

Electrical Level 1



Conductors and Cables 26109-14



Objectives

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

1. From the cable markings, describe the insulation and jacket material, conductor size and type, number of conductors, temperature rating, voltage rating, and permitted uses.
2. Determine the allowable ampacity of a conductor for a given application.
3. Identify the *NEC*® requirements for color coding of conductors.
4. Install conductors in a raceway system.



Performance Task

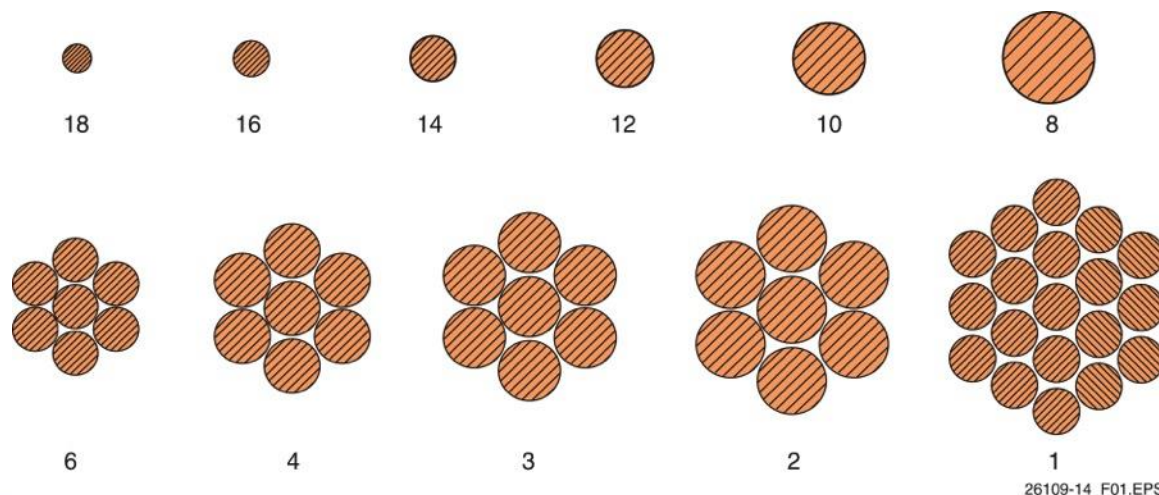
Install conductors in a raceway system.



1.0.0 – 2.1.3

Introduction; Conductors and Insulation

- Conductors are identified by size and insulation material.
- The size refers to the cross-sectional area of the current-carrying portion of the wire and is expressed in American Wire Gauge (AWG) numbers.
- Conductor ampacity is affected by the conductor material and size, insulation, and installation location.



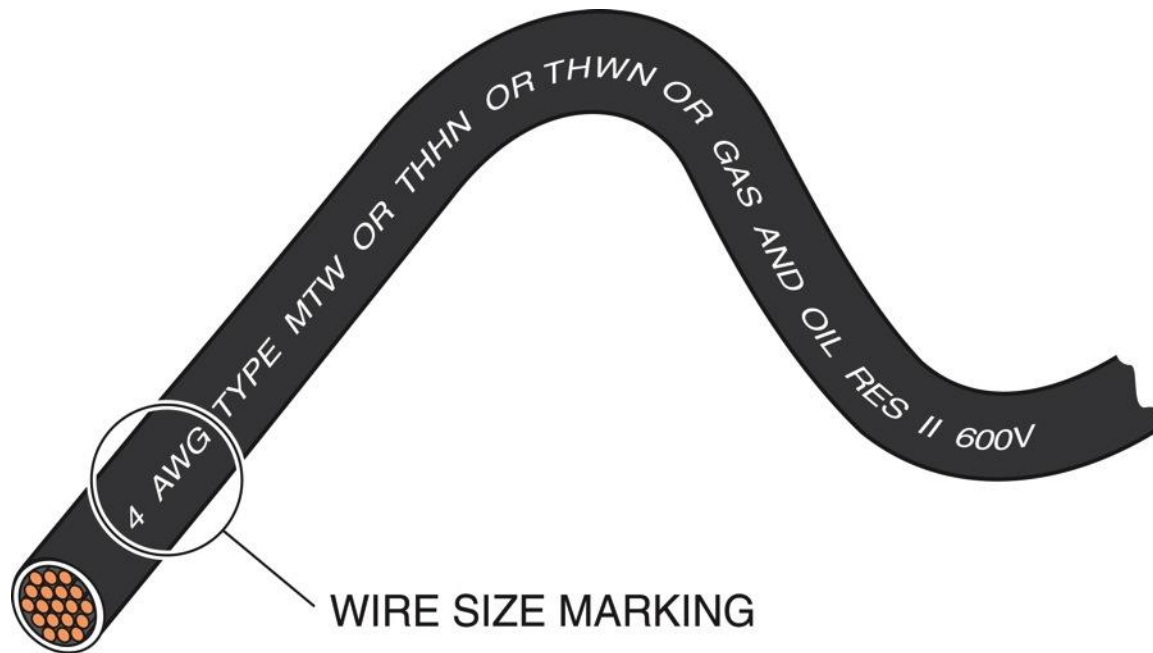
26109-14_F01.EPS



1.0.0 – 2.1.3

Wire Size Marking

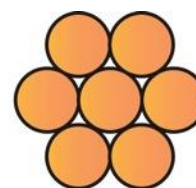
For wire sizes larger than No. 16 AWG, the wire size is marked on the conductor insulation.



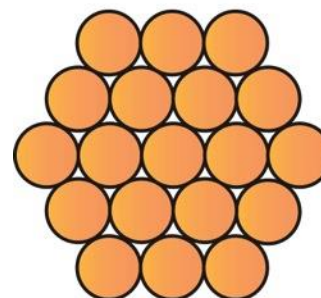
26109-14_F02.EPS

Strand Configurations

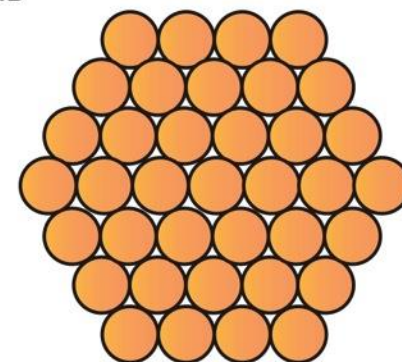
- Wire stranding provides conductor flexibility for pulling.
- Wire sizes No. 18 to No. 2 have 7 strands.
- Wire sizes No. 1 to 4/0 have 19 strands.
- Wire sizes 250 kcmil to 500 kcmil have 37 strands.
(A kcmil is 1,000 circular mils or 0.001 inch.)



