CHAROONG THAI
WIRE & CABLE PCL.

# CABLE HANDLING AND INSTALLATION GUIDE

Cables installed into conduits or trays have installation parameters such as maximum pulling tensions, sidewall pressure, clearance, and jamming, which must be considered. Other installations, such as buried and aerial, have different installation parameters. Most installations involve some general considerations, such as field handling, storage, training of ends, and junction box sizes. These and other considerations can make the difference between a good installation and one resulting in a damaged cable.

Cable damaged during installation can cause service failures. Mechanical stress during installation is generally more severe than those encountered while in service.

The following information provides guidance in recognizing these conditions and provides a methodology to aid in keeping them within acceptable limits.

## GENERAL FIELD PRATICES

### Introduction

The small details can make the difference between successful installations and having to remove damaged cables. In preparing for a cable pull, it is just as important to cover the small details as it is to assure that the cable does not exceed maximum sidewall pressure; minimum bending radii and maximum pulling tensions. General field practices are provided to aid in preparing for large and small cable installations.

### Preplanning

Preplanning for a pull is very important and should include the following steps:

1. Review all applicable local, state, and federal codes.

2. Consult local inspector.

3. Consult applicable information provided by national standards, cable manufacturers, and accessory and other suppliers.

4. Check cable for: a. Correct size and type b. Shipping damage c. End seals d. Special instructions

5. Check the reels for: a. Damage b. Protruding nails that might damage cable c. Staples

6. Consult equipment and cable manufacturer for approval of proper pulling equipment: a. When using wood reels, use reel jack stands to support an axle through the arbor hole during payoff. b. Steel reels or special reinforced wood reels are acceptable for use with electric roller payoff methods. Caution: Electric rollers can severely damage or completely collapse non-reinforced wood reels during installation.

## Low Ambient Temperature

Low temperatures are a cause for concern when installing cables. Cable should be handled more carefully and pulled more slowly during cold weather. When cables are to be installed in cold weather, they should be kept in heated storage for at least 24 hours before installation. Cables should not be installed at ambient temperatures lower than the following:

| Type of Insulation or Jacket | Min. Temperature for Installation (Degree C) |
|---|---|
| PVC | - 10 |
| EPR | - 40 |
| PE | - 40 |
| XLPE | - 40 |
| Solonon | - 40 |
| PVC (Arctic) | - 40 |
| CSPE or CPE | - 20 |

In climates where there are large temperature swings either intermittently or from summer to winter, jacket movement and shrinkback can occur at splices and terminations. This is probably due to a ratcheting effect associated with the expansion and contraction cycles of the environment and cable. Under certain conditions, terminations may allow entry of moisture and contaminants into the cable, thus precipitating insulation failure. Mechanical restraints, such as hose clamps and shrinkable sleeves that extend over part of the jacket and termination, that apply pressure at those points, have proven to be effective at restraining the jacket movement.

## Equipment

Some of the equipment and arrangements used to install cables are illustrated in the following figures:

a) At the feed-in, the curvature of the cable feed is in the same continuous arc with no reverse bends. At the pull-out, the pulling rope exits the duct directly to a pulling sheave.

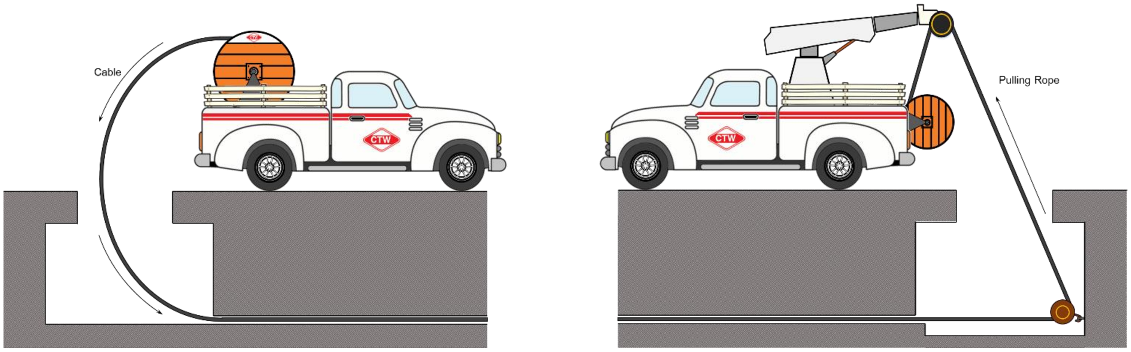



Figure F-1

Pulling Cable in Duct

b) The cable is fed from the cable reel directly into the conduit at floor level. The cable is fed from the bottom of the reel so that its curvature is continuous with no reversed bends.

