Energy Cable Installation Guideline

Overview

The Energy Cable Installation Guideline contains recommendations for handling and installing Superior Essex energy cables. Failure to adhere to these guidelines may void the product warranty.

IMPORTANT: Use the conventions and notations below to acquire a better understanding of the guide:

CONVENTION	DESCRIPTION
Bold	**Indicates references to industry publications**
Italics	*Indicates industry terms, concepts and references to other Technical Guidelines*
NOTE	Indicates supplemental or additional information
TIP	Indicates information helpful to complete a procedure but not required
⚠	Cautionary Information for safe testing or installation of cable media

Confidential and Proprietary Statement

The information included in the Energy Cable Installation Guideline is intended to be used for Superior Essex cables only.

Technical Support and Customer Service

For Technical Support and Customer Service contact Superior Essex:

- Call Technical Support at 877-263-2818
- Call Customer Service at 800-249-0014
- Or email **Comm.TechSupport@spsx.com**

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NOTE: These installation instructions have been written for qualified, experienced personnel. Please read them thoroughly before beginning work. Superior Essex disclaims any liability or responsibility for the result of improper or unsafe installation practices.

Introduction

Energy Cables

Superior Essex services the Commercial, Industrial, and Utility markets with Low Voltage 300V and 600V instrumentation cables for control systems, audio, intercoms, energy management, and alarm controls; Low Voltage 600V control and power cables for industrial or utility power or station control circuits; and Medium Voltage 5kV through 46kV power cables for primary power and distribution circuits in industrial, commercial, and utility installations.

Superior Essex manufactures the following cable types:

LV Instrumentation

- PVC/PVC, 300V Type PLTC/ITC, Pairs and Triads
- PVC/Nylon/PVC, 600V Instrumentation, Type TC-ER, Pairs and Triads
- XLPE/PVC, 600V Instrumentation, Type TC-ER, Pairs and Triads

LV Control

- PE/PVC/PVC, 600V Control (20/10)
- PVC/Nylon/PVC, 600V Control, Type TC-ER
- XLPE/PVC, 600V Control, Type TC-ER

LV Power

- PVC/Nylon/PVC, 600V Power, Type TC-ERE
- XLPE/PVC, 600V Power, Type TC-ER
- XLPE/PVC, 600V Power, Type TC-ER, AL-8000

MV-105 Power

- EPR/CTS/PVC Power, Type MV-105
- EPR/CTS/PVC Power, Type MV-105, 3 Conductor

MV Primary UD

- TR-XLPE/CN/LLDPE Power, Type Primary UD (Unfilled)
- EPR/CN/LLDPE Power, Type Primary UD (Unfilled)

Aluminum Interlock Armored

- XLPE/AIA/PVC, 600V Control, Type MC
- XLPE/AIA/PVC, 600V Power, Type MC
- XLPE/AIA/PVC, 600V Power, Type MC, AL-8000

For more information about specific products, please visit the Superior Essex website at **ce.SuperiorEssex.com/products**

Pre-Installation

Before beginning any installation, it is important to review all applicable codes, specifications and standards. This step will ensure that the cable being installed meets the requirements for the application in which it is being used. This guideline references the United States National Electrical Code (NEC), as well as applicable industry standards and Superior Essex design specification as a basis. Other jurisdictions may enforce additional requirements. Installers and end users must be familiar with the applicable requirements for their locale. The local Authority Having Jurisdiction (AHJ) should be consulted for final approval before installation begins.

Energy cables are designed with installation in mind. That being said, the following recommendations will help ensure a safe and successful installation.

Cable Verification

Ensure the product received meets the voltage rating, insulation type, ampacity and any code requirements for the intended application. Selecting the appropriate cable for the intended application is critical to the overall safety and performance of the system. If there are any concerns, please contact the AHJ for final approval before attempting installation.