7 STRAND



19 STRAND



37 STRAND

26109-14_F03.EPS

1.0.0 – 2.1.3

Aluminum Conductors

Aluminum conductors are designed with compact (compressed) stranding.



26109-14_F04.EPS

Conductors and Cables 26109-14



2.2.0 – 2.4.5

Ampacity; Conductor Material; Conductor Insulation

Table 1 Insulation Coding

Letter	Description
B	Braid
E	Ethylene or Entrance
F	Fluorinated or Feeder
H	Heat-Rated or Flame-Retardant
N	Nylon
P	Propylene
R	Rubber
S	Silicon or Synthetic
T	Thermoplastic
U	Underground
W	Weather-Rated
X	Cross-Linked Polyethylene
Z	Modified Ethylene Tetrafluoroethylene
TW	Weather-Rated Thermoplastic (60°C/140°F)
FEP	Fluorinated Ethylene Propylene
FEPB	Fluorinated Ethylene Propylene with Glass Braid
MI	Mineral Insulation
MTW	Moisture, Heat, and Oil-Resistant Thermoplastic
PFA	Perfluoroalkoxy
RHH	Flame-Retardant Heat-Rated Rubber
RHW	Weather-Rated, Heat-Rated Rubber (75°C/167°F)
SA	Silicon
SIS	Synthetic Heat-Resistant
TBS	Thermoplastic Braided Silicon
TFE	Extended Polytetrafluoroethylene
THHN	Heat-Resistant Thermoplastic
THHW	Moisture and Heat-Resistant Thermoplastic
THW	Moisture and Heat-Resistant Thermoplastic
THWN	Weather-Rated, Heat-Rated Thermoplastic with Nylon Cover
UF	Underground Feeder
USE	Underground Service Entrance
XHH	Thermoset
XHHW	Heat-Rated, Flame-Retardant, Weather-Rated Thermoset
ZW	Weather-Rated Modified Ethylene Tetrafluoroethylene

26109-14_T01.EPS

- Ampacity is the safe current-carrying capacity of a conductor at a specified temperature rating. Conductor ampacities are given in **NEC Tables 310.15(B)(16) through 310.15(B)(21)**.
- Conductors are selected based on conductor material and the correct insulation for the application. The insulation type is typically stamped on the wire.

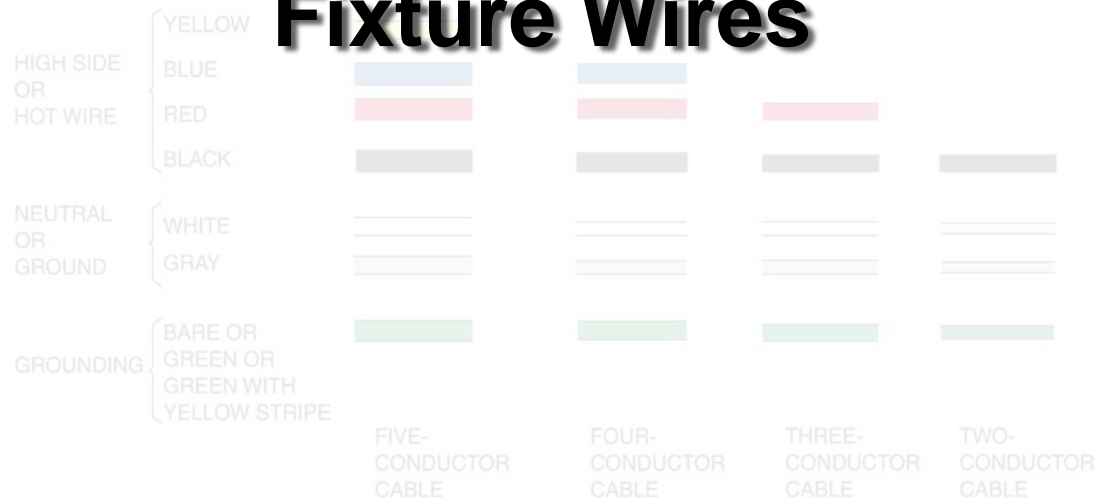


2.2.0 – 2.4.5

Next Session... Cable Insulation Color Codes

- A color code is used to help identify the individual wires in cable by the color of the insulation.
- In addition to selecting a wire of the correct size and number of conductors, wire selection must also consider the ambient temperature and termination point.

Fixture Wires



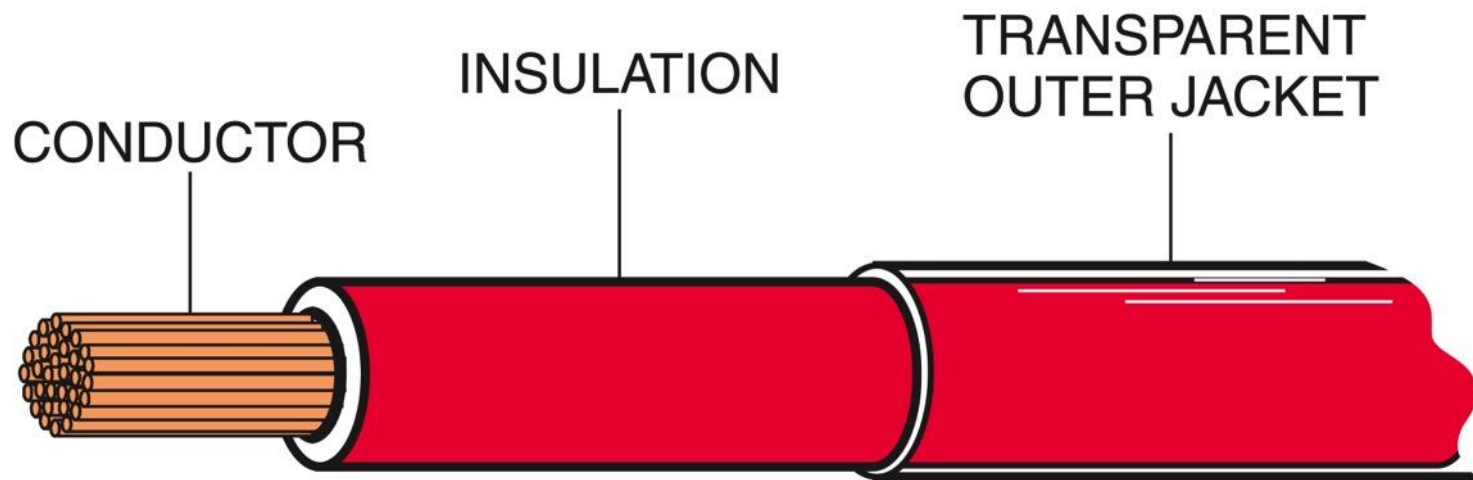
26109-14_F05.EPS



2.5.0

Fixture Wires

- Fixture wire is used to wire fixtures such as luminaires to a power source.
- Guidelines for fixture wire can be found in **NEC Article 402**.