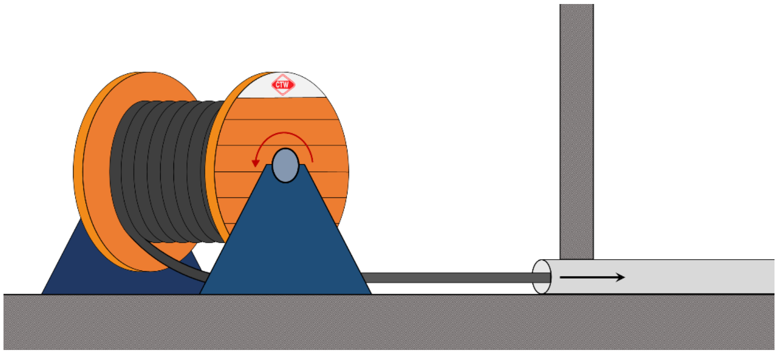


Figure F-2

Cable Feed into Conduit at Floor Level

c) From cable reel to cable tray, the cable is fed from the top of the reel to maintain the required curvature. Sheaves, or a shoe, may be used to guide the cable into the tray.

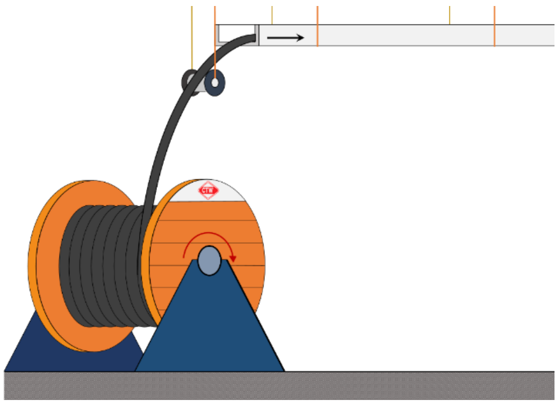


Figure F-3

Cable Feed into Cable Tray

d) Cable sheaves or a shoe may be used to guide cables into the desired direction, maintain minimum bend radius, and reduce friction. Examples of proper and improper sheave arrangements are illustrated in the following figures.

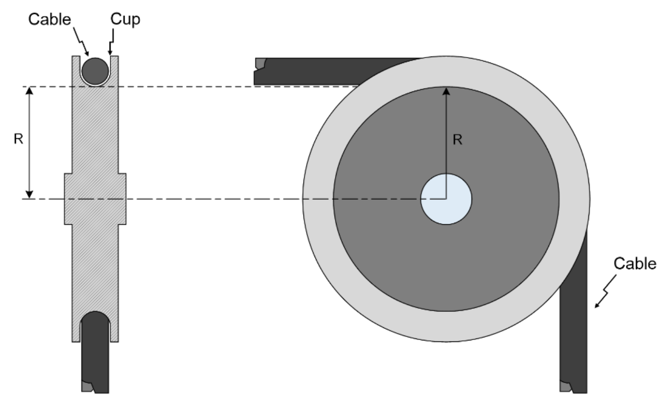



Figure F-4

Single Sheave for 90 degree Change of Direction

(R is radius used to calculate sidewall pressure, SP)

