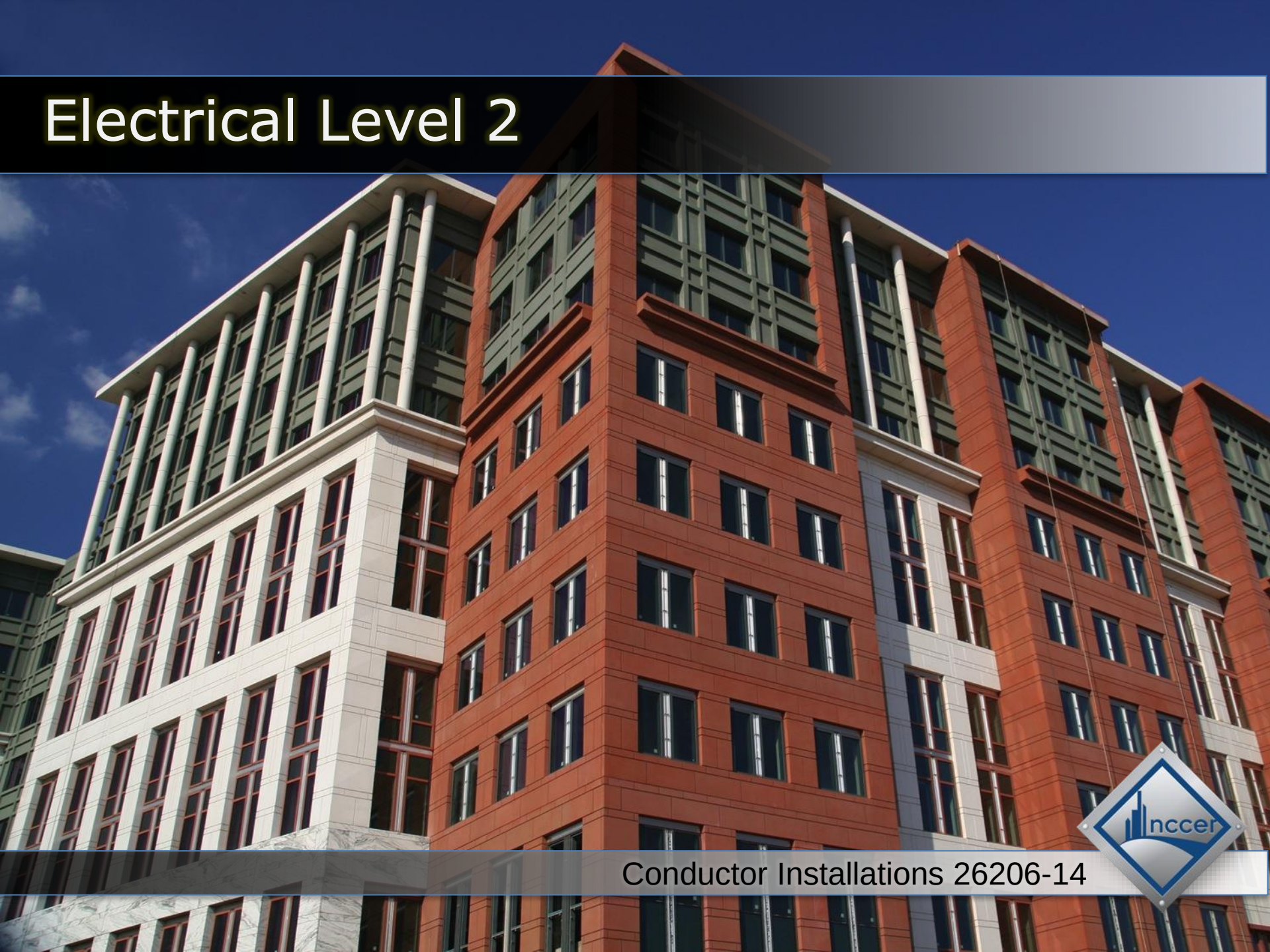
Electrical Level 2



Conductor Installations 26206-14

Objectives

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

1. Explain the importance of communication during a cable-pulling operation.
2. Plan and set up for a cable pull.
3. Set up reel stands and spindles for a wire-pulling installation.
4. Explain how mandrels, swabs, and brushes are used to prepare conduit for conductors.
5. Properly install a pull line for a cable-pulling operation.
6. Explain how and when to support conductors in vertical conduit runs.
7. Describe the installation of cables in cable trays.
8. Calculate the probable stress or tension in cable pulls.

Performance Tasks

1. Prepare multiple conductors for pulling in a raceway system.
2. Prepare multiple conductors for pulling using a wire-pulling basket.

Introduction

- There are three types of fish tape: steel, nylon, and fiberglass. Combination blower/fish tape systems can be used to simplify the installation in longer runs of conduit.
- Basket grips are used to hold the conductor to the fish tape and eliminate the need for taping wires.

26206-14_F01.EPS

Wire Dispensers

- Wire dispensers are used to keep conductors from tangling during a pull. All of the wires for the run are pulled straight off the caddy or a wall-mounted reel.
- Wheeled caddies make it easy to move large spools between pulling locations.

CABLE DISPENSER

WIRE CADDY

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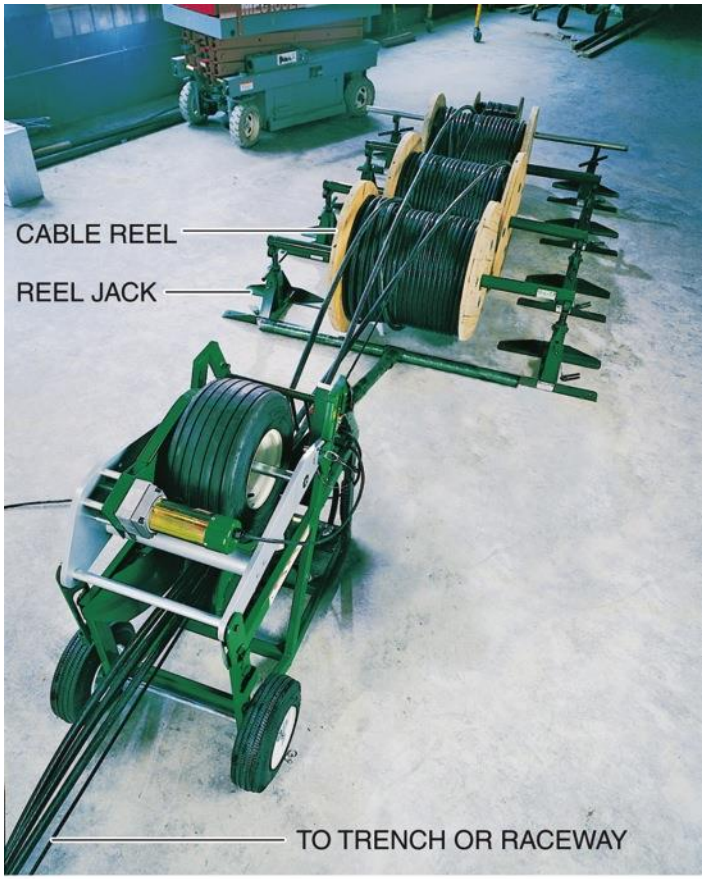
Planning the Installation

- Proper planning is critical to ensuring both safety and the success of a cable pull.
- Before pulling, the run must be measured and the cable ordered so the reel length matches the pull. Cable should be pulled from the shipping reels whenever possible to minimize damage and waste.



