to bring them flush with the masonry surface.



26108-14_F73.EPS

Metal Stud Environment

- Wiring in a metal stud environment is easier than wiring in concrete or masonry.
- Metal studs often include pre-punched holes for routing conductors. If not, a hole can be easily punched in the desired location.

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NM Cable Protected by Grommets

NM cable must be protect using listed bushings or grommets.

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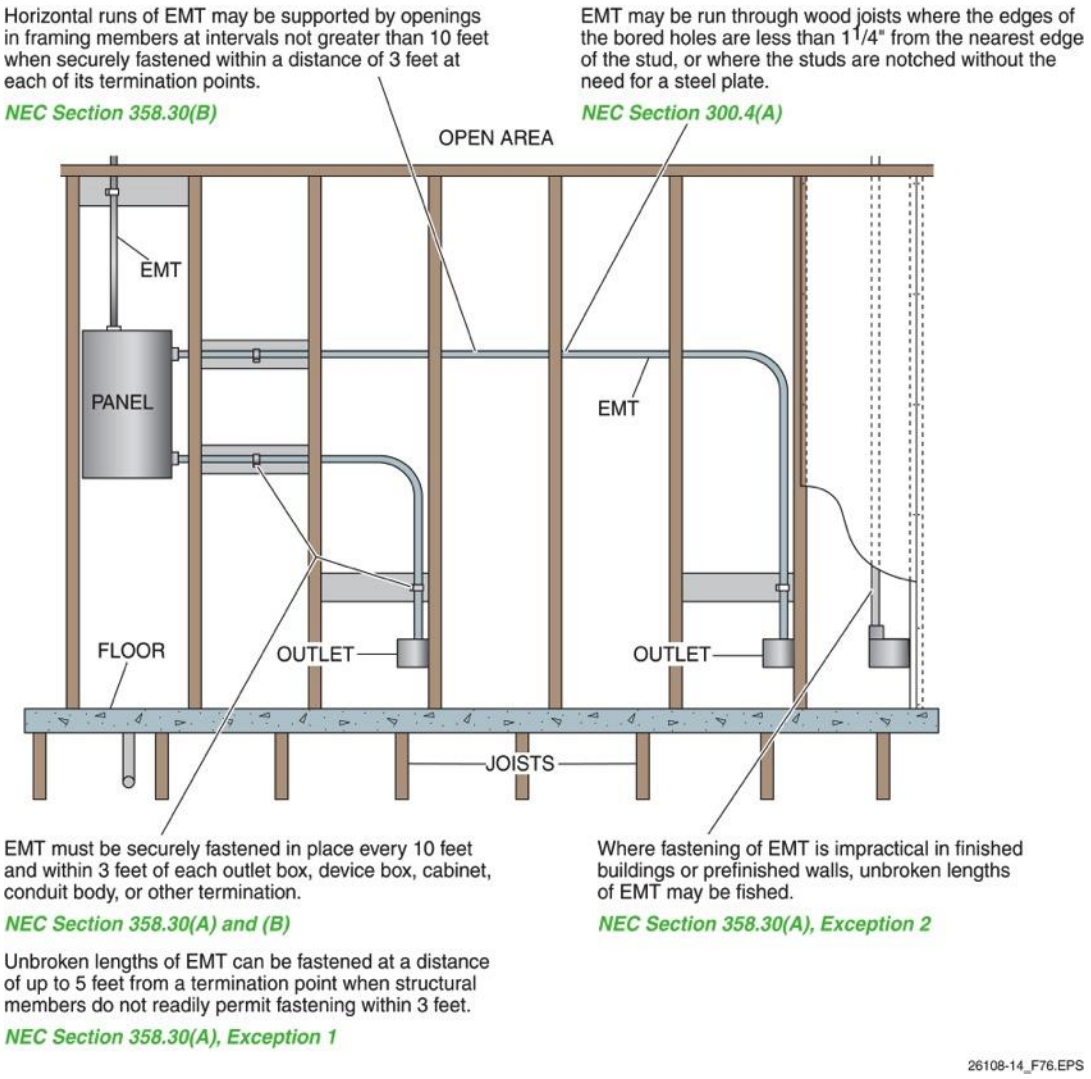
14.3.0



Wood Frame Environment

EMT can be run through wooden members using either notching or boring. Boring is the preferred method.