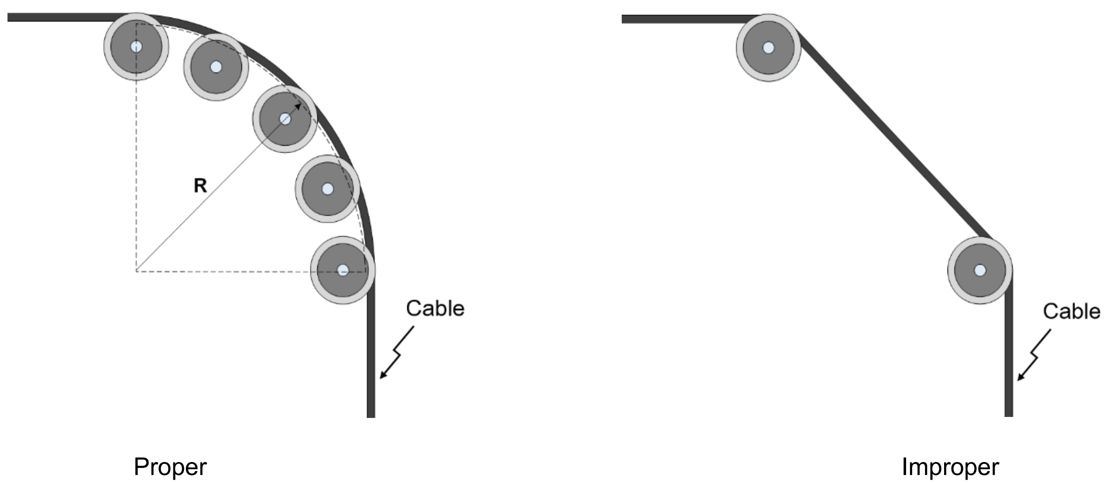
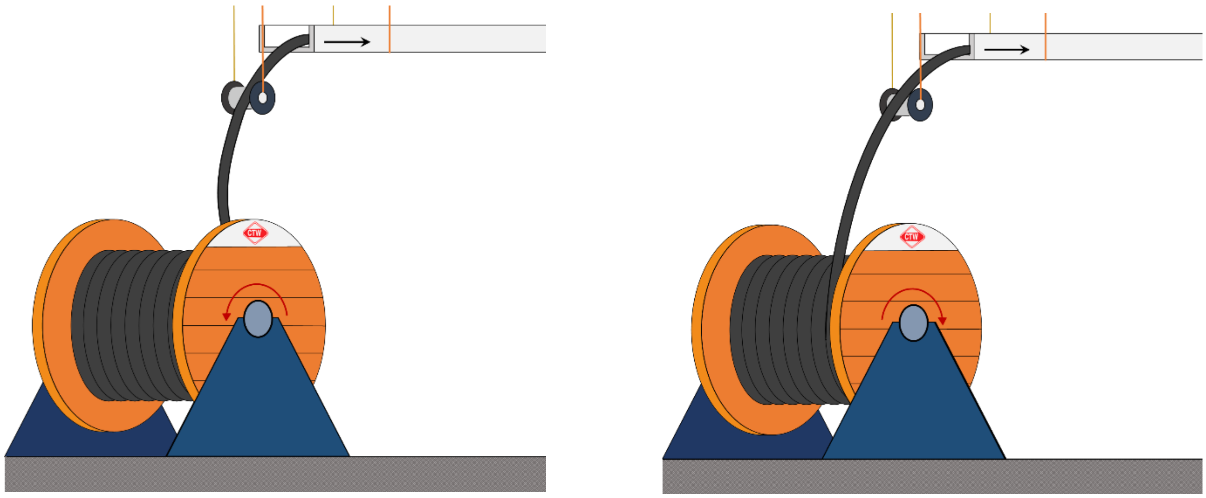



Figure F-5

Multiple Sheaves



Proper Improper

Figure F-6

Sheave Arrangements for feeding into Cable Tray

## Cable Pulling

If a cable is bent in a radius which is too severe and/or pulled with a tension that exceeds maximum allowable limits, the cable structure may be damaged. Experience in the field combined with data obtained in laboratory tests have been used to determine the minimum bending radii, maximum allowable pulling tensions and sidewall bearing pressures for various cable designs.

Before commencing cable installation, it is recommended that checks be done to ensure that bends, pulling tensions and sidewall bearing pressures will not exceed specified limits. It is important to note that different cable constructions may demonstrate varying degrees of resistance to physical damage. Good raceway design and careful installation practices are essential to ensure long, reliable cable performance.