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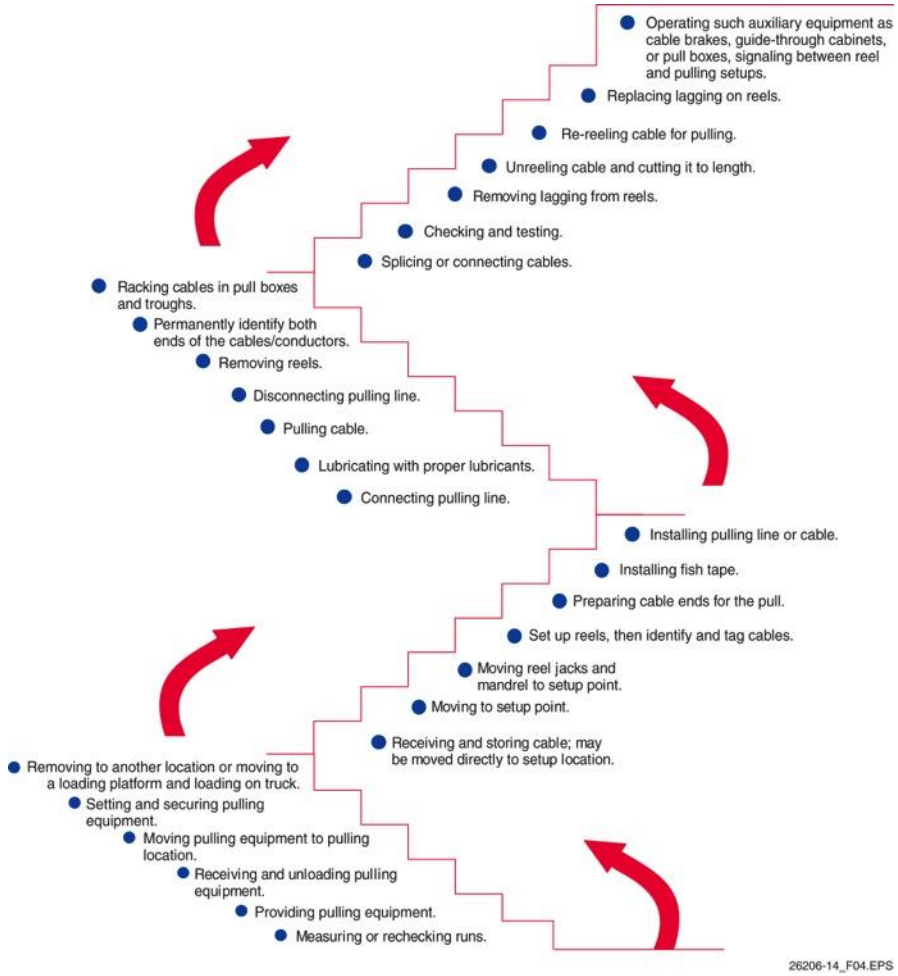
Basic Steps of a Wire-Pulling Operation



Setting Up for Wire Pulling

- An equipment checklist will save time when setting up for a cable pull.
- Different items may be needed based on the type of equipment used and the installation.

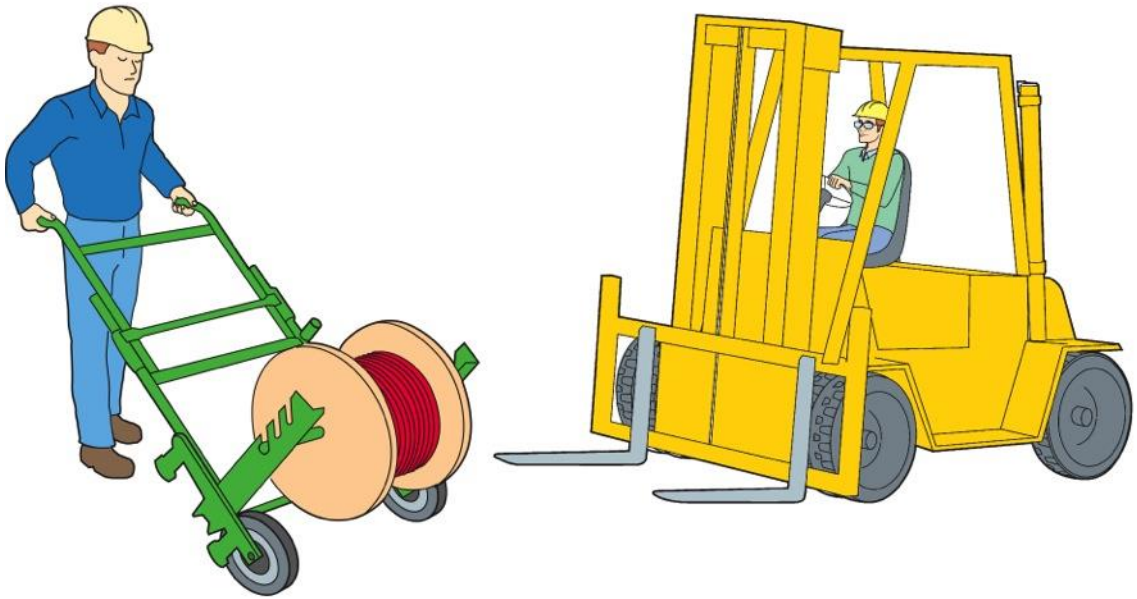
EQUIPMENT CHECKLIST

- PORTABLE ELECTRIC GENERATOR
- EXTENSION CORDS AND GFCI
- PUMP, DIAPHRAGM
- MAKEUP BLOWER AND HOSE
- MANHOLE COVER HOOKS
- WARNING FLAGS, SIGNS
- ELECTROSTATIC kV TESTER
- ELECTRIC SAFETY BLANKETS AND CLAMPS
- RADIOS OR TELEPHONES
- GLOVES
- FLOOD LAMPS
- FISH TAPE OR STRING BLOWER/VACUUM
- HAND LINE
- DUCT-CLEANING MANDRELS
- DUCT-TESTING MANDRELS
- CAPSTAN-TYPE PULLER
- SNATCH BLOCKS
- SHORT ROPES FOR TEMPORARY TIE-OFFS
- GUIDE-IN FLEXIBLE TUBING (ELEPHANT TRUNKS)
- SEVERAL WIRE ROPE SLINGS OF VARIOUS LENGTHS
- SHACKLES/ROPE CLEVIS
- GANG ROLLERS WITH AT LEAST 4' EFFECTIVE RADIUS
- HAND WINCHES
- MANHOLE EDGE SHEAVE
- PULLING ROPE
- SWIVELS
- BASKET GRIP PULLERS
- 0-1/5/10 KIP DYNAMOMETER
- REEL ANCHOR
- REEL JACKS
- CABLE CUTTERS
- LINT-FREE RAGS
- CABLE-PULLING LUBRICANTS
- PRELUBING DEVICES
- PLYWOOD SHEETS
- DIAMETER TAPE
- 50' MEASURING TAPE
- SILICONE CAULKING (TO SEAL CABLE ENDS)

26206-14_F05.EPS

Two Methods of Transporting Cable Reels

- Cable reels are very heavy and should not be lifted by hand.
- Large reels can be rolled to the pulling location or moved using a forklift. Smaller reels can be moved using a wheeled caddy or a cable reel transporter.