Cable Inspection

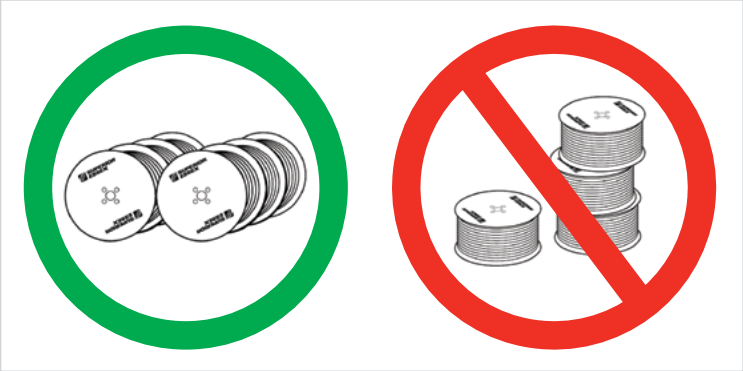
Inspect the cable and reels for any type of damage. If damage is discovered, follow local procedures for damages claim or contact Superior Essex for assistance. Do not attempt installation of damaged cable. Use caution in installing cable from damaged reels which could damage the cable or create a safety hazard.

Pre-Installation Testing

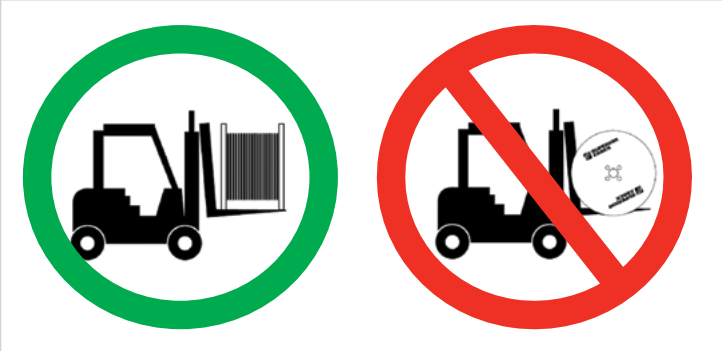
Superior Essex energy cables are manufactured to high standards and tested rigorously in order to relieve end users of the burden of pre-installation testing. In normal situations, such testing is not necessary and the cable can be installed, as received, with confidence. However, pre-installation testing should be conducted if the customer specification requires it or if there is evidence of cable mishandling or damage.

Cable Handling and Storage

All reels are shipped in the upright position. Transporting reels with the flange side down can damage the flange. It may also cause the cable layers to shift, which can result in cable tangling and snagging during payoff.



Reels must be moved upright by lifting the cable with a fork lift or reel mover. The forks must be placed under the reel with the forks always perpendicular to the reel flange.



For additional guidance, refer to Superior Essex Technical Guideline *"OSP Cable Reel Handling and Storage"* at **ce.superioressex.com/uploadedFiles/docs/pdf/technical-guidelines/TG08-OSP-Reel-Handling-Storage.pdf**.

Pathway Considerations

Conduit

All conduits should be verified to meet applicable code requirements (material, fill ratio, etc.) prior to cable installation. For assistance calculating conduit fill ratio, see our Technical Guideline *"How to Calculate Conduit Fill"* at **ce.superioressex.com/uploadedFiles/docs/pdf/technical-guidelines/TG16-Conduit-Fill-Requirements.pdf**.

Conduit runs should not contain more than 360 degrees of bend between pull boxes. Additional pull boxes may be required at strategic locations on difficult pulls.

Conduits bends must accommodate the minimum bend radius of the cables being installed.

When verifying the ability to use an existing conduit or sizing a new conduit, the "jam factor" should be taken into consideration. Jamming is a condition that may occur if the sum of the cable diameters is about equal to the inside diameter of the conduit. It will typically occur at bends when one cable is forced between the other two cables and wedges them against the inner wall of the conduits.

To calculate the Jam Factor:

Jam factor = (1.05) x (D/d)

- **D = inside diameter of the conduit**
- **d = overall diameter of conductor(s)**

The (1.05) multiplier takes into account the oval shape of bends.

