Cable Installation Notes

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The following information is supplied as a guide for ShawFlex cable 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.

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 and 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 apparatus 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 axis 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 (pounds)
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 can be calculated as follows:

$T = k_2 \times n \times A$

Where:

T = Maximum Allowable Pulling Tension (pounds)
k_2 = Constant; 0.008 (copper conductors only)
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.

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 (feet)
H = height of top of roller above tray surface (feet)
T = tension (pounds)
W = weight per foot of cables (pounds per foot)

Installation Without Rollers

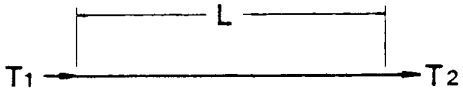
Cables with interlocked armor must not be installed on ladder trays without rollers.

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

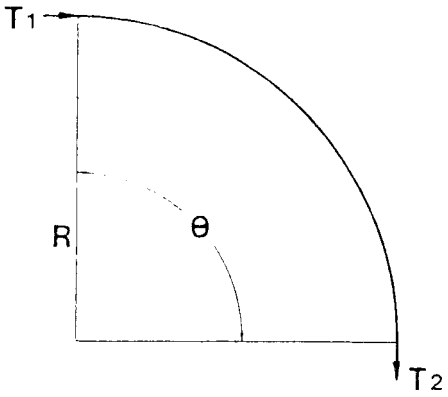


$$T_2 = T_1 + W \bullet f \bullet L$$

Where:

T_2 = Tension at the end of the section (pounds)
T_1 = Tension at the beginning of the section (pounds)
f = Coefficient of friction
W = Weight of the cable (pounds per foot)
L = Length of the straight section (feet)

Horizontal Bend



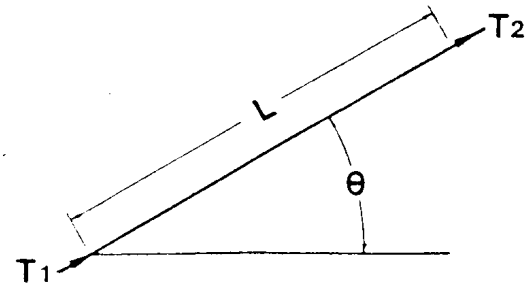
$$T_2 = T_1 \bullet e^{(f \bullet \Theta)}$$

Where:

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

Note: to convert degrees to radians multiply by 0.01745

Upward Pull

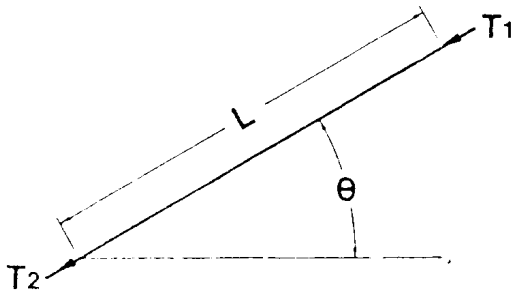


$$T2 = T1 + W \bullet L (\sin\Theta + f \bullet \cos\Theta)$$

Where:

T_2 = Tension at the end of the section (pounds)
T_1 = Tension at the beginning of the section (pounds)
f = Coefficient of friction
W = Weight of the cable (pounds per foot)
L = Length of the straight section (feet)
Θ = Angle of Slope (radians)

Downward Pull



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

Where:

T_2 = Tension at the end of the section (pounds)
T_1 = Tension at the beginning of the section (pounds)
f = Coefficient of friction
W = Weight of the cable (pounds per foot)
L = Length of the straight section (feet)
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 doesn't usually add any appreciable error to the calculation.

$SWBP = T_2/R$

Where:

SWBP = Sidewall Bearing Pressure (pounds per foot)
T_2 = Tension at the end of the section (pounds)
R = Radius of the bend (feet)

A conservative upper limit for SWBP covering most multi-conductor low voltage cable constructions is 200 lb/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 #239 APPENDIX "D"

Low Temperature Handling D1.

The term "Do Not Handle Below -40°C" found in many CSA standards is being 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 and/or cold impact test under carefully controlled laboratory conditions. These conditions may or may not reflect actual field conditions. It is therefore recommended that all cables be warmed to at least -10°C before installation.

Minimum Pulling Temperature without Pre-heating Cable

ShawFlex rates some cables constructions suitable for installation at -25°C without pre-heating of the cable (please confirm! Standard cable types may be installed only down to -10°C.). 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 installation, cable 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.

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