CABLE REEL TRANSPORTER

FORKLIFT

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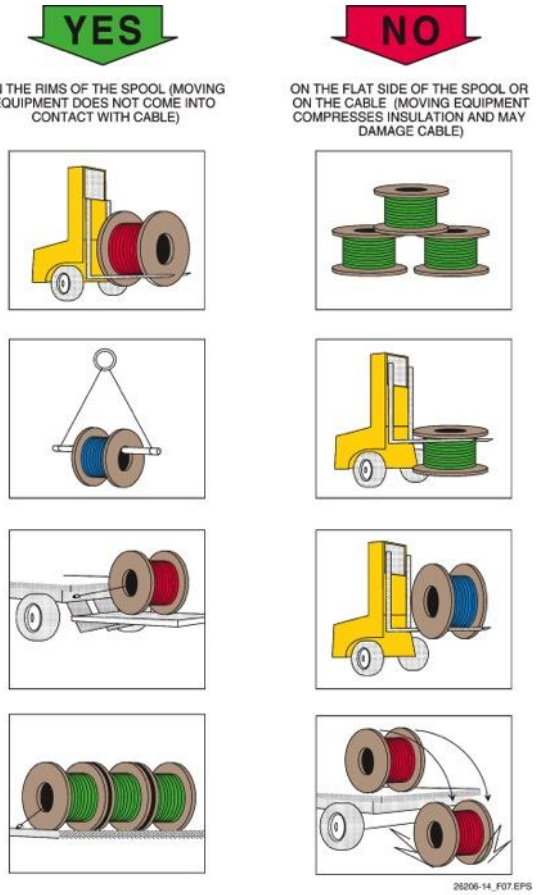
Proper and Improper Ways of Transporting Cable Reels

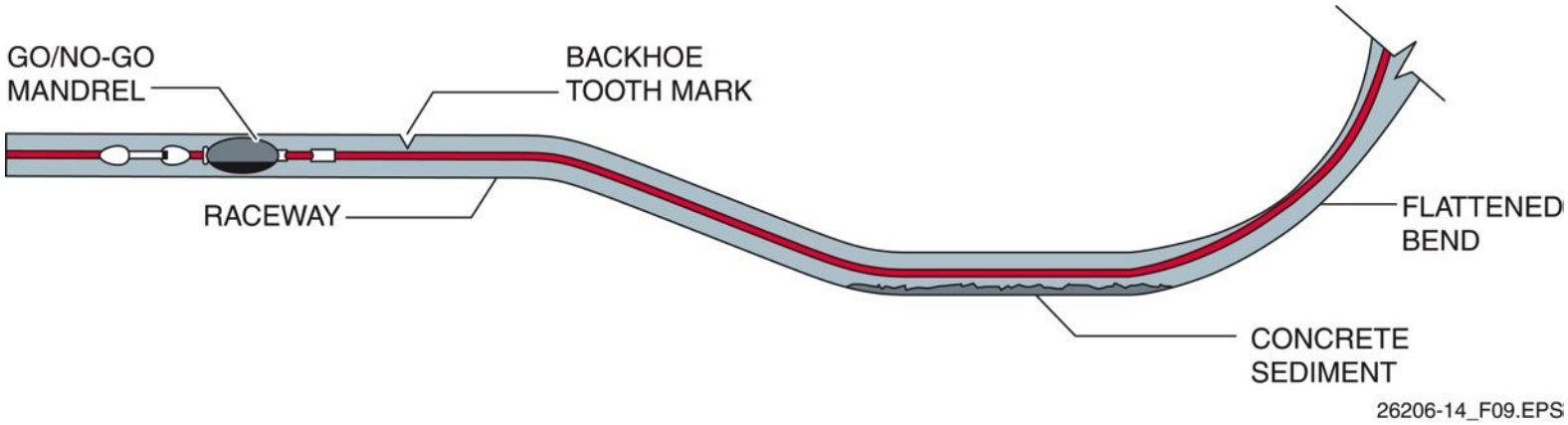


Typical Reel Stands

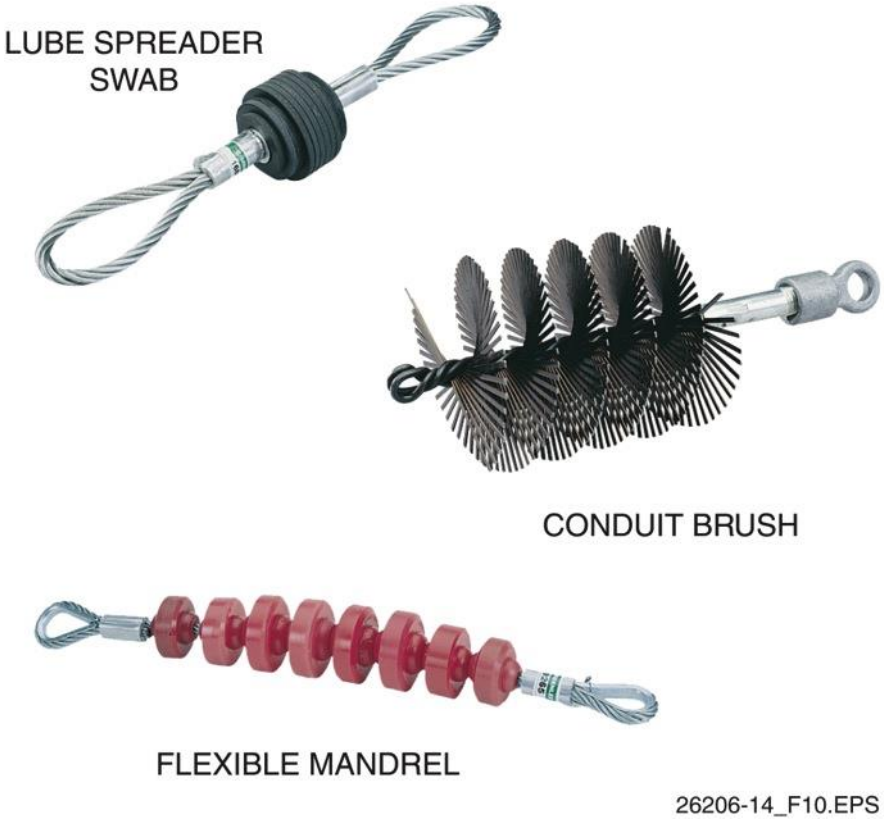
- Reel jacks are used to hold reels of cable during installation.
- Two stands and a spindle are required for each reel. The stand height can be adjusted to accommodate various reel diameters.

Faults that may be Detected with a Conduit Mandrel

- The raceway must be inspected prior to pulling to ensure that it is not blocked or damaged.
- A test pull is used to detect any obstructions prior to the pull.