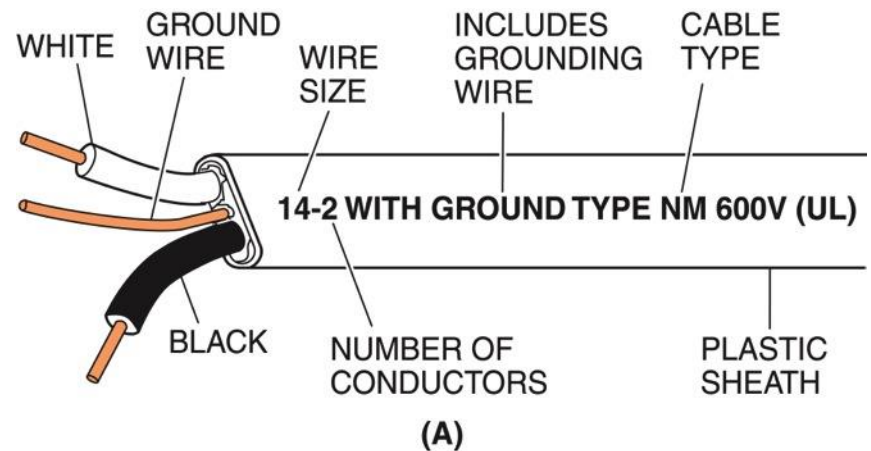


26109-14_F06.EPS

2.6.0 – 2.6.1

Cables

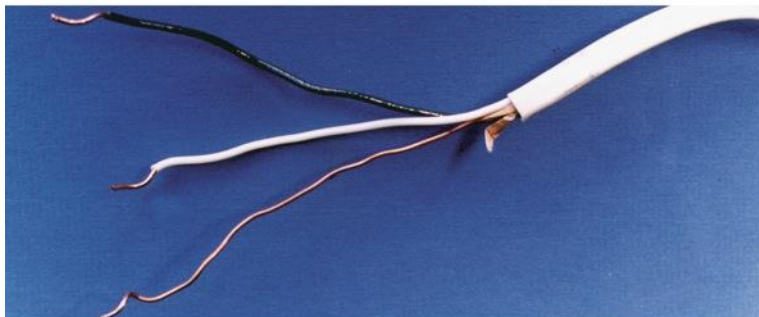
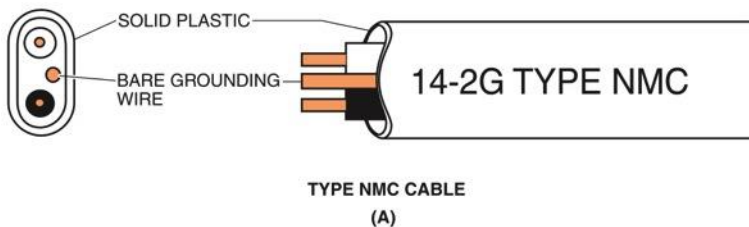
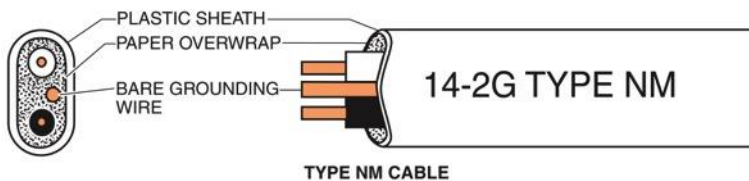
- Cables contain two or more insulated wires and may contain a grounding wire covered by an outer jacket or sheath.
- Cables are classified for use in dry, wet, or damp locations.
- Cables are marked to show the wire size, number of conductors, cable type, and voltage rating.



26109-14_F07.EPS

2.6.2 – 2.6.4

Nonmetallic-Sheathed Cable; Type UF Cable; Type NMS Cable



(B)

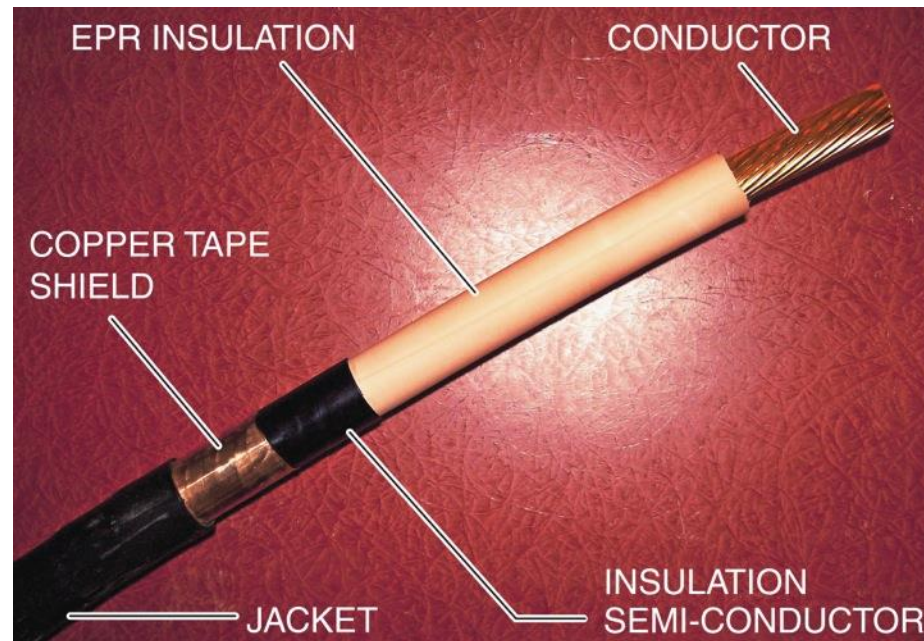
26109-14_F08.EPS

- Nonmetallic-sheathed cable (Types NM and NMC) is widely used in residential and commercial branch circuits and feeders.
- Type NMS contains power, signaling, and communications conductors in one cable.
- Guidelines for NM/NMC/NMS cable can be found in **NEC Article 334**.