- **If jam factor is < 2.5, jamming is not likely.**
- **If jam factor is < 3.0 but > 2.5, jamming is very likely.**
- **If jam factor is > 3.0, jamming is not likely.**

Conduits must be free of debris and obstructions, such as gravel, concrete and other building materials. Never assume that conduits are clean. Pull a mandrel/swab through each conduit to loosen any obstructions. Mandrel should be at least 12 inches long and no less than ¼ inch smaller than the inside diameter of the conduit. After pulling the mandrel/swab, a stiff bristle brush of the same size or slightly larger than the conduit should be pulled through the conduits. Repeat process until conduits are free of obstructions.

Cable Tray

All cable tray should be verified to meet applicable code requirements (material, fill ratio, grounding, etc.) prior to cable installation. Refer to article 392 of the NEC, or other applicable code for the use of power conductors and cables in cable tray.

Cable tray should not be loaded more than recommended by the cable tray manufacturer.

Rollers should be installed, spaced appropriately, to prevent cable from rubbing against the tray during installation.

Direct Burial

All buried pathways should be verified to meet applicable code requirements (depth, ampacity, separation, etc.) prior to cable installation. Direct buried cables must be installed with the same care as those being installed in other pathways.

Direct buried cables should be installed at a depth that is below the frost line.

Cable may be installed in open trench by rolling the reel along the trench and laying the cable in, or by pulling the cable into the trench. When pulling into the trench, temporary rollers must be installed along the length of the pull.

Screened backfill should be used to avoid damage to the cable from rocks and debris.

Cable Limitations

Energy cables are designed with installation in mind. That being said, there are certain limitations to cable performance that must be respected during installation. Limitations vary among cables types, sizes, and even manufacturers. It is critical for the designer and installer to be familiar with these criteria before the installation process begins.

Installation Temperature

Low ambient temperature typically creates a more challenging installation environment as cable materials stiffen. The handling and pulling of cables in excessively low temperatures can cause damage to cable jackets and insulation. The following minimum installation temperature limitations are provided in *IEEE 525-1992 - IEEE Guide for the Design and Installation of Cable Systems in Substations*. These temperature guidelines are applicable to traditional energy cable designs manufactured to industry standards. These guidelines are provided for convenience purposes only and do not replace or overrule individual cable performance specifications.

CABLE INSULATION / OVERALL JACKET MATERIAL	LOW TEMPERATURE LIMITS	
EPR (Ethylene Propylene Rubber)	-40°C	-40°F
CPE (Chlorinated Polyethylene)	-20°C	-4°F
PVC (Polyvinyl Chloride)	-10°C	+14°F
CSPE (Chlorosulfonated Polyethylene)	-20°C	-4°F
Neoprene (Polychloroprene)	-20°C	-4°F
PE (Polyethylene)/**XLPE** (Cross-Linked Polythylene)	-40°C	-40°F

Pre-installation Conditioning

Cables subject to cold temperature installation are often exposed to even colder temperatures during transportation and storage. To ensure that all the cable materials are safely within the installation temperature rating, cables should be temperature conditioned just prior to installation. Results of the conditioning will be determined by the duration and temperature of the conditioning as well as the initial temperature and amount of cable being conditioned. As a general guideline, begin with a minimum of 24 hours at or above 18°C (65°F) and increase the duration and/or temperature as needed to obtain the desired handling characteristics. Beware of a cable reel's self-insulating effect which will keep inner layers cold even as the outer layers warm to acceptable levels.

Sidewall Bearing Pressure

Sidewall bearing pressure (SWBP) is the compressive force that is exerted on the cable as it is pulled around a bend such as an elbow or sheave wheel. This factor has a dramatic effect on the sizing of a pathway system because it relates directly to the radii of the bends, the pulling tension, and the cable's weight. Excessive SWBP will flatten the insulation as it passes through bends. As such, SWBP will usually be the limiting factor in most installations. The following chart provides the maximum SWBP that each cable type is designed to withstand.

MAXIMUM SIDEWALL BEARING PRESSURE (SWBP)	
Cable Type	SWBP in (lbs/ft)
300 Volt – Non Shielded; 300V and 600V Shielded Control and Instrumentation	500
600 Volt – Non Shielded Control and Instrumentation	500
600 Volt – Non Shielded Power	1000
600 Volt – Shielded Power	500
5kv thru 35 KV (medium voltage) – Shielded Power	1000
Interlocked Armor Type Cables – (Any Voltage)	300

SWPB is calculated based on cable tension, bend radius, and weight correction factor as described below. It should be calculated at each bend in the pull to ensure the maximum allowable limit is not exceeded. Information on calculating SWPB is included in the Cable Pulling section below.