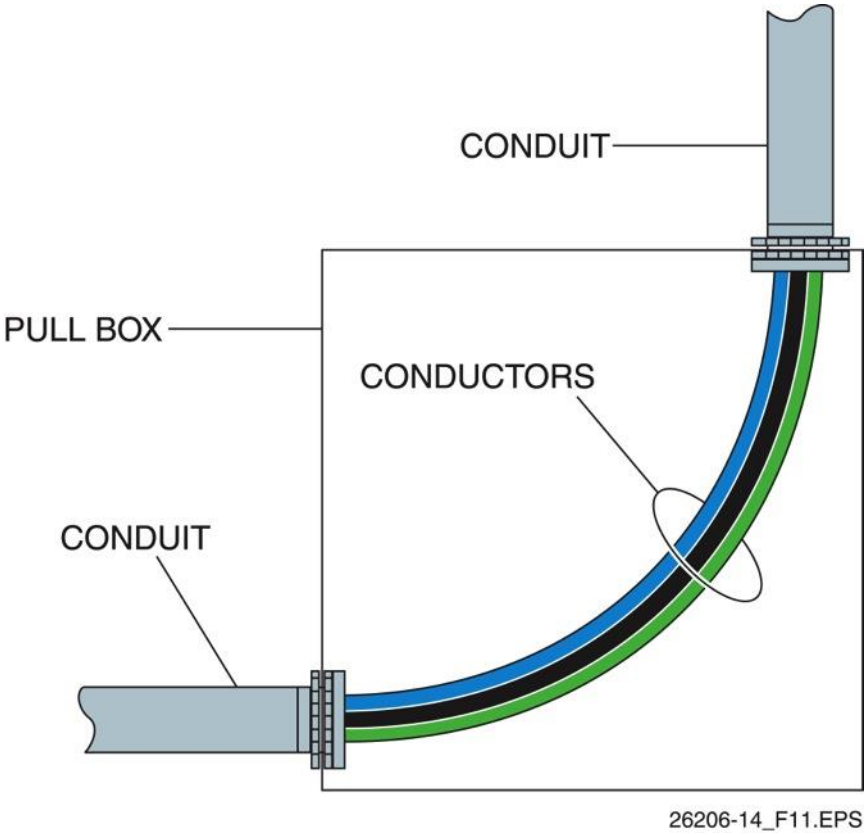


Devices Used to Inspect, Clean, and Lubricate Raceway Systems



- A mandrel is used to make a go/no-go check before pulling conductors.
- A conduit swab is used to remove debris and apply a film of pulling compound for easier pulling.
- A conduit brush can be used to remove sand and other light obstructions.

Obtaining the Greatest Possible Conductor Sweep in a Pull Box



- When measuring conductor runs, be sure to allow sufficient room through pull boxes.
- Allow the largest possible conductor sweep to eliminate sharp bends and potential damage to the conductors.

Power Fishing System

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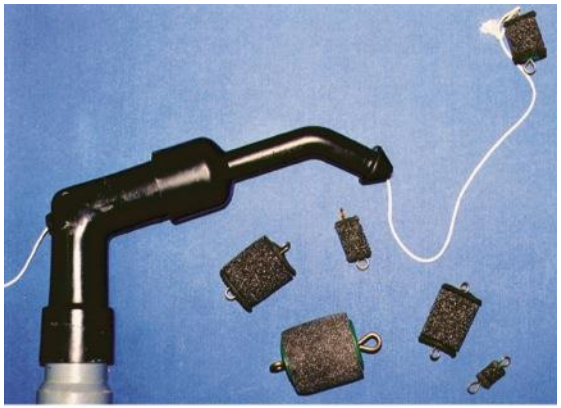

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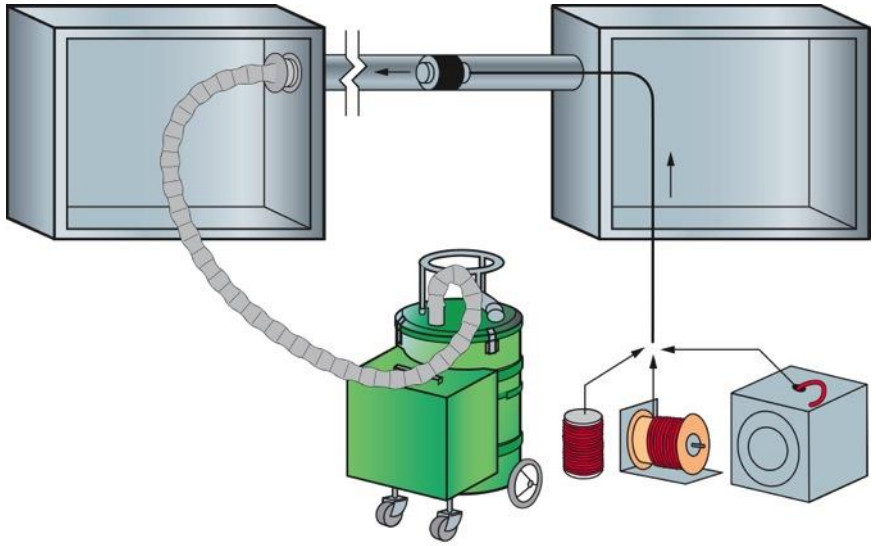
- A blower/vacuum fish tape system can be used to either blow or vacuum pull a foam piston through the conduit.
- The piston is attached to a fish tape or measuring line.



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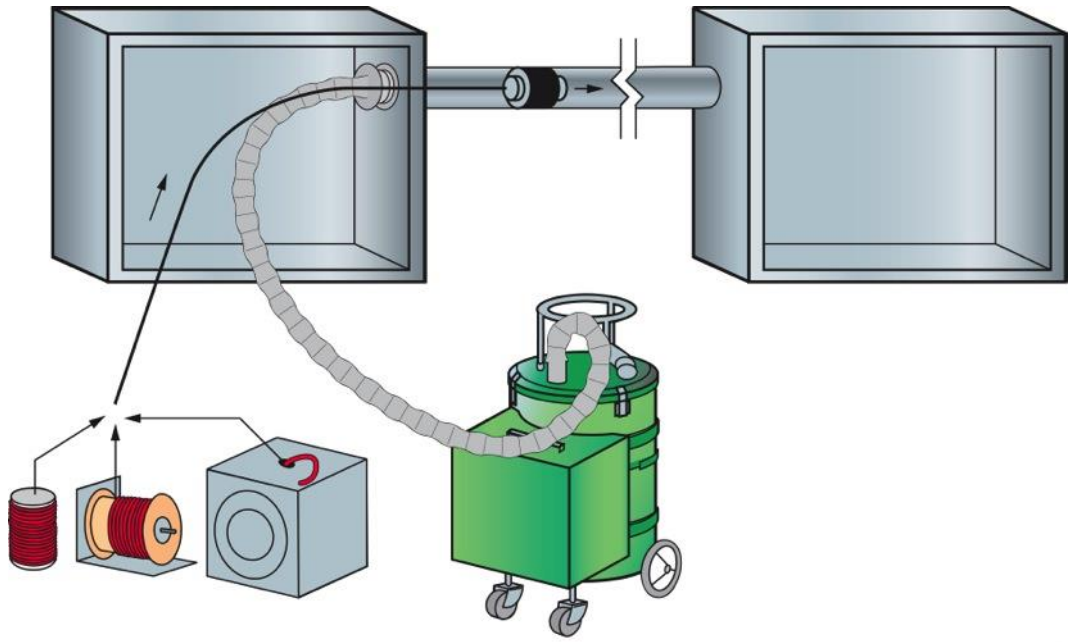
Blower/Vacuum Fish Tape System Used to Blow a Pull Line in Conduit

Most blower/vacuum systems provide enough pressure to clean dirt or water from the conduit system during the fishing operation.