2.6.5

Type MV Cable

- Medium-voltage (MV) cable is used with voltages ranging from 2,001V to 35,000V.
- Guidelines for MV cable can be found in **NEC Article 328**.



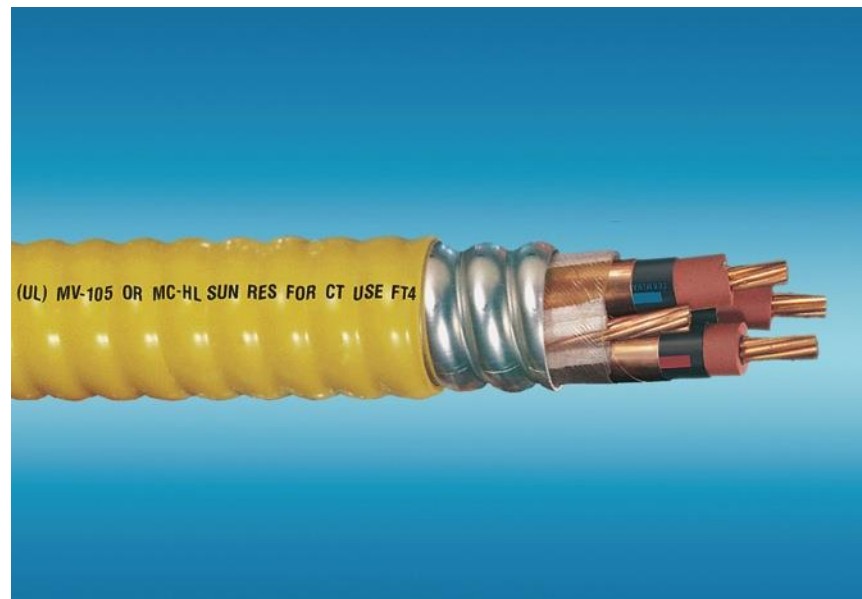
26109-14_F09.EPS



2.6.6

Type MC Cable

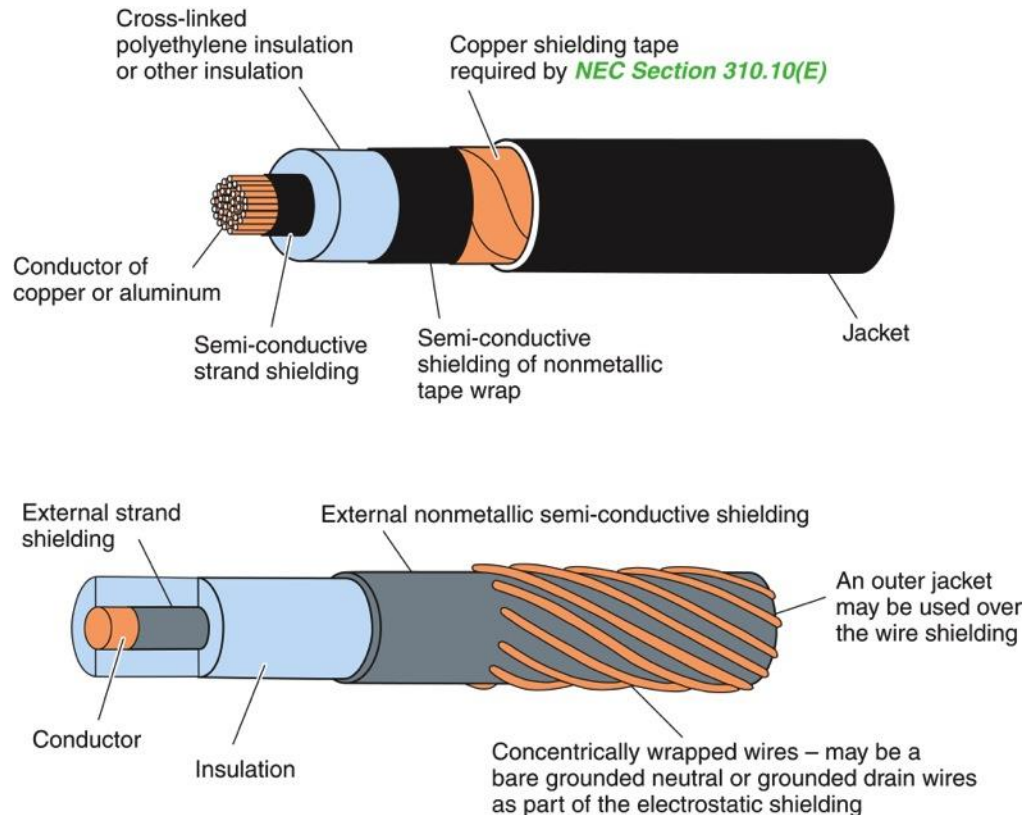
- Metal-clad (MC) cable contains one or more insulated conductors in a flexible metal tape or metallic sheath that may be covered in a nonmetallic jacket.
- Guidelines for MC cable can be found in **NEC Article 330**.