The design limits indicated herein may be modified if experience and/or knowledge of a particular installation warrant an alternate approach. It should also be noted that the sidewall bearing pressures and allowable bending radii indicated are not necessarily applicable to cable pulled around rollers or sheaves. These apparatuses tend to apply more severe point force to a cable as opposed to the more evenly distributed forces experienced by a cable installed, for example, in conduit.

## Bending Radius

The following table outlines the minimum bending radii that are generally acceptable for low voltage power, control and instrumentation cables if maximum allowable sidewall bearing pressures and pulling tensions are not exceeded.

| | MINIMUM BEND RADIUS (MULTIPLES OF CABLE OD) | |
|---|---|---|
| Cable Type | LV Cable | MV-HV Cable |
| no Armour, no Shield | 6 | 8 |
| no Armour, with Shield | 12 | 12 |
| with Armour | 12 | 12 |

Note: In all cases, the minimum bending radius specified refers to the inner surface of the cable and not to the centerline of the cable.

## Pulling Tension

The maximum allowable pulling tension that can be applied to a particular cable is determined by the physical limitations of the cable, both tensile and crushing (sidewall bearing) strength, whether pulling eyes or cable grips are used, and the design of the raceway, duct system, etc. When using steel wire basket grips, the maximum recommended pulling tensions are typically limited by the tensile strength and frictional forces of the outer layers of a cable as they interact with the cable core. This method of cable pulling is typically not as reliable or robust as when pulling eyes are employed. Pulling eyes act directly on the cable core via the conductors, therefore maximum allowable pulling tension is usually determined by the total cross-sectional area of all current-carrying conductors within a given cable. It is recommended that shield drain wires in instrumentation cables not be used for cable pulling.

The maximum tension on an individual conductor should not exceed

$$T_{cond} = K \ x \ A$$

Where;

$T_{cond}$ : is the maximum allowable pulling tension on individual conductor, (N)

$A$ : is the cross-sectional area of each conductor, ($mm^2$)

$K$ : equals 70 N/$mm^2$ for annealed copper and hard aluminium

When pulling together two or three conductors of equal size, the pulling tension should not exceed twice the maximum tension of an individual conductor, i.e.,

$$T_{max} = 2 \ x \ T_{cond}$$

When pulling more than three conductors of equal size together, the pulling tension should not exceed 60% of the maximum tension of an individual conductor, times the number of conductors (N), i.e.,

$$T_{max} = 0.6\ x\ N\ x\ T_{cond}$$

When pulling using a pulling eye, the maximum tension for a single-conductor cable should not exceed 22.2 kN, and the maximum tension for two or more conductors should not exceed 26.7 kN.

When pulling by basket grip over a nonleaded jacketed cable, pulling tension should not exceed 4.45 kN

## Sidewall Pressure

Sidewall pressure, P, is defined as the tension out of a bend expressed in newtons divided by radius of the bend expressed in millimeters The sidewall pressure on a cable can be calculated by the following equations;

Single cable in conduit;

$$P = \frac{T_0}{R}$$

Where;

$P$ : is the sidewall pressure, (N/m)

$T_0$ : is the tension out of the bend, (N)

$R$ : is the inside radius of bend, (m)

The maximum allowable sidewall pressure is 7,300 N/m of radius.

## Handling and Storage Guidelines

a. Unloading equipment should not come in contact with the cable or its protective covering.

b. If a crane is used to unload cable, a shaft through the arbor hole or a cradle supporting both reel flanges should be used.

c. Forklifts must lift the reel by contacting both flanges.

d. Ramps must be wide enough to support both reel flanges.

e. Store reels on hard surface so that the flanges will not sink and allow reel weight to rest on cable.