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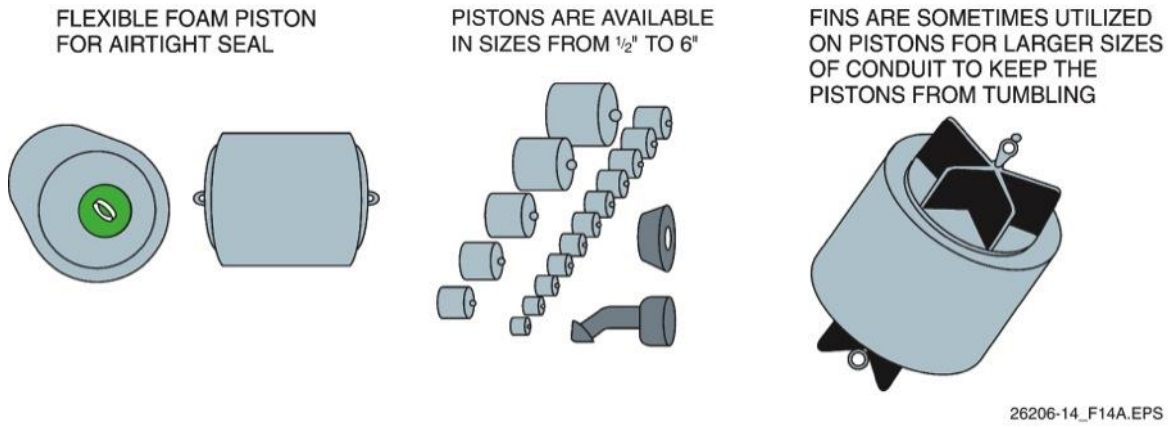
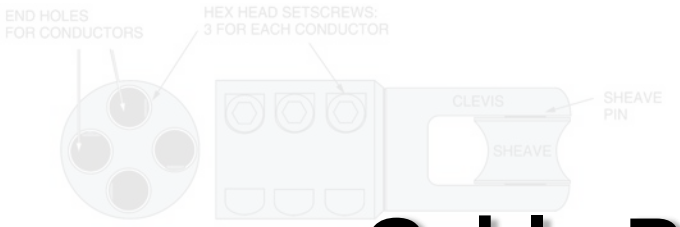
Types of Pistons in Common Use



- Blower/vacuum systems are provided with piston kits to accommodate various conduit sizes.
- Guide vanes are supplied on pistons for larger conduit.

Next Session…

Various Types of Pulling Grips Used During Conductor Installation



- The conductors must be securely attached to the pull line for safety. Basket grips are typically used on [illegible] pulls use a cable grip connection.
- All equipment used in a pull must have a working load rating in excess of the maximum force applied during the pull.

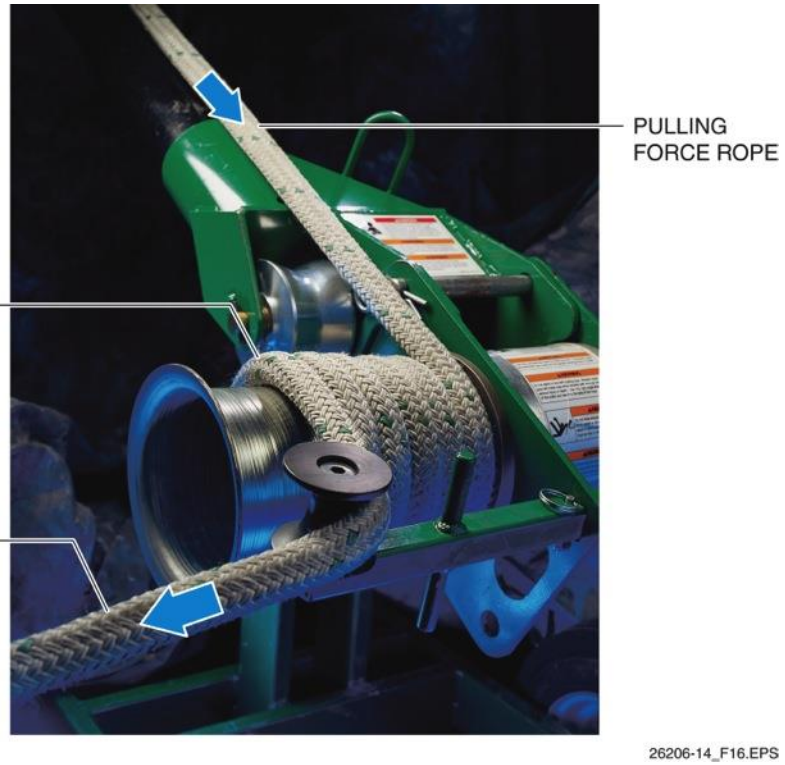
Performance Task

This session will conclude with trainees preparing multiple conductors for pulling using a wire-pulling basket.

Cable-Pulling Equipment

Cable-Pulling Equipment

- The number of wraps on the capstan determines the force of the cable pull.
- To facilitate pulling, wire lubricant is swabbed through the conduit and applied on the cable. Use lubricant compatible with the wire being pulled.



Example Pulling Forces for Various Wraps

- The pulling force and number of wraps vary by equipment model and manufacturer.
- Due to the strain on the cable, discard the wrapped portion of the cable after making a pull.

Number of Wraps	Operator Force (Lbs)	Pulling Force (Lbs)
1	10	21
2	10	48
3	10	106
4	10	233
5	10	512
6	10	1,127
7	10	2,478

(A) MECHANICAL CABLE PULLER

(B) POWER CABLE PULLERS

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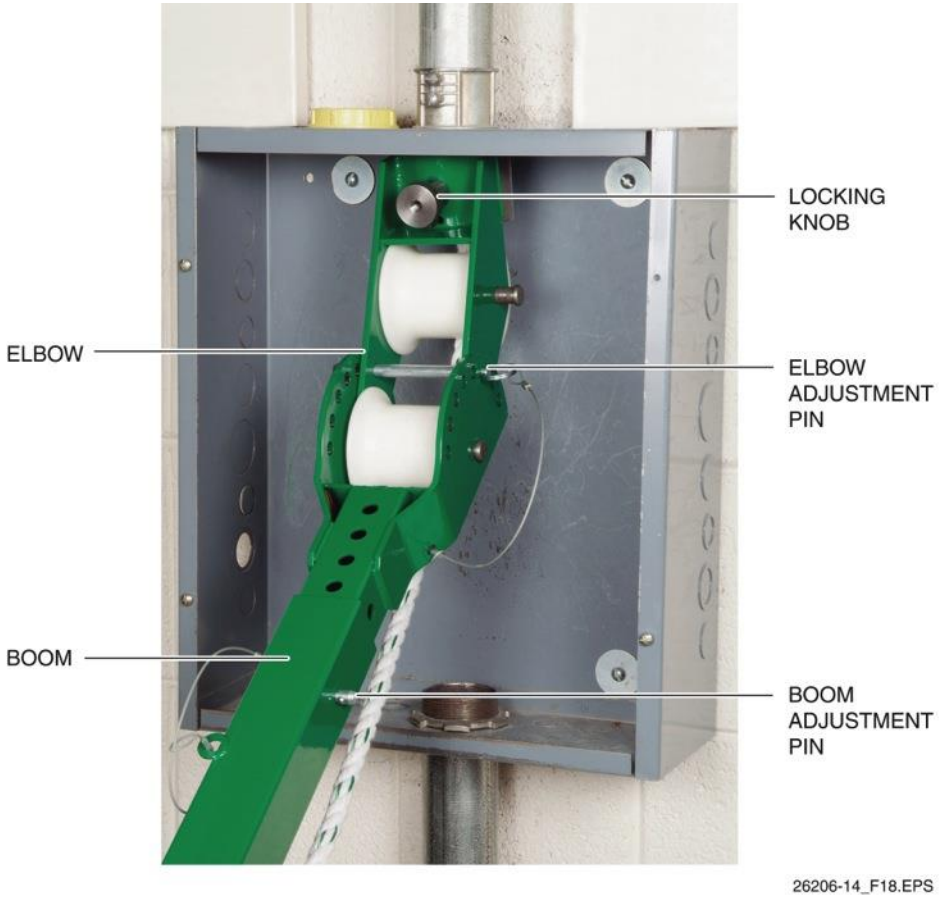
Cable Pullers

- Hand-crank wire pullers are used on small jobs with only a few cable runs.
- Power cable pullers are available in a wide variety of capacities. Cable pulling equipment must be properly anchored for safety.