Maximum Allowable Pulling Tension

Separate from the tension used in the calculation of SWBP, each cable has a maximum allowable pulling tension, which is the force that can be applied to a cable or cable assembly during installation without risking damage to the conductors. It is based on conductor material, size and number and is calculated as follows:

For 3 or Fewer Conductors

Tm = K x n x CMA

- **Tm** = maximum pulling tension (lbs)*
- **K** = constant (0.008 for copper conductors; 0.006 for aluminum conductors)
- **n** = number of conductors
- **CMA** = circular mill area of one conductor

*This is the value of the maximum tension that can be placed on the cable or a group of individual cables pulled at the same time. If the number of conductors (n) is greater than three, calculate maximum pulling tension with the revised formula:

For 4 or More Conductors

Tm = K x n x CMA x 0.8

The following chart was calculated using the above formulas for maximum allowable pulling tensions for both copper and aluminum conductors.

MAXIMUM ALLOWABLE PULLING TENSION (LBS)								
AREA kcmil	Number of Copper Conductors				Number of Aluminum Conductors			
	1	2	3	4	1	2	3	4
2	531	1,062	1,593	1,699	398	796	1,194	1,274
1	670	1,339	2,009	2,142	502	1,004	1,506	1,607
1/0	845	1,690	2,534	2,703	634	1,267	1,901	2,028
2/0	1,065	2,130	3,194	3,407	799	1,597	2,396	2,556
3/0	1,342	2,685	4,027	4,296	1,007	2,014	3,020	3,222
4/0	1,693	3,386	5,078	5,417	1,270	2,539	3,809	4,063
250	2,000	4,000	6,000	6,400	1,500	3,000	4,500	4,800
300	2,400	4,800	7,200	7,680	1,800	3,600	5,400	5,760
350	2,800	5,600	8,400	8,960	2,100	4,200	6,300	6,720
400	3,200	6,400	9,600	10,240	2,400	4,800	7,200	7,680
500	4,000	8,000	12,000	12,800	3,000	6,000	9,000	9,600
600	4,800	9,600	14,400	15,360	3,600	7,200	10,800	11,520
750	6,000	12,000	18,000	19,200	4,500	9,000	13,500	14,400
1000	8,000	16,000	24,000	25,600	6,000	12,000	18,000	19,200

Minimum Bending Radius—Training Cables

A cable's minimum bending radius is related directly to its type of construction and insulation type. Cable bends must not exceed either Superior Essex published information or other published codes such as the NEC. Exceeding the minimum bend radius may damage the conductor assembly, shielding, insulation or armor.

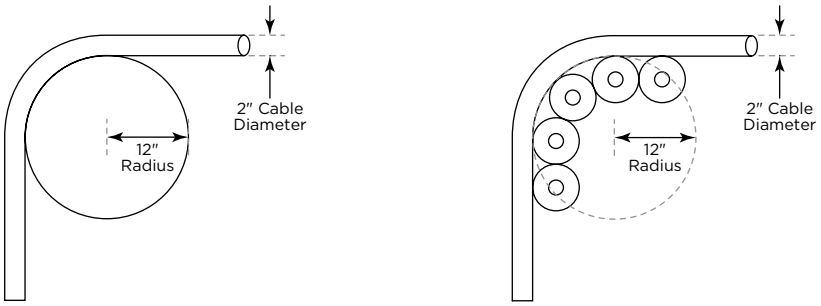
Please reference the following chart for recommended bend radius. This information is provided in Section 330.24 & Section 300.34 of the NEC.