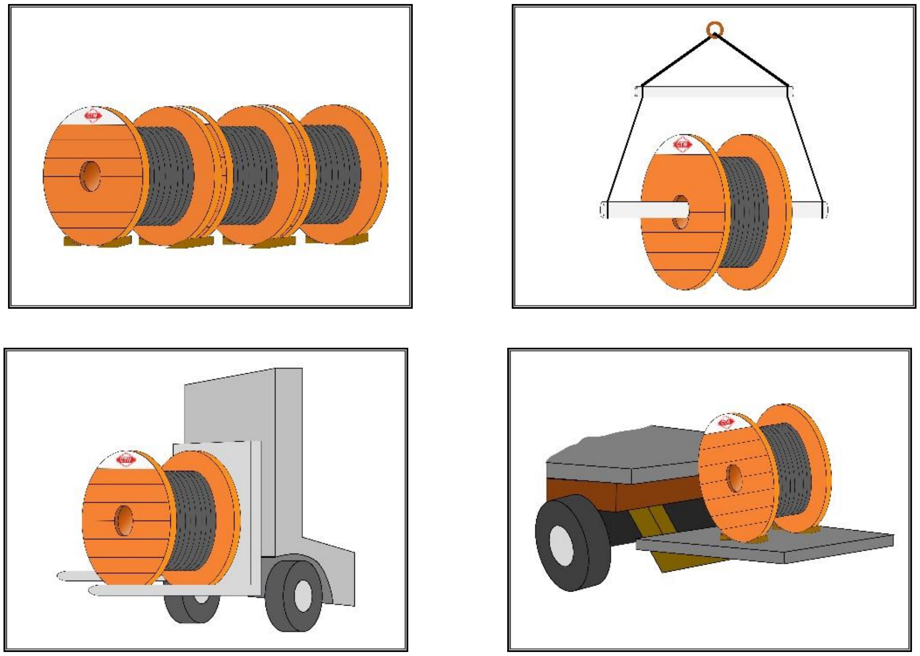


Figure F-7

Proper Reel Handling

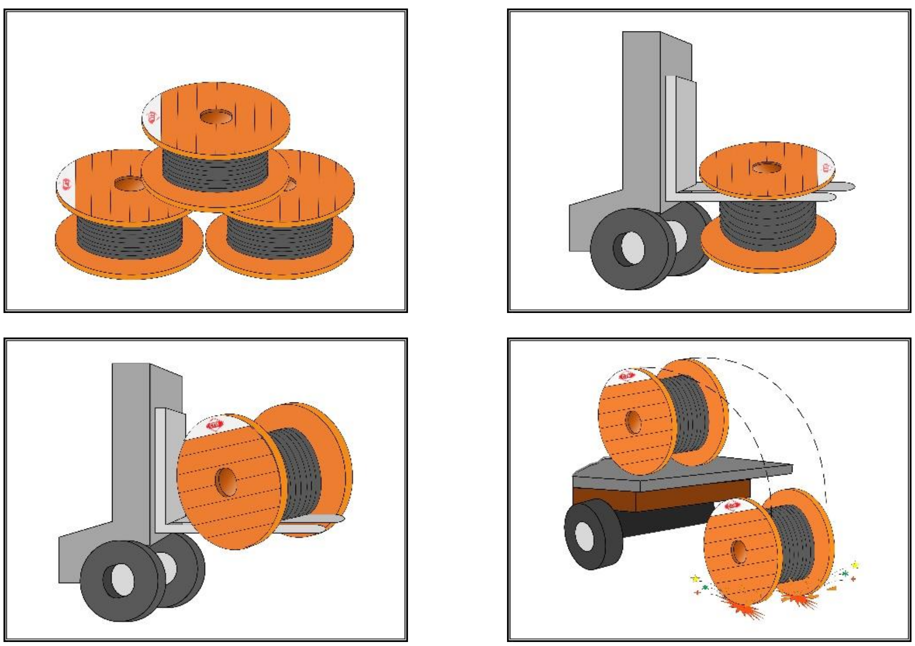


Figure F-8

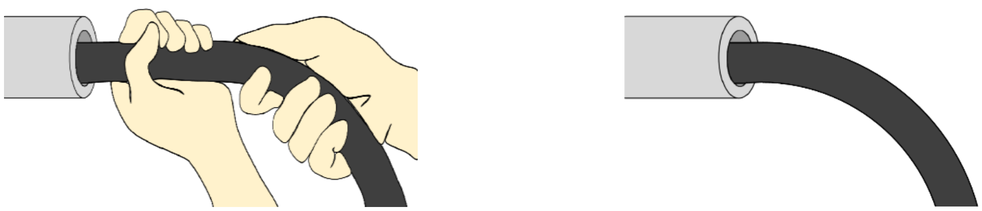
Improper Reel Handling

f. Reels should be stored out of harm's way. Consider both physical and environmental hazards.

g. Cable ends must always be sealed to prevent the entrance of moisture, etc.

h. Remove temporary cable lashing.

i. While pulling, in order to eliminate sharp bend and crossovers, always have a person feed the cable(s) straight into the conduit by hand or, for larger cables, over a large diameter sheave.