Puller Setup for a Down Pull



- To set up for a down pull, adjust the elbow and boom of the puller to the correct angle and lock the elbow to the upper conduit.
- This unit has a universal conduit latch for use with multiple conduit sizes.

Puller Setup for an Up Pull

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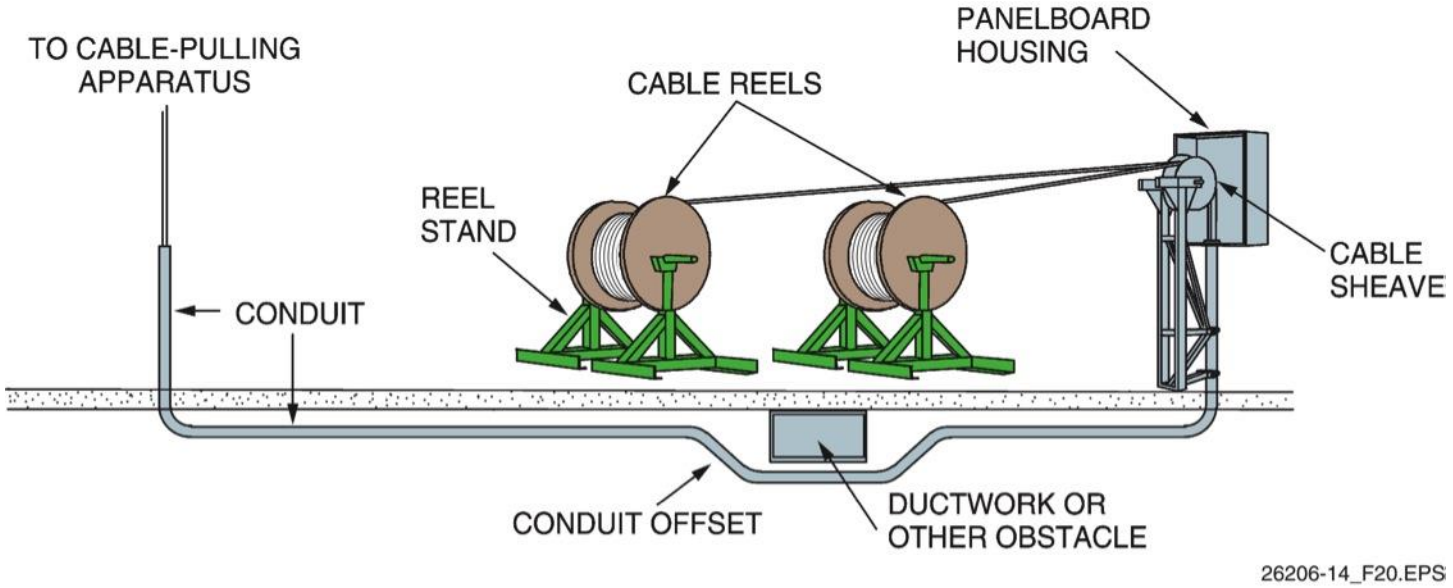
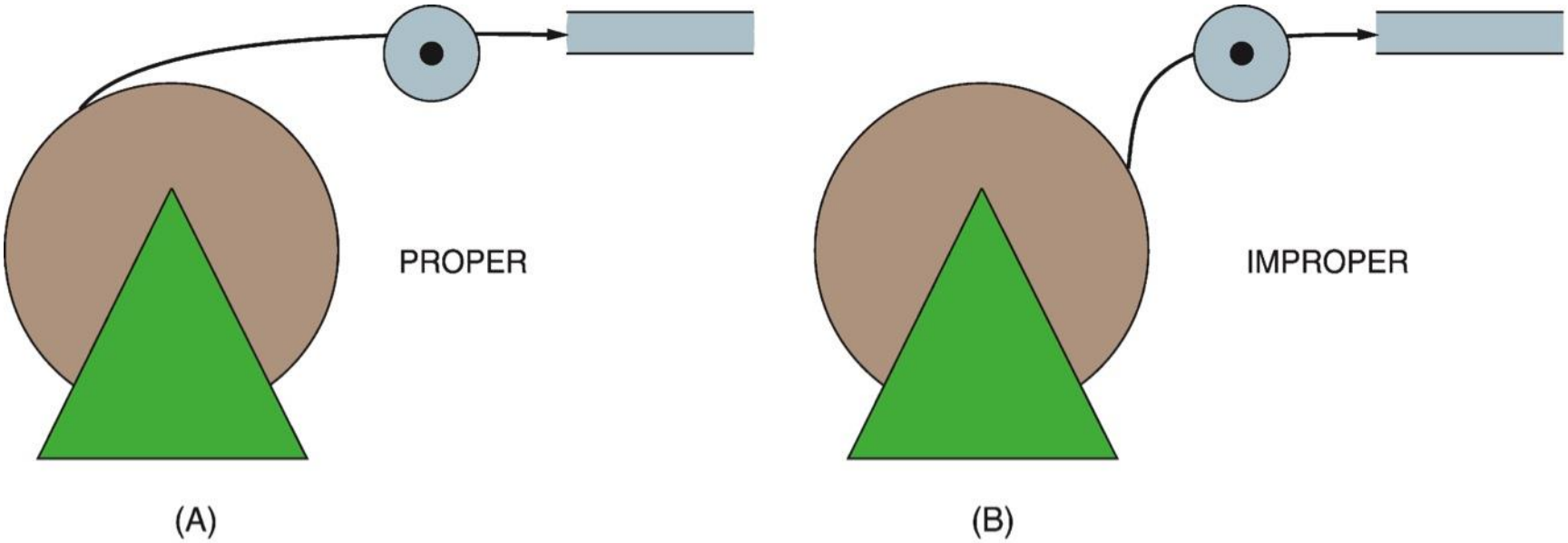
An up pull is set up in the same way as a down pull except the unit is attached to the bottom conduit.

High-Force Cable Pullers

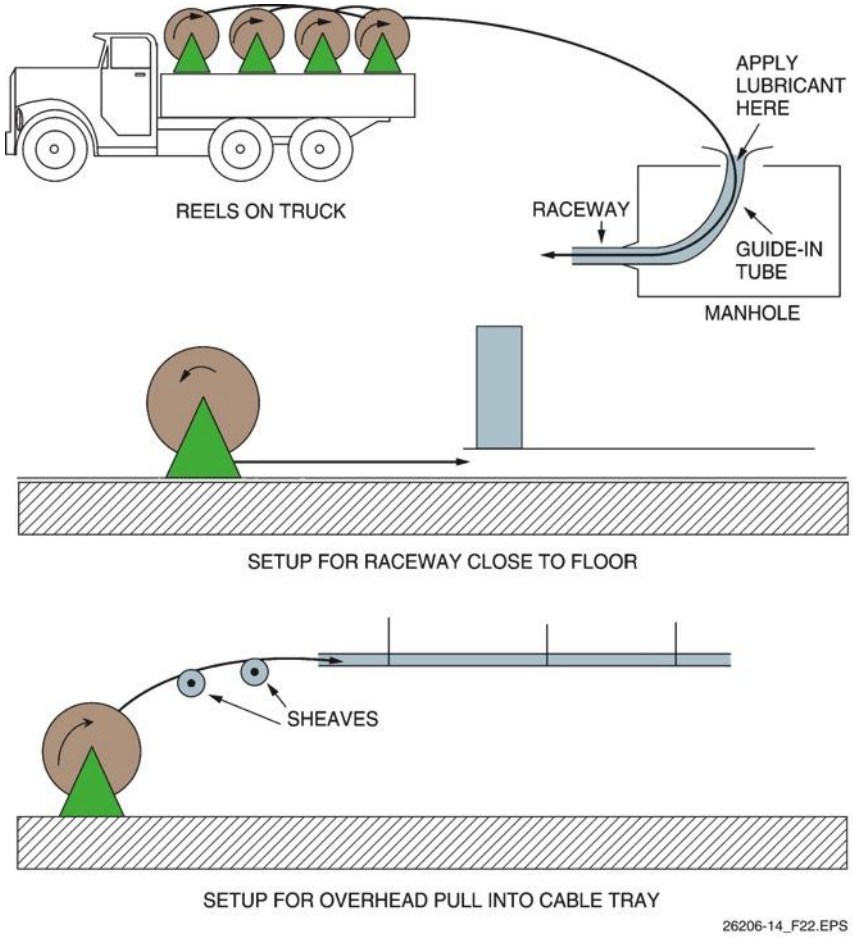
- High-force cable pulling requires careful planning to ensure a safe and smooth operation.
- Communications equipment is required between both ends of the pull.