26109-14_F10.EPS

2.6.7

High-Voltage Shielded Cable



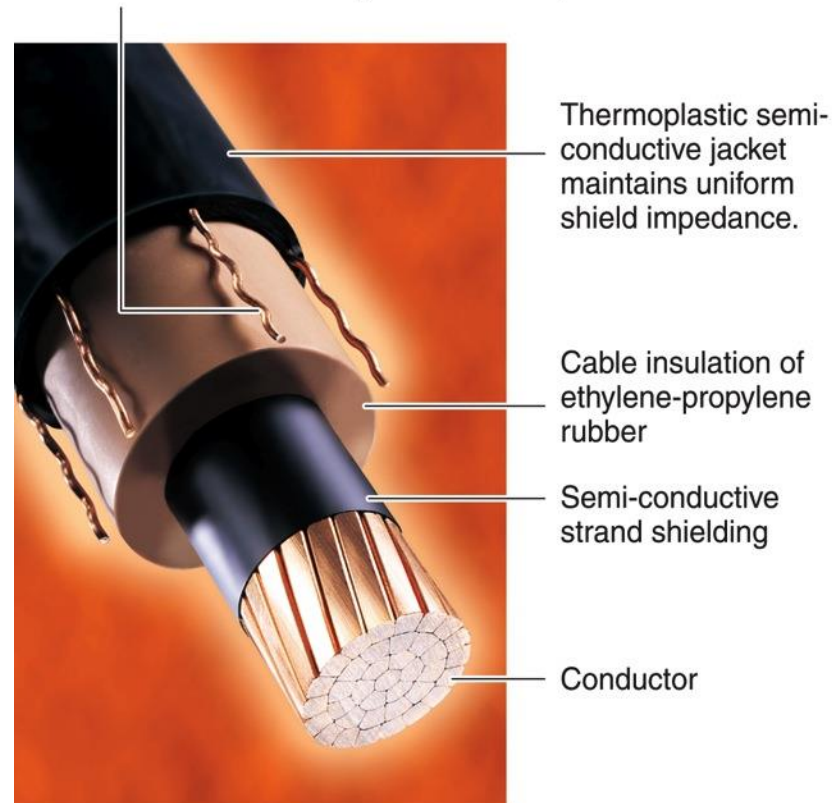
26109-14_F11.EPS

- Shielding is used with high-voltage cables to protect against surface discharge or burning due to corona discharge in ionized air.
- Various layers of shielding may be used in a single conductor.

2.6.7

Corrugated Drain Wire Shielding

Six corrugated copper drain wires embedded in semi-conductive jacket provide shielding instead of tape shield, and can be pulled out of the way (ripped out of the jacket) to allow stress cone assembly at the correct point.

