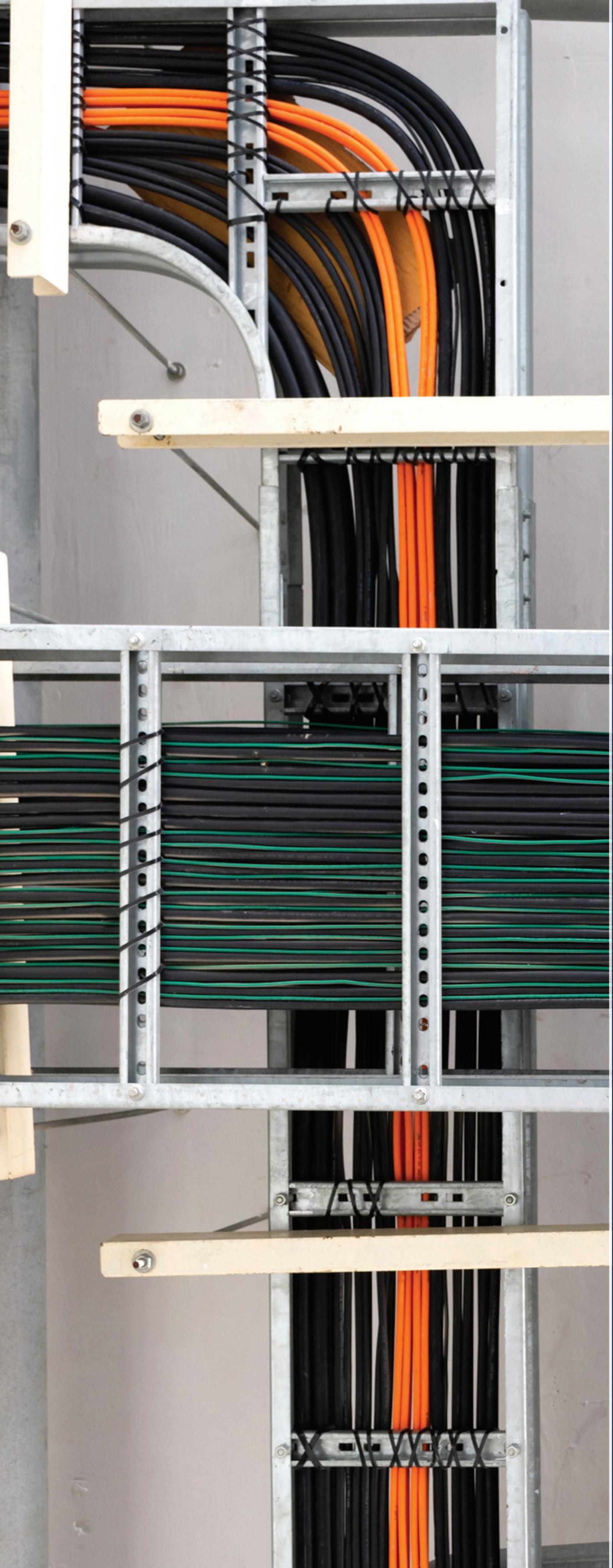


SHAWFLEX

Cable Handling, Storage and Installation Guide

Cable Handling, Storage & Installation

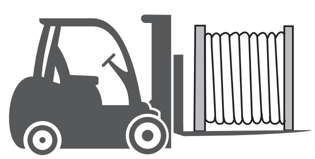
The following information is supplied as a guide for Shawflex cable handling, storage and installation. Important considerations in any cable installation are ambient temperature, equipment used, conduit or tray fill, friction forces, mechanical layout of a raceway and physical limitations of the cable. This document is not intended to be an all inclusive reference. It simply highlights some pertinent aspects of cable installation and should be viewed as a complement to good working practices.

Handling Guidelines

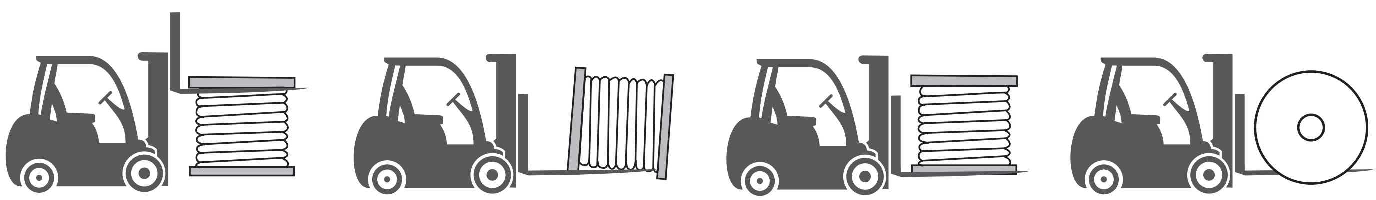
Cable Handling

The following procedures are recommended to prevent cable damage during handling.