Unreel the Cable Along its Natural Curvature



Cable Feed-In Setups



- Auxiliary equipment can be used to facilitate installation.
- Typical equipment includes reels, guides, and sheaves.

Cable Sheaves

- Single sheaves are available in various sizes to guide cable through the conduit.
- Sheave assemblies are also available for pulling around bends. The sheave radius must be matched to the bend to ensure a smooth pull.

(A) SINGLE SHEAVES

(B) SHEAVE ASSEMBLY

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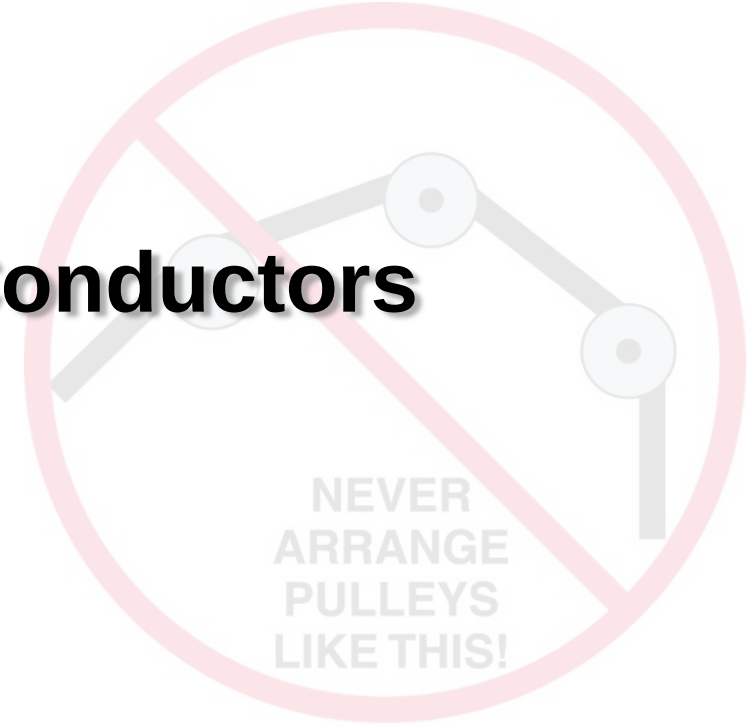
Next Session…

Supporting Conductors

- Sheaves and pulleys must be positioned carefully to ensure a smooth radius at sharp turns.
- Sharp turns increase the resistance when pulling and may result in conductor damage.



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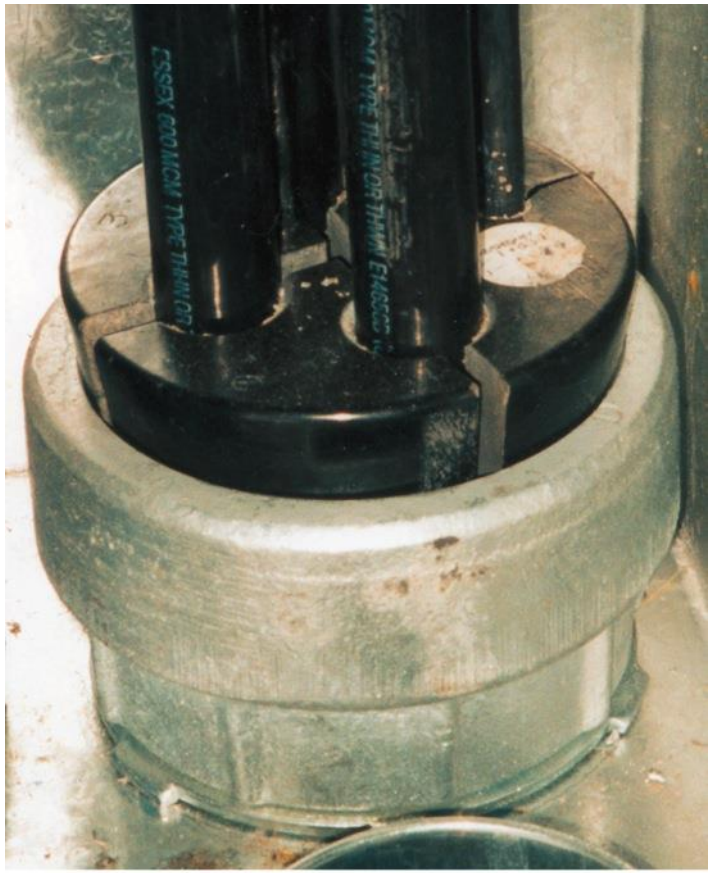
Supporting Conductors

- ***NEC Section 300.19*** contains requirements for vertical raceway supports.
- One conductor support must be installed at the top of the vertical raceway and intermediate supports must be provided at intervals no greater than the lengths shown here.

Conductor Size	Support (Aluminum or Copper-Clad Aluminum Conductor)	Support (Copper Conductor)
18 AWG through 8 AWG	≤ 100'	≤ 100'
6 AWG through 1/0 AWG	≤ 200'	≤ 100'
2/0 AWG through 4/0 AWG	≤ 180'	≤ 80'
Over 4/0 through 350 kcmil	≤ 135'	≤ 60'
Over 350 kcmil through 500 kcmil	≤ 120'	≤ 50'
Over 500 kcmil through 750 kcmil	≤ 95'	≤ 40'
Over 750 kcmil	≤ 85'	≤ 35'

Conductors Supported with Wedges

- Conductors installed in vertical raceways can be supported with wedges. Conductor clamps are also required where wedges cannot offer sufficient support.
- Conductors may also be supported by installing covered boxes at the required intervals.