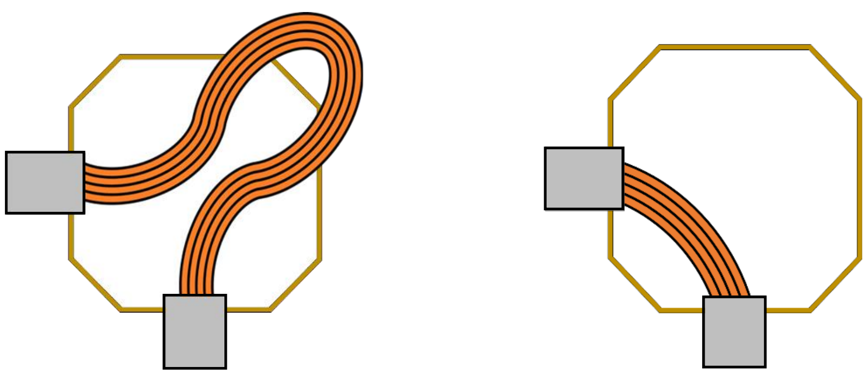


Proper Improper

Figure F-9

Feed into Conduit

j. Do not pull cable directly across short, sharp angles. After pulling completely out of one side of the enclosure, feed cable into the other side of the enclosure and pull that segment.



Proper Improper

*Caution. Minimum bending radii must be maintained.

Figure F-10

Pull-Through Enclosure

For more information on sizing of pull and junction boxes, refer to the NEC Article 314. Information on the spacing of conductors at pull and junction boxes is presented in Table 3.

TABLE 3

CONDUIT SPACING (INCHES)

CENTER-TO-CENTER SPACING

| Size | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 2 1/2 | 3 | 3 1/2 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/2 | 1.38 | | | | | | | | | | | |
| 3/4 | 1.50 | 1.62 | | | | | | | | | | |
| 1 | 1.75 | 1.88 | 2.00 | | | | | | | | | |
| 1 1/4 | 2.00 | 2.12 | 2.25 | 2.50 | | | | | | | | |
| 1 1/2 | 2.12 | 2.25 | 2.38 | 2.62 | 2.75 | | | | | | | |
| 2 | 2.38 | 2.50 | 2.75 | 3.00 | 3.12 | 3.38 | | | | | | |
| 2 1/2 | 2.62 | 2.75 | 3.00 | 3.25 | 3.38 | 3.00 | 4.00 | | | | | |
| 3 | 3.00 | 3.12 | 3.38 | 3.62 | 3.75 | 4.00 | 4.38 | 4.75 | | | | |
| 3 1/2 | 3.38 | 3.50 | 3.62 | 3.88 | 4.00 | 4.38 | 4.62 | 5.00 | 5.38 | | | |
| 4 | 3.69 | 3.88 | 4.00 | 4.25 | 4.38 | 4.75 | 5.00 | 5.38 | 5.62 | 6.00 | | |
| 5 | 4.38 | 4.50 | 4.62 | 4.88 | 5.00 | 5.38 | 5.62 | 6.00 | 6.25 | 6.62 | 7.25 | |
| 5 | 5.00 | 5.12 | 5.25 | 5.50 | 5.62 | 6.00 | 6.25 | 6.62 | 7.00 | 7.25 | 8.00 | 8.62 |

## Cable Lubrication Selection

1. Reducing the coefficient of friction is the primary factor in the selection of a lubricant.

2. Compatibility of the lubricant with cable and conduit is extremely important. The lubricant should not have any deleterious effects on the conduit or on the physical or electrical properties of the cable insulation, semiconducting, or jacket materials.