When using a forklift to move reels, the forks must be placed at a 90° angle to the flanges and must be long enough to make contact with both flanges fully. Never lift reels with the forks between the flanges. Do not allow the forks to contact the cable.

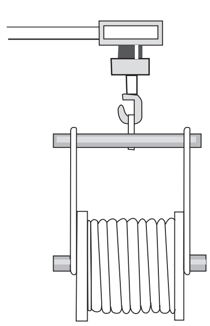


Correct



Incorrect

When using a crane or other overhead lifting device to move reels, insert a steel lifting bar in the reel arbor hole and use a lifting yoke or spreader bar to prevent (1) damage to the reel flanges and (2) unbalanced lifting conditions.



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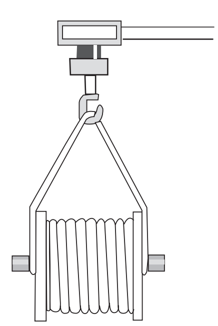
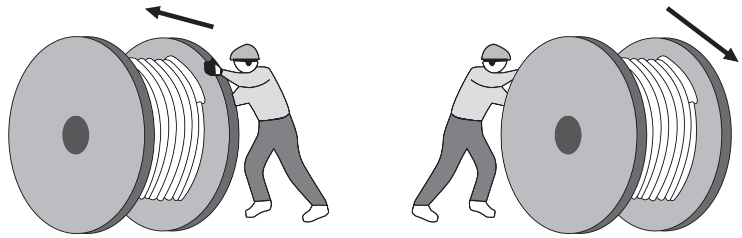


Incorrect

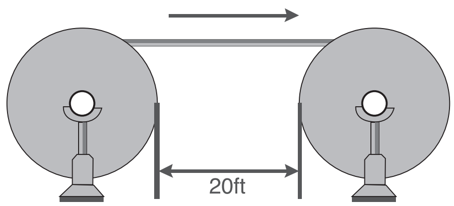
Before a reel is rolled from one point to another, ensure that the cable end is secured onto the reel. Roll reels only in the same direction as the cable was wound onto the reel. Rolling in the opposite direction may loosen the turns of cable on the reel. This loosening may result in turns crossing over one another and subsequently causing snags in the cable as it is removed from the reel.



Correct Incorrect

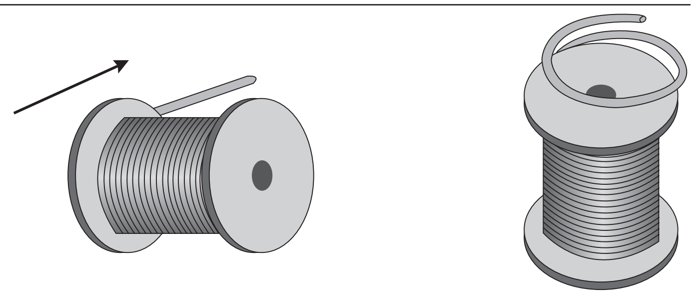
Cable Removal and Rewinding

Support the reels on reel jacks or stands using a suitable diameter bar through the reel arbor holes. The distance between the pay-off and take-up reel should be at least 20 feet to allow the cable to unwind naturally and straighten. The cable unwinding and rewinding can take place from the top or bottom of both reels. Avoid reverse bending caused by unwinding from opposite ends of the two reels.



Correct Incorrect

Do not pull the cable over the end of the reel flange. This can produce kinks and twists in the cable.



Correct Incorrect

Storage Guidelines

Cable Storage

Reels should be stored indoors on a smooth, hard, dry surface whenever possible. Each reel should be chocked from both sides. Reels should be stored in an orderly manner, aligned flange to flange. If outside storage is necessary, ideally the cable should be stored in the same manner. Additionally the cables should be protected from the weather and UV radiation. When it is not possible to store the reels on a smooth, hard, dry surface, the reels should be supported at the flanges, off the ground, so that the flanges do not become embedded in the ground which could damage the cable.

If a portion of the cable is used, the end of the remaining cable should be resealed immediately in a manner equivalent to the factory seal to prevent moisture ingress. The end should be fixed to the inside edge of the reel flange to prevent it from extending beyond the flanges during reel movement.