RECOMMENDED MINIMUM BENDING RADIUS				
Volts	Cable Type			Multiplier x Cable OD
≤ 600 Volts	Metal Clad Cables: Type MC (NEC 330.24)	Interlocked or Corrugated Sheath		7
		Smooth Sheath	Maximum diameter ≤ 0.75"	10
			Diameter > 0.75 but ≤ 1.50"	12
			Diameter > 1.50"	15
		Shielded Conductors	Individual conductors	12
			Multi-conductor cable	7
	Power and Control Tray Cables: Type TC (NEC 336.24)		Diameter ≤ 1"	4
			Diameters > 1.0" but ≤ 2.0"	5
			Diameters > 2.0"	6
			Metallic Sheath	12
Over 600 Volts	NEC Section 300.34	Non-Shielded Conductors		8
		Shielded or Lead Covered (during/after installation)		12
		Multi-conductor or Multiplexed		12*/7

**12 times the individual shielded conductor or 7 times overall cable diameter, whichever is greater.*

Example—Minimum Bend Radius

A tray cable with an overall diameter of 2″ would have a minimum bend radius of 12″ (6 x O.D). Any radius roller or sheave wheel used would require a minimum diameter of 24″.



Cable Pulling

Pulling Equipment

When pulling large conductors, pulling tension can easily reach thousands of pounds. Ensure that all equipment used, such as the pulling eyes, ropes, clevis, and tuggers, is rated for the installation.

Tension must be applied to all elements of the cable. Pulling on just the sheath will likely damage it. Conversely, pulling solely on the core may pull it out of the sheath. In either case, care must be taken to avoid damaging the conductors. The recommended method for ensuring that tension is applied to all elements is by using pulling eyes, basket grips, or pulling grips recommended for the specific installation. The working load specified by the manufacturer of any pulling device should not be exceeded.

If the planned cable run contains several bends, start the pull closest to the majority of the bends to reduce pulling tensions. The worst condition is to pull out of a bend at or near the end of the run.

Accelerate slowly up to a constant pulling speed.

Avoid stopping the cable mid-pull, because friction is greatly increased when re-starting the pull.

Lubricants

The use of a pulling lubricant is highly recommended to minimize friction on the cable jacket. Superior Essex recommends any commercial available pulling lubricant that is UL and/or CSA Listed and has been verified compatible with the applicable jacket material per IEEE Std 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable. It is important to also ensure the pulling lubricant is compatible with the conduit material.

Pulley and Sheave Sizes

Pulleys and sheaves must be sized so that they are larger than the minimum bend radius of the cables being installed. If multiple pulleys are required, they should be arranged so that the cable is supported and transitions easily in and out of the conduit. Larger cables may require the use of radius rollers, where multiple wheels will be required to meet the minimum bend radius.

Rollers and sheaves should be installed in several locations to help avoid abrasion and damage to the cable. The correct placement of these will also help reduce installation time. Pulleys should be located between the reel and the conduit in which the cable is being installed, at cable bends, and at the point where the cable exits the conduit. These are the three most critical locations for reducing the sidewall pressure and pulling tensions.

Calculating SWPB

SWBP should be calculated at each bend in the pull to ensure the maximum allowable limit is not exceeded.

SWBP FORMULAS

Number of Conductors	Position	SWBP Equation
1	Single	SWBP = T ÷ R
3	Cradled	SWBP = [(3w - 2) x T] ÷ 3R
3	Triangular	SWBP = (w x T) ÷ 2R
4	Diamond	SWBP = (w - 1) x (T ÷ R)

- **T** = tension exiting the bend in pounds
- **R** = bend radius in feet
- **w** = weight correction factor
- **SWBP** = sidewall bearing pressure in pounds/foot

Calculating Pulling Tension

Estimated pulling tension should be calculated to ensure that the maximum allowable tension is not exceeded and to ensure that SWBP is not exceeded. Tensions can be estimated using appropriate combinations of the following formulas:

Equation 1 (for straight sections)

$$T = T_i + w\mu lW$$

Equation 2 (for inclined sections)

$$T = T_i + lW(w\mu\cos\theta + \sin\theta)$$

Equation 3 (for deviated sections and bends)

$$T = T_i e^{\mu\theta w}$$

- **T** = Tension at the end of section (lbs)
- $\mathbf{T_i}$ = Tension at the beginning of section (lbs)
- **μ** = coefficient of friction (between cable and duct or guide)
- **l** = length of section (ft)
- **W** = cable weight (lbs/ft)
- **w** = weight correction factor
- **θ** = angle of inclination, deviation or bend