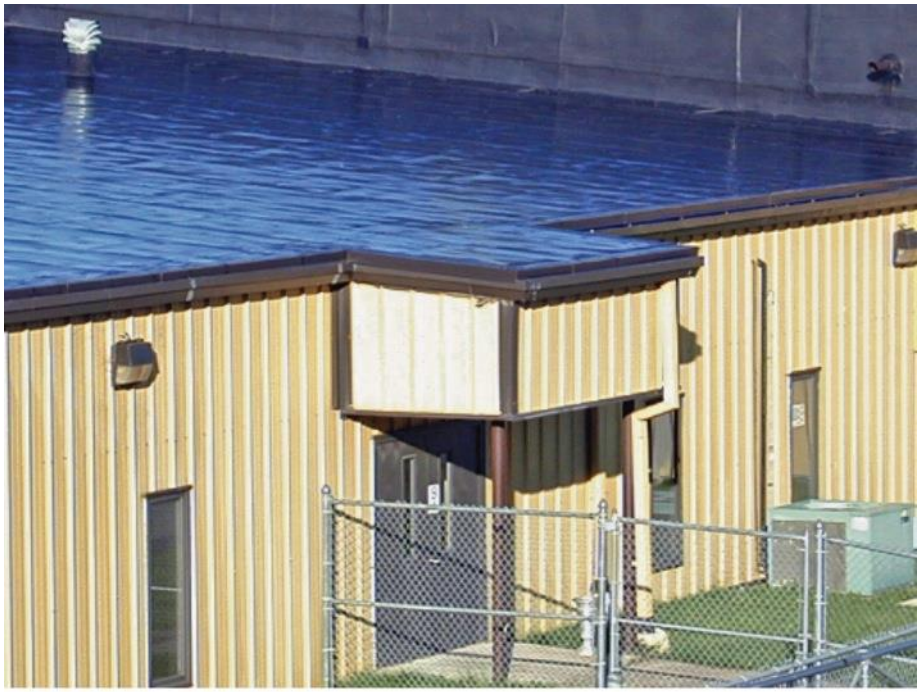
Steel Nail Plate

- A nail plate is required to protect the conductors where the wiring is installed less than 1¼" from the nearest edge.
- Nail plates are also required to protect the conductors in all wooden members.

26108-14_F77.EPS

- Conduit can be routed across the structural members that support the roof in metal building construction so long as it is no less than 1½" away from the roof decking.
- The roof structure of a metal building can consist of either beams and purlins or open-web steel joists.