Reels should not be stored on their sides or stacked one on top of another: they should be stored upright (i.e. flanges perpendicular to the floor).

Installation Guidelines

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.*

There are two bending radii involved when installing cable:

1. Pulling (during installation, while pulling with tension applied along the cable axis)
2. Training (following installation, with no tension along the cable axis)

	MINIMUM BEND RADIUS (MULTIPLES OF CABLE OD)	
CABLE TYPE	PULLING	TRAINING
No Armour, No Shield	9	6
With Shield, no Armour	18	12
Interlocked Armour	18	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.

Cable Grip

The maximum allowable pulling tension when incorporating a cable grip may be calculated as follows:

$$T = k_1 \times t \times (D - t)$$

Where:

T = Maximum Allowable Pulling Tension (lbs)
k_1 = Constant; 3,140
t = Jacket Thickness (inches)
D = Cable Outside Diameter (inches)

Pulling Eye

Pulling eyes are recommended for heavy pulls and should be used in conjunction with a swivel joint. The maximum allowable pulling tension when incorporating a pulling eye can be calculated as follows:

$$T = k_2 \times n \times A$$

Where:

T = Maximum Allowable Pulling Tension (lbs)
k_2 = Constant; 0.008 for copper conductors | 0.006 for aluminum conductors
n = Number of Conductors Attached to Pulling Eye
A = Area of One Conductor (circular mils, cmil)

Friction

The coefficient of friction is a critical component of cable pulling calculations and must be selected with care. It is dependent on the cable exterior covering, raceway or duct material, and type of pulling lubricant used. Typically, values between .25 and .50 are experienced for polymeric covered cables installed in a clean, smooth, well lubricated raceway. If this value is unknown, a conservative value of f = .50 is usually sufficient for estimation purposes. Typical coefficients of friction are tabulated below for various raceway materials interacting with PVC cable jackets using water based pulling lubricants.

RACEWAY MATERIAL	COEFFICIENT OF FRICTION, f (KINETIC)
PVC	0.35
Polyethylene	0.25
Steel	0.50
Installed over rollers	0.15

Note: Static coefficients of friction are generally higher than kinetic coefficients of friction. It is therefore preferable to not stop a cable pull that is in progress, especially one that is approaching maximum allowable design limits for pulling tension and sidewall bearing pressure.

Use only approved lubricants that are compatible with the cable outer covering. During pulling, qualified personnel should be located at sufficiently close intervals to monitor the movement of the cable during installation. Accelerate slowly and smoothly from rest to a constant pulling speed in the range of 15 ft/min to 50 ft/min.

Ambient temperatures over 80°F (27°C) can increase the coefficient of dynamic friction for conductors or cables having a polymeric jacket.

Installation With Rollers

The maximum required spacing of rollers along the cable route varies with cable weight, pulling tension, cable construction, and the amount of clearance between the rollers and the tray bottom. Near the end of the pull, where the tension is approaching the maximum value, the spacing can be greater on straight sections than at the beginning of the pull, where the tension is at the minimum, as less cable sag is experienced. For relatively flexible cable constructions, the following expression can be used as an approximation in determining roller spacing.

$$S = \sqrt{(8 \times H \times T / W)}$$

Where:

S = distance between rollers (ft)
H = height of top of roller above tray surface (ft)
T = tension (lbs)

W = weight per foot of cables (lbs/ft)

Installation Without Rollers

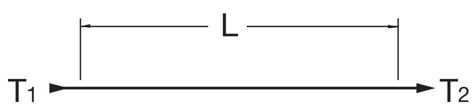
Cables with interlocked armor must not be installed on ladder trays without rollers.

For smooth unarmored cables (e.g. Type TC) a coefficient of friction of 0.25 is suggested. If more than one layer of cable is installed in the tray, and cable is dragged over other installed cables, a coefficient of 0.5 will yield reasonably accurate results.

Pulling Tension Calculations

The final pulling tension for a particular installation may be determined by summing the contribution of each section of a cable route. Where the run contains a bend (or several bends) a reduction in pulling tension can be achieved if the cable is fed into the raceway at the end closest to the bend(s). The calculations to be used for each of these sections are described below.