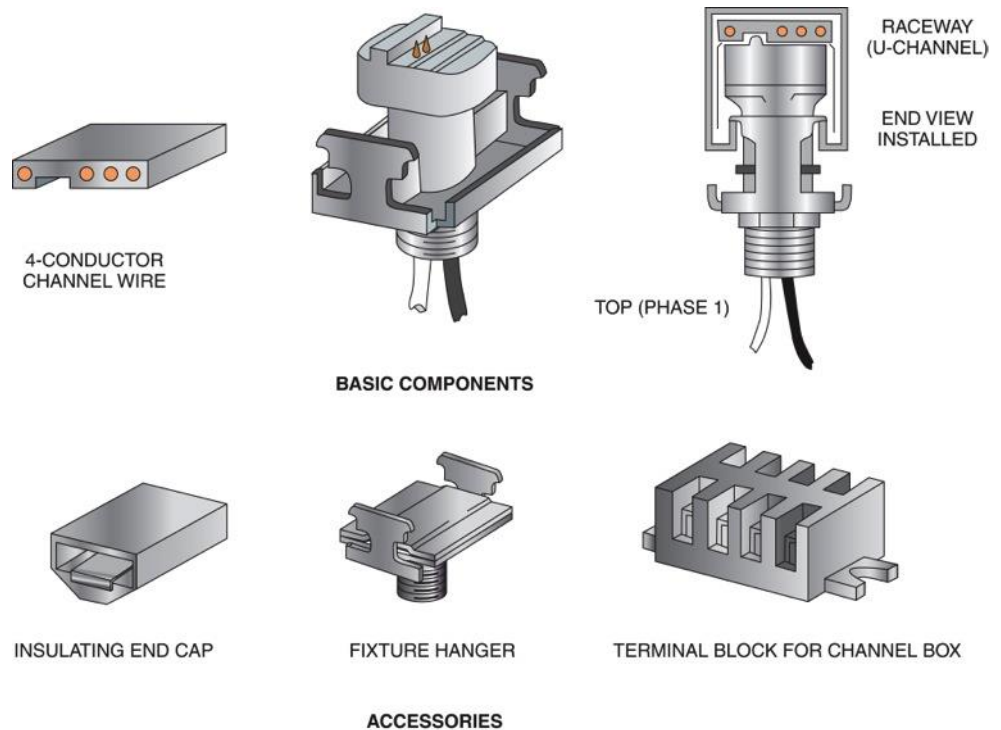


26109-14_F12.EPS

2.6.8 – 2.6.9

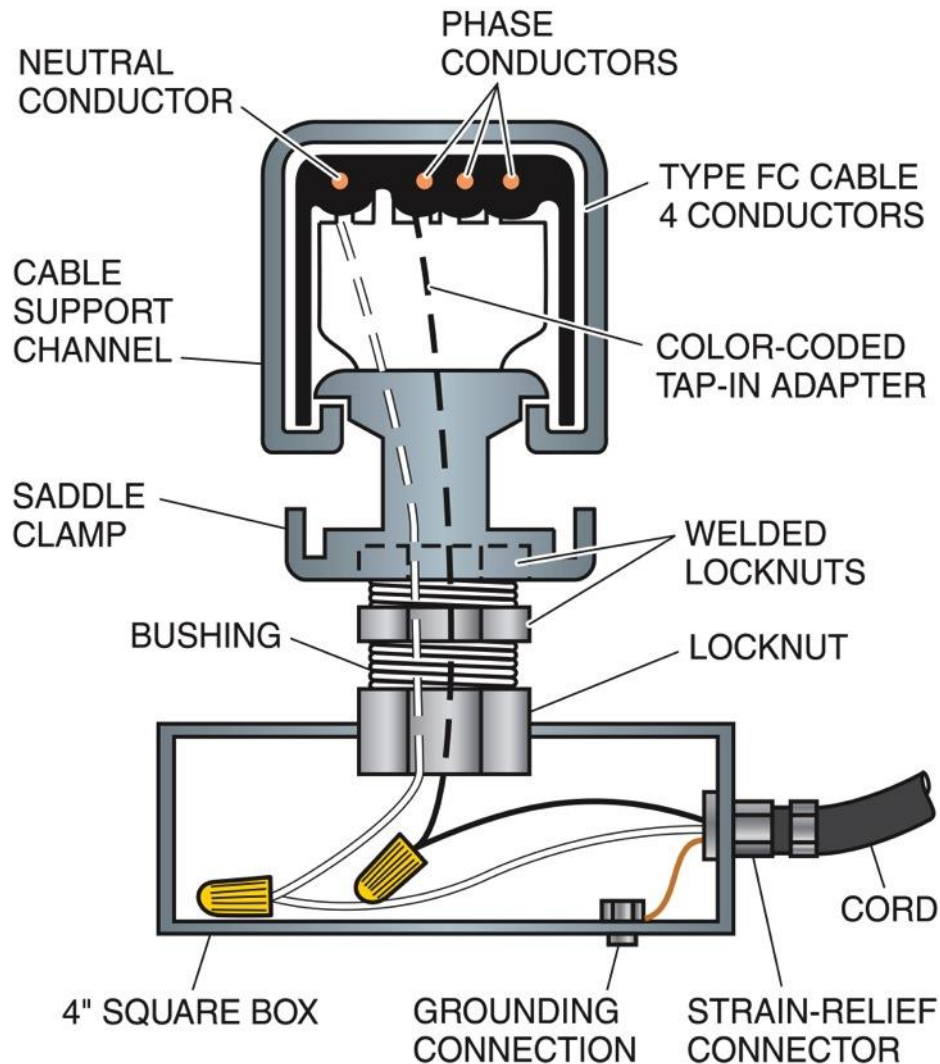
Channel Wire Assemblies

- Channel wire assemblies (Type FC) contain all of the wiring, supports, and taps in a single assembly that can be used to supply power to lighting fixtures or outlets.
- Guidelines for channel wire assemblies can be found in **NEC Article 322**.



26109-14_F13.EPS

2.6.8 – 2.6.9



26109-14_F14.EPS

Type FC Connection

- Tap devices can be inserted anywhere along the assembly.
- Channel wire assemblies are only suitable for use in exposed locations and may not be concealed under walls or ceilings.

2.6.10

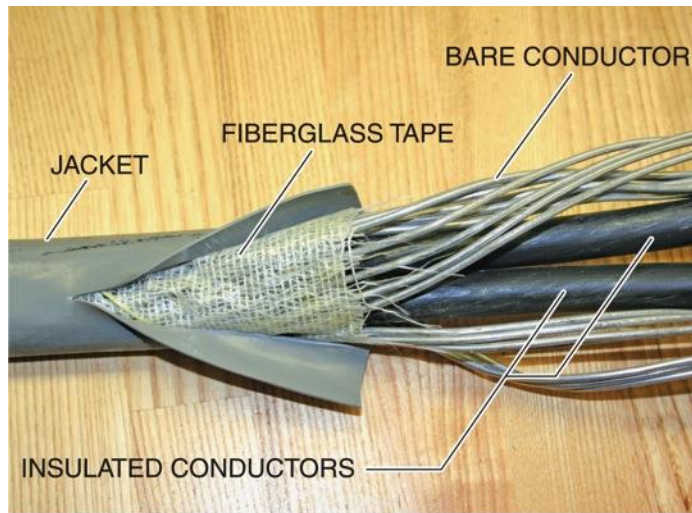
Type TC Cable



26109-14_F15.EPS

- Power and control tray (Type TC) cable contains two or more twisted conductors and is commonly used in cable tray, raceways, or underground applications.
- Guidelines for power and control tray cable can be found in **NEC Article 336**.

2.6.11

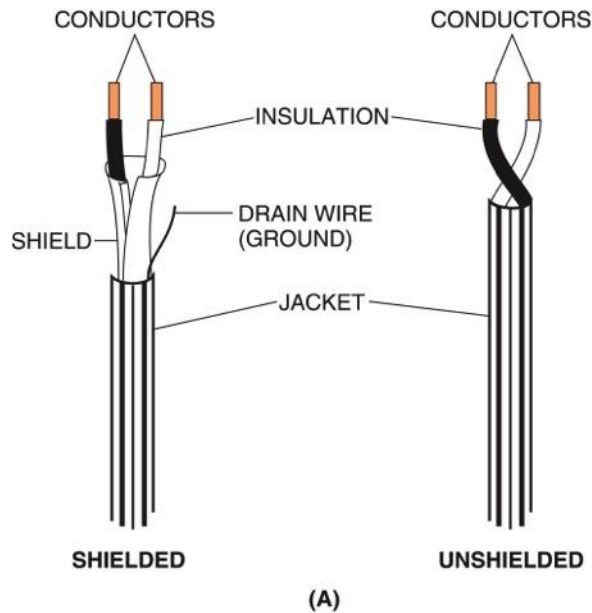


26109-14_F16.EPS

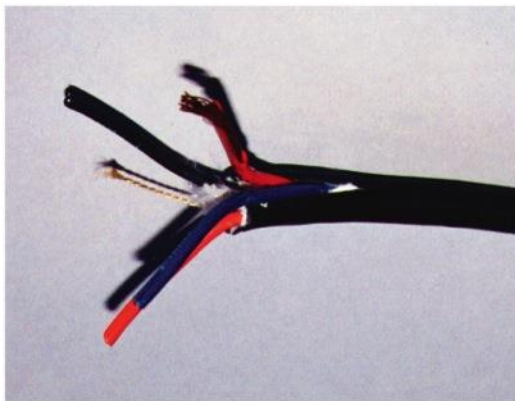
SE and USE Cable

- Where service-entrance (Type SE) or underground service-entrance (Type USE) cable is used to supply power to a service entrance, it must be installed as specified in **NEC Article 230**.
- Additional guidelines for service-entrance and underground service-entrance cable can be found in **NEC Article 338**.

2.7.0 – 2.7.3



(A)



(B)

26109-14_F17.EPS

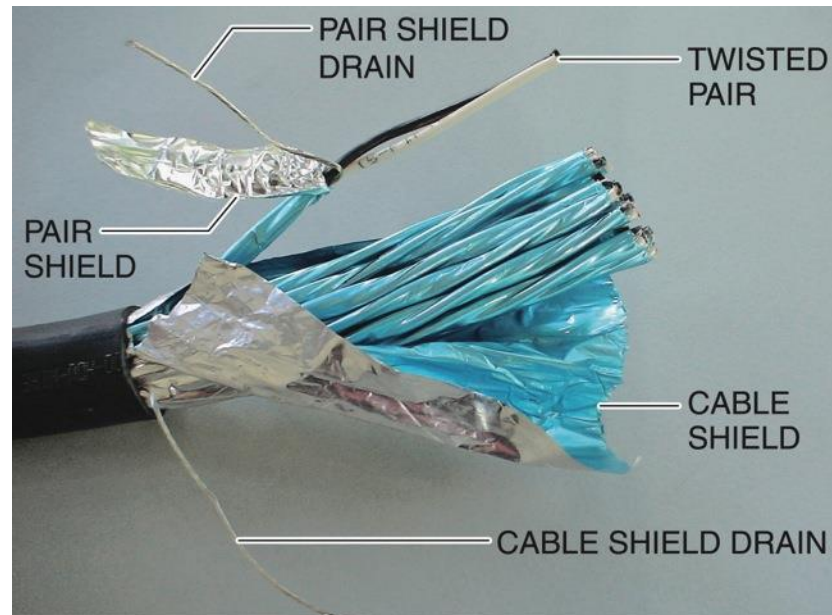
Instrumentation Control Wiring

- Instrumentation control wiring is supplied in pairs.
- A multi-pair cable typically has 12, 24, or 36 pairs of conductors.