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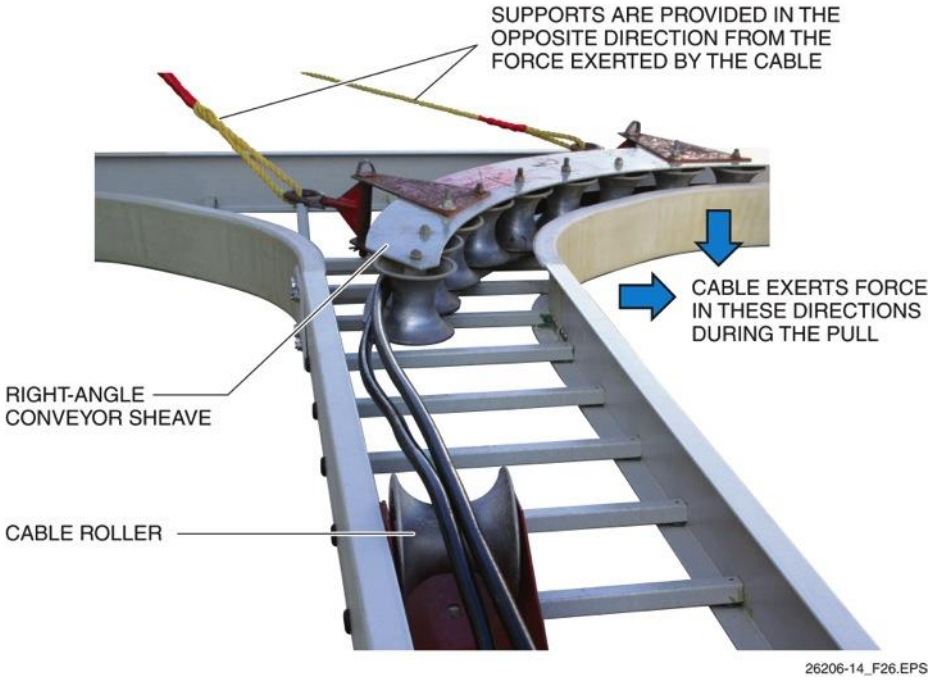
Pulling Cable in Cable Trays

- Cable tray installations require the use of sheaves and rollers to prevent excess strain and insulation damage.
- Sheaves must be supported in the opposite direction of the pull to compensate for the force on the cable.
- Whenever possible, install cables in a steady, continuous pull.



Physical Limitations of Cable

- Pulling subjects cable to extreme stress and can result in damage if precautions are not followed. Be aware of the cable's maximum pulling tension as well as sidewall loading and bending radii.
- The allowable tensions on various types of conductors are shown here.

Material	Cable Type	Temper	Lbs/Cmil
Copper	All	Soft	0.008
Aluminum	Power	Hard	0.008
Aluminum	Power	¾ Hard	0.006
Aluminum	Power	AWM	0.005
Aluminum	URD (solid)	Soft (½ hard)	0.003
All	Thermocouple	—	0.008

Angle of Bend Vs. Coefficients of Friction

- To calculate the tension in horizontal pulls, multiply the length of the raceway times the weight of the cable times the coefficient of friction ($T = L \times w \times f$).
- For curved sections, multiply the tension into the bend by the logarithmic value of the friction at a specific angle ($T_{OUT} = T_{IN}e^{fa}$). The e^{fa} values for various bends are shown here.

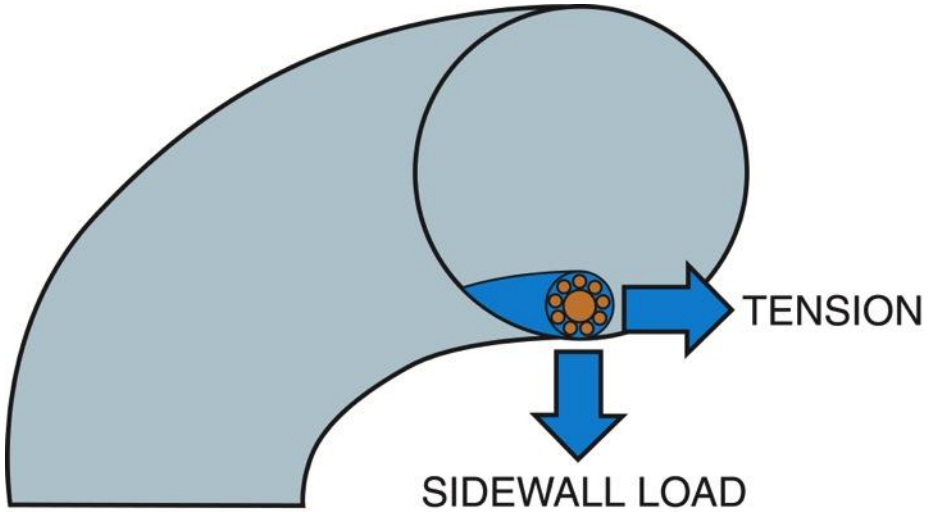
Angle of Bend (degrees/ radians)	Values of e^{fa} for Coefficients of Friction		
	f = 0.75	f = 0.50	f = 0.35
15/0.2618	1.22	1.14	1.10
30/0.5236	1.48	1.30	1.20
45/0.7854	1.80	1.48	1.32
60/1.0472	2.19	1.68	1.44
90/1.5708	3.25	2.20	1.73

Performance Task

This session will conclude with trainees preparing multiple conductors for pulling in a raceway system.

Sidewall Loading

- The sidewall load is the radial force exerted on a cable being pulled around a conduit bend or sheave.
- Excess sidewall loading can crush a cable and can be reduced by increasing the radius of the bend.



Maximum Sidewall Pressures for Various Types of Cable

- The sidewall load on any raceway run should not exceed the values shown here.
- These values may vary by manufacturer. Always refer to the specifications for the cable in use.

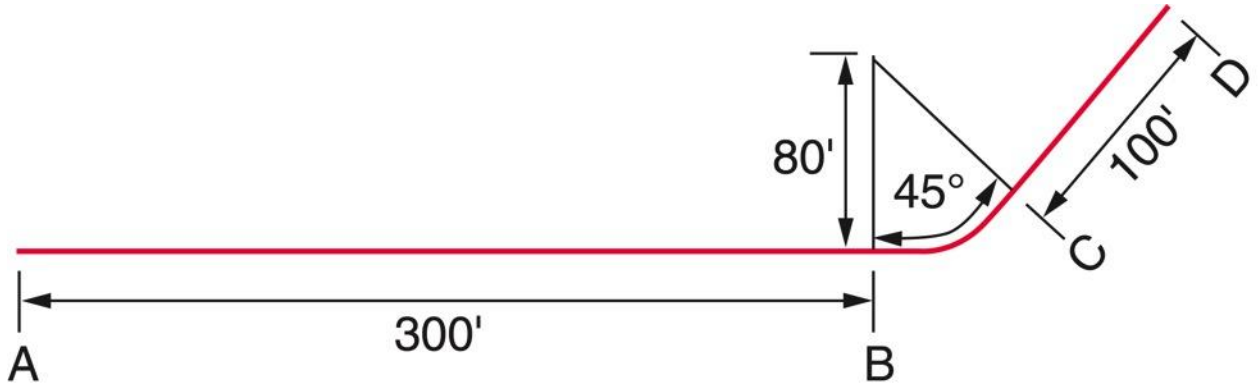
Cable Type	Sidewall Pressure in Pounds/Foot of Bend Radius
600V nonshielded control	300
600V and a kV nonshielded EP power	500
5kV and 15kV EP power	500
25kV and 35kV power	300
Interlocked armored cable (all voltages)	300

Sample Conduit Run

Assuming that the cable installed here weighs 8 pounds/foot, the tension between points A and B can be calculated as follows:

$T_1 = L_1 \times w \times f$

$T_1 = 300 \times 8 \times 0.5 = 1{,}200$ pounds



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Cable-Pulling Instruments

- Cable length meters can be used to determine the precise length of cables on reels prior to pulling.
- These instruments are calibrated for various wire sizes, and the cable size is typically selected using a switch on the instrument.

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Next Session… Circuit Tester

- Circuit testers can be used to trace conductors on unenergized circuits.
- These instruments are helpful when marking unidentified conductors.

Wrap Up

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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.