Straight Pull

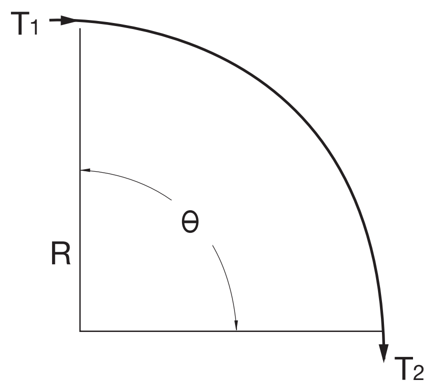


$$T_2 = T_1 + W \cdot f \cdot L$$

Where:

T_2 = Tension at the end of the section (lbs)
T_1 = Tension at the beginning of the section (lbs)
f = Coefficient of friction
W = Weight of the cable (lbs/ft)
L = Length of the straight section (ft)

Horizontal Bend



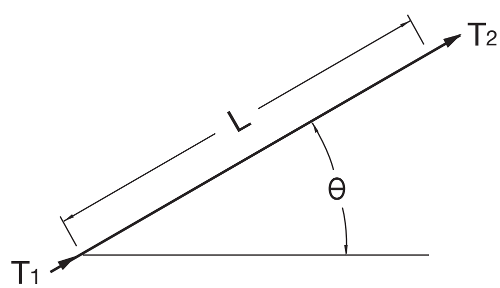
$T_2 = T_1 \cdot e^{(f \cdot \Theta)}$

Where:

T_2 = Tension at the end of the section (lbs)
T_1 = Tension at the beginning of the section (lbs)
f = Coefficient of friction
Θ = Angle of Bend (radians)

Note: to convert degrees to radians multiply by 0.01745

Upward Pull

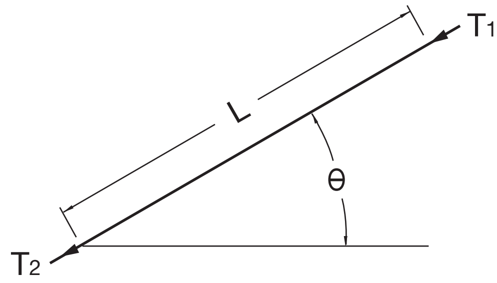


$T_2 = T_1 + W \cdot L\,(\sin\Theta + f \cdot \cos\Theta)$

Where:

T_2 = Tension at the end of the section (lbs)
T_1 = Tension at the beginning of the section (lbs)
f = Coefficient of friction
W = Weight of the cable (lbs/ft)
L = Length of the straight section (ft)
Θ = Angle of Slope (radians)

Downward Pull



$T_2 = T_1 - W \cdot L (\sin\Theta - f \cdot \cos\Theta)$

Where:

T_2 = Tension at the end of the section (lbs)
T_1 = Tension at the beginning of the section (lbs)
f = Coefficient of friction
W = Weight of the cable (lbs/ft)
L = Length of the straight section (ft)
Θ = Angle of Slope (radians)

Sidewall Bearing Pressure

Sidewall bearing pressure is the compressive force that is applied to a cable as it is pulled around a bend. A simplified version of the formula for calculating this value is shown below. It excludes the influence of the weight of the cable itself.

This assumption does not usually add any appreciable error to the calculation.

$SWBP = T_2 / R$

Where:

SWBP = Sidewall Bearing Pressure (lbs/ft)
T_2 = Tension at the end of the section (lbs)
R = Radius of the bend (ft)

A conservative upper limit for SWBP covering most multi-conductor low voltage cable constructions is 300 lbs/ft.

Cold Temperature Installations

The low temperature marking on cables should not be taken as the minimum cable installation temperature. The actual rigors of cable installation may surpass the test performance parameters associated with laboratory test conditions. CSA addresses this in the following disclaimer:

CSA C22.2 No. 239, Annex D

Low-temperature handling

D.1 The instruction "Do Not Handle Below -40°C", which is found in many CSA Group standards, has been removed because of its ambiguity and the implication that cables can be handled at -40°C without precaution. The -40°C marking indicates that the cables have passed a cold bend or cold impact test under carefully controlled laboratory conditions. These conditions might not reflect actual field conditions. All cables should be warmed to at least -10°C before installation.

Minimum pulling temperature without pre-heating of cable

Standard cable types may be installed only down to -10°C without pre-heating. Shawflex rates some cable constructions suitable for installation down to -25°C without pre-heating of the cable (please check with us for more details).

If it is absolutely necessary to install below this temperature, it is required that the cables be stored in a building heated to room temperature for 48 hours immediately prior to the cable pull. The cables will then be easier to install and less prone to damage.

During cold weather installations, cables should be pulled more slowly and trained in place the same day it is removed from storage. Do not impact, drop, kink or bend the cable sharply in cold temperatures. Most cable failures are due to mechanical damage during installation.