2.7.0 – 2.7.3

Shields

- Shields are used in instrumentation cable to protect against electrical noise or interference.
- A shield drain is a bare copper wire connected at one end to carry induced charges to ground.



26109-14_F18.EPS

2.7.0 – 2.7.3

Next Session... Jackets



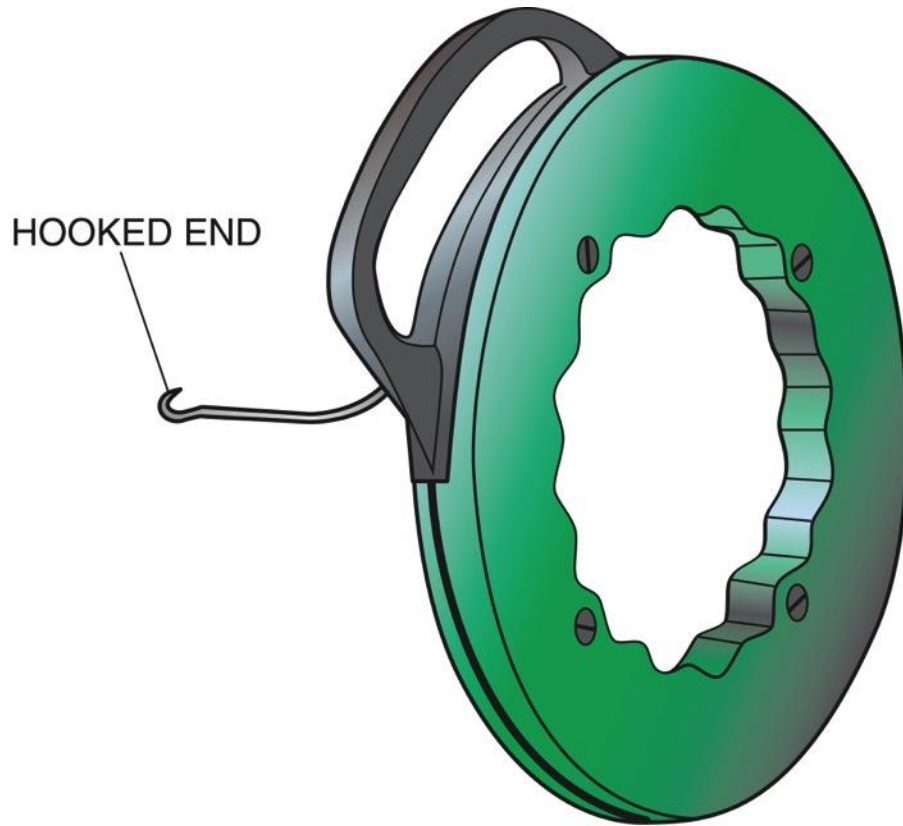
Installing Conductors in Conduit Systems

26109-14_F19.EPS

- Common insulation types for instrumentation control wiring include polyethylene (PE) and polyvinyl chloride (PVC). PE jackets include a rip cord for safer insulation removal when making terminations.