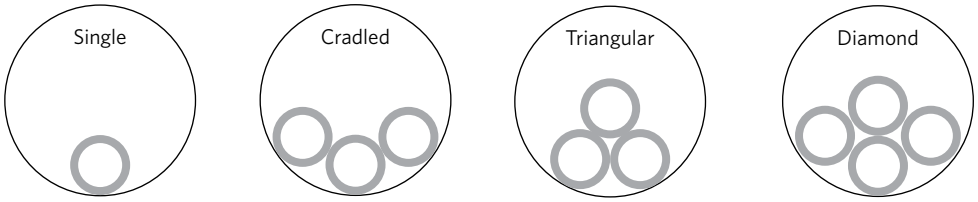
The total tension is the accumulation of the tensions of all the sections, including the back tension on the reel which will be T_i for the first section.

Determining Position or D/d Ratio

In a conduit installation, the geometric position that cables tend to assume has a direct effect on the frictional force, or drag, exerted on the cables. Position can be determined from the D/d Ratio.

$$\text{D/d Ratio} = \frac{\text{Inside Diameter of Conduit}}{\text{Outside Diameter of Individual Cable}}$$

After calculating the ratio, reference the following information to determine the geometric position of the cable(s):



Calculating Weight Correction Factor

The Weight Correction Factor (w) is required to more accurately predict pulling tension in conduit. If unsure about the final position, always assume that the cables will sit in a cradled position (unless pulling triplexed cables from a single reel), because this will yield a more conservative pulling tension calculation.

Using the calculated D/d Ratio and knowing the setup for the pull, determine the geometric position of the cables. Reference the following formulas to calculate the "weight correction factor" for your particular pull:

Single

$$w = 1$$

Cradled

This position may occur when pulling 3 conductors from 3 separate reels and the D/d Ratio is between 2.3 and 3.0. This is the least favorable configuration since it will add the most drag during the pull. Use the below formula for the cradled position.

$$w = 1 + 1.33 \times [d/(D-d)]^2$$

Triangular

This position may occur when pulling 3 individual conductors from 3 separate reels and the D/d Ratio is less than 2.5. It also applies to a triplexed cable from a single reel. Use the below formula for the cradled position. It is also recommended as a conservative approach for puling dual cables.

$$w = 1/\sqrt{(1 - [d/(D-d)]^2}$$

Diamond

This position occurs when pulling 4 conductors from 4 separate reels and the D/d Ratio is less than 3.0. It also applies to a single quadruplexed conductor pulled from a single reel.

$$w = 1 + 2 \times [d/(D-d)^2]$$

Cable/Conductor Termination

Cables and conductors should be terminated using appropriately listed devices rated for their intended application. System reliability is directly related to the proper termination of the cables and conductors. Follow the connector's manufacturer instructions when terminating copper and aluminum cables and conductors.

Superior Essex does not recommend a periodic re-torqueing or retightening program for mechanical set-screw terminations. Superior Essex recommends an initial thermal benchmarking at energization followed by a periodic maintenance program which compares subsequent values to evaluate termination reliability. Terminations that show excessive heating should be checked for unbalanced loads or loose connection. Loose connections should be cleaned and re-torqued. Re-torqueing connections that do not show excessive heating may damage the conductor over time.

Firestopping

Firestopping is the process of installing an approved system to stop the progress of fire along the cable pathway through fire-resistance rated walls, partitions, floors or ceilings. Approved firestopping methods and materials are used to significantly reduce the possibility of spreading fire, smoke, and toxic gases throughout a building. This is a life safety issue enforced by national and/or local code(s). Refer to the applicable codes to determine the requirements. Then, follow the firestopping system's manufacturer instructions for proper installation.

Appendix

American Wire Gauge Sizes

ce.superioressex.com/uploadedFiles/docs/pdf/technical-guidelines/Energy-Prod-Key-AWG-Metric-Conv.pdf

Metric Conversions

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Energy Cable Common Color Sequence

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Reel Dimensions and Capacities

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