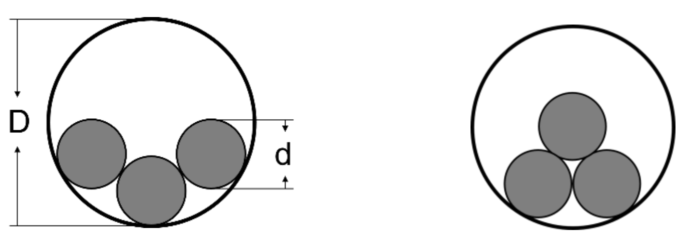
3. The lubricant and its residue should not propagate flame.

4. The lubricant should be UL or CSA listed.

5. The lubricant should contain no waxes or greases.

## Configuration

The configuration of three single-conductor cables in a conduit is determined by the ratio of the conduit inner diameter (D) to the outer diameter (d) of one of the single cables (D/d ratio).



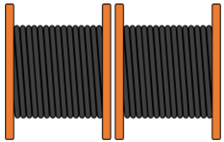

Cradled Triangular

Figure F-13

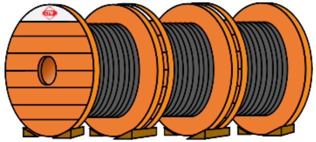
Configuration of Three Single Conductors

A cradled configuration develops when three single-conductor cables are pulled into a conduit where the D/d ratio is 2.5 or greater. A triangular configuration develops when three single conductor cables are pulled into a conduit where the D/d ratio is less than 2.5. These cables may be pulled from individual reels, tandem reels, or a single reel with parallel wound cables.

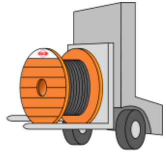
# RECOMMENDED HANDLING STORAGE & INSTALLATION INSTRUCTIONS



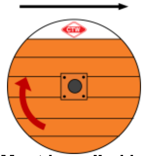
Must be appropriately wedged and stored in a vertical position.



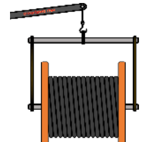
Always load with flanges on edge and block.



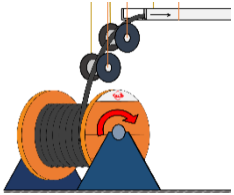
Cradle both reel flanges between forks.



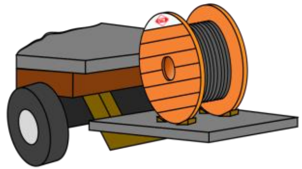
Must be rolled in direction of arrow pointed.



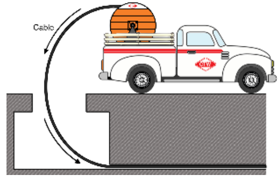
Reels can be hoisted with shaft Extending through both flanges.



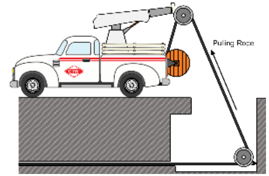
Feed-in setup should unreel cable with a natural curvature



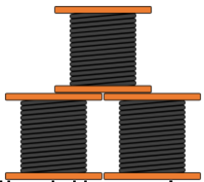
Lower reels from truck using hydraulic gate or fork lift



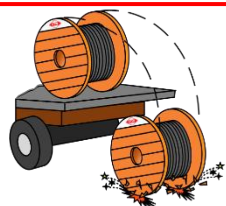

The curvature of the cable feed is in the same continuous arc with no reverse bends



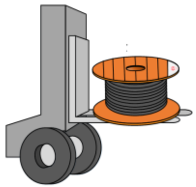

The pulling rope exits the duct directly to a pulling sheave



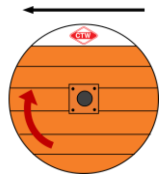
Upended heavy reels will often arrive damaged



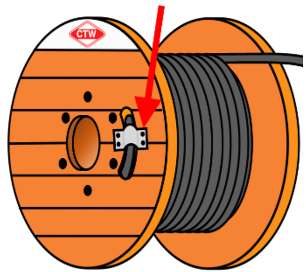
Never drop reels



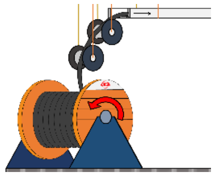
Don't lift by top flange



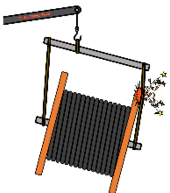
Don't rolled in the opposite.