3.0.0 – 3.8.0

Installing Conductors in Conduit Systems

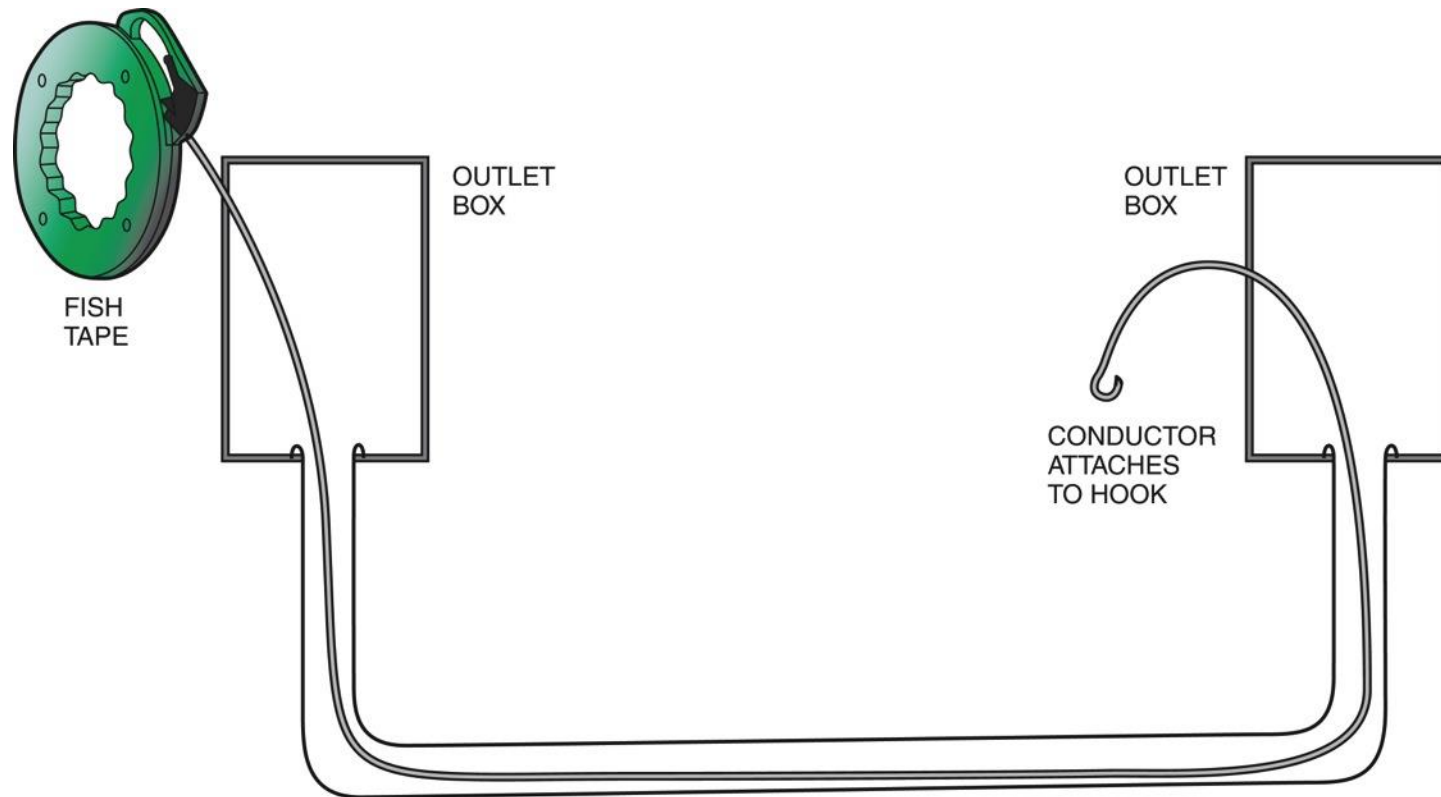


26109-14_F20.EPS

- Conductor installations are performed using fish tape, pull lines, and manual or power pulling equipment.
- Fish tape is made of flexible steel or nylon and is available in lengths between 25' and 200'.

Fish Tape Installation

Fish tape is fed between outlets or junction boxes.



26109-14_F21.EPS

3.0.0 – 3.8.0

Rodder

A rodder is a rigid fishing tool used in longer conduit runs (up to 1,000').

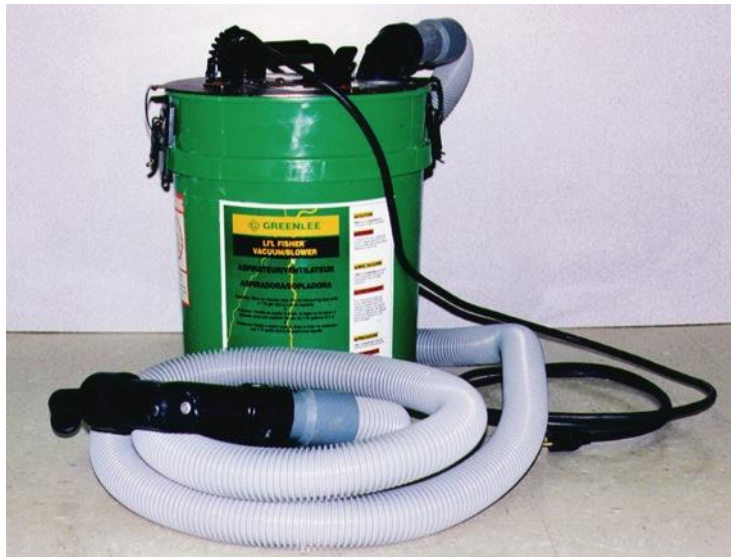


26109-14_F22.EPS

3.0.0 – 3.8.0

Power Conduit Fishing Systems

- Power fishing tools use a vacuum/blower system to either pull or push a plug and its string line through the conduit.
- A pull rope or conductor is then attached to the string line and the conductors installed.



VACUUM BLOWER UNIT



FOAM PLUGS

26109-14_F23.EPS

3.0.0 – 3.8.0

Wire Grips

- Various types of wire grips are used to attach cable to the pull tape.
- With a basket grip, the fish tape hook holds the conductor and the pull on the tape tightens the basket for a secure connection.
- Pull lines are used with difficult pulls or larger conductors.



26109-14_F24.EPS

3.0.0 – 3.8.0

Pulling Equipment

- Pulling equipment can be either manual or electrically powered.
- Follow all jobsite and manufacturer safety precautions when making cable pulls!

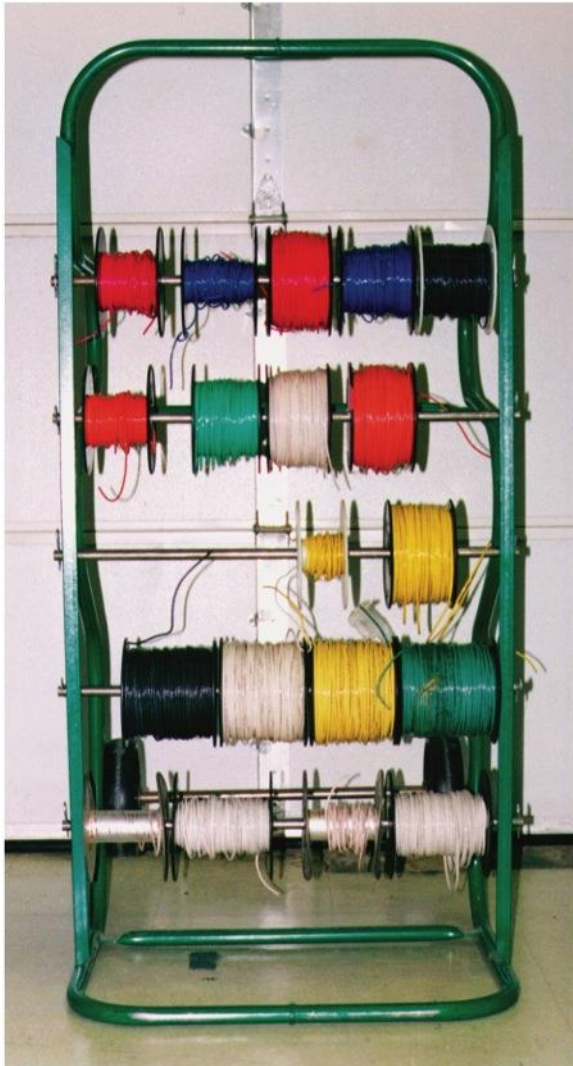


(A) MANUAL WIRE PULLER



(B) POWER PULLER

26109-14_F25.EPS



26109-14_F26.EPS

Feeding Conductors into Conduit

- A reel cart is used when several conductors are pulled at once.
- Lubricate conductors as necessary using the correct compound for the insulation type and application.

Performance Task

This session will conclude with trainees practicing installing cable in a raceway system.

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.