Metal Buildings



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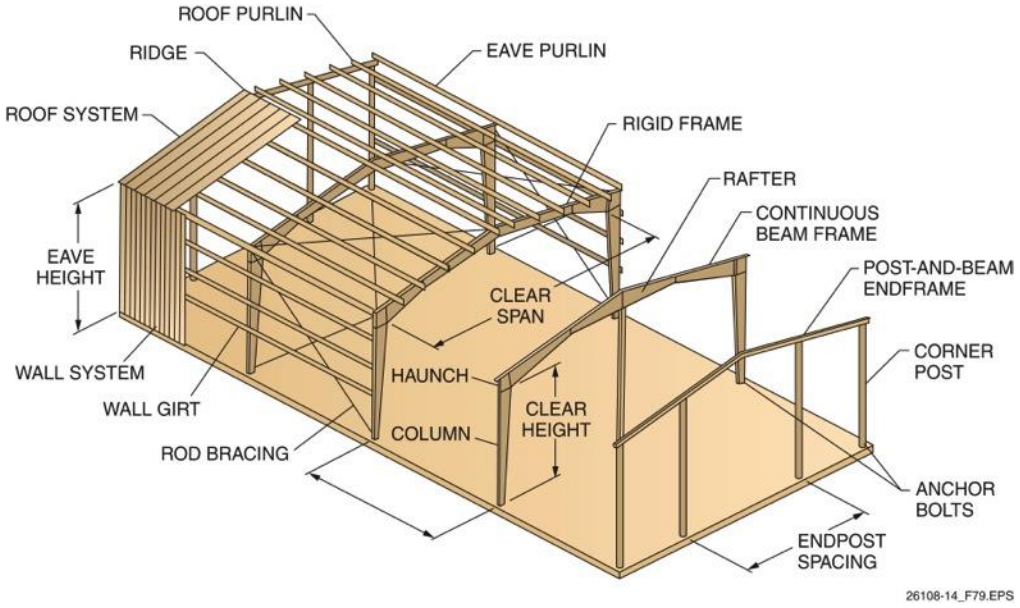
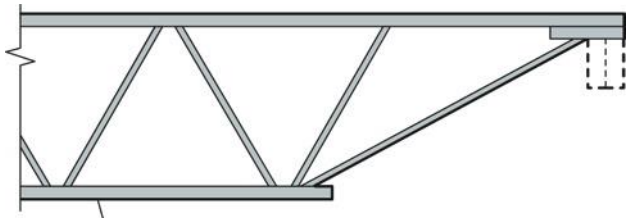
Beam and Purlin Roof System

- Beams and purlins should not be drilled. Instead, the conduit is supported from the metal beams using special anchoring devices.
- All conduit is run exposed and must be plumb, level, and neat.



Open-Web Steel Joist Roof Supports



TYPICAL OPEN-WEB STEEL JOIST

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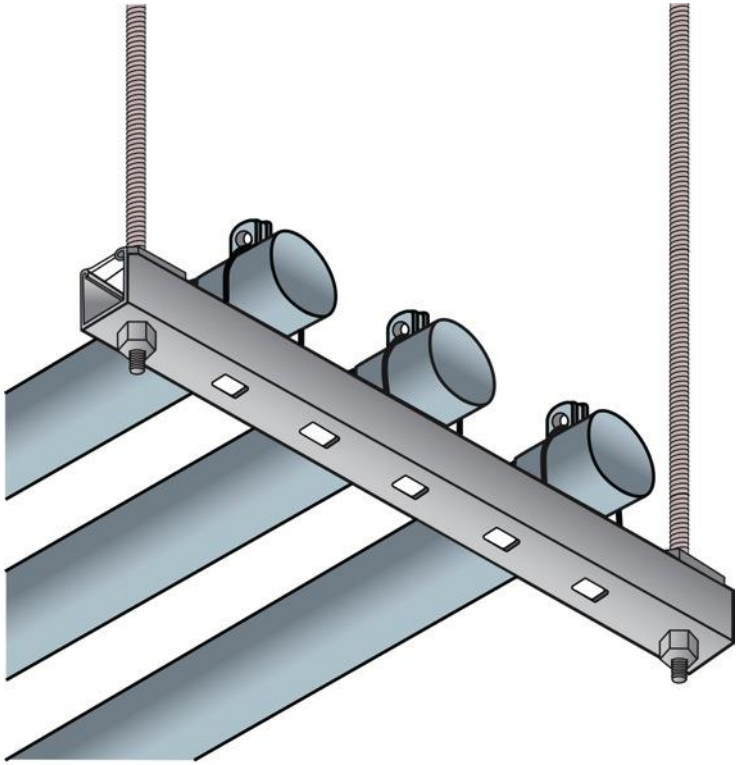
Steel Strut System

Rigid metal conduit is often required in steel building construction.



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Performance Task

This session will conclude with trainees installing a flexible raceway system.

What's wrong with this picture?

26108-14_SA14.EPS

Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.