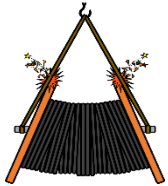
Release the cable start end from the outside flange of the reel



Feed-in setup shouldn't unreel cable with a S curvature



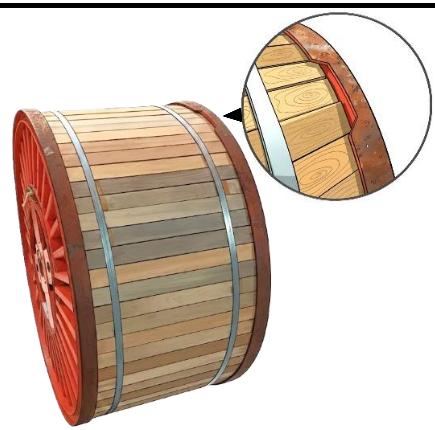
Don't hoisted reels if shaft not center



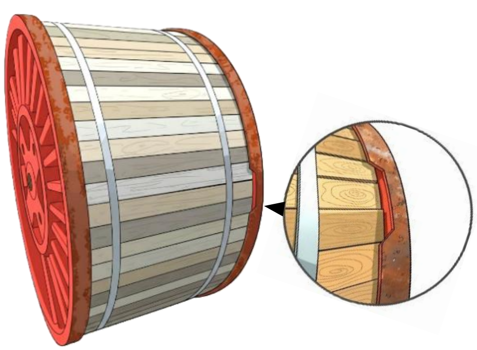
Use a spreader bar to prevent bending reel flanges and mashing the cable

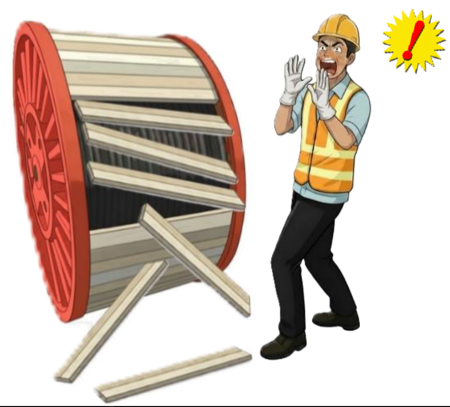
QR Code for Fully Instructions

# Recommended Instructions for Removing the Wooden Lagging from a Cable Drum. (Steel Drum)



1. Roll the drum so that the wooden insert slot is positioned upward.
2. Use wooden blocks or other suitable devices to secure the drum to prevent it from rolling until the wooden lagging has been completely removed.
3. Cut and remove the steel straps from both sides of the cable drum.
4. Removal of the wooden lagging shall begin at the wooden insert slot, and the removed wooden lagging shall be stacked neatly to ensure safety.

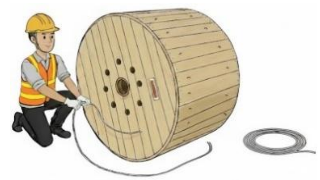




Do not roll the drum with the wooden insert slot positioned on the side before removing the wooden lagging, as the upper wooden lagging may fall during removal and damage the cable.

# Recommended Instructions for Removing the Wooden Lagging from a Cable Drum. (Wooden Drum)

**1.** Cut the securing wire.



**2.** Remove the securing wires from both sides of the cable drum.

**3.** Use wooden blocks or other suitable devices to secure the drum and prevent it from rolling.

**4.** Use a hammer to pry out the nails securing the wooden lagging. Exercise caution to ensure that neither the nails nor the wooden lagging come into contact with the cable.

**5.** Remove the wooden lagging one plank at a time to prevent nails from damaging the cable.

**6.** Stack the removed wooden lagging neatly to ensure safety from protruding nails.

**1.** Do not use a crowbar to pry off the wooden lagging, as it may damage the cable inside the drum.

**2.** Do not remove the wooden lagging before removing the steel wire, as the nails attached to the wooden lagging may catch on and damage the cable.

**3.** Do not place the removed wooden lagging in the rolling path of the drum, as the drum may roll into the wooden lagging with protruding nails, which could result in damage to the cable.