

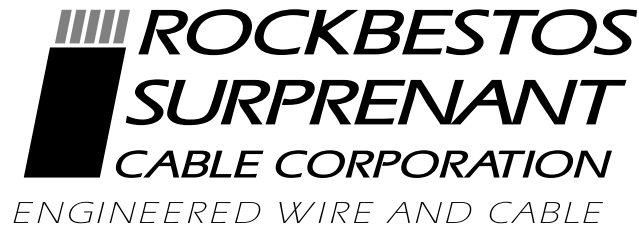
GARDEX[®]

Installation Manual



 **ROCKBESTOS
SURPRENANT**
CABLE CORPORATION
ENGINEERED WIRE AND CABLE

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Gardex® Installation Manual

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1. Introduction

This manual covers installation, and termination recommendations for Rockbestos-Surprenant Cable Corporation (RSCC) Gardex® cable with aluminum armor. The focus is on installation in trays, since this is the predominant use for this construction. It is assumed that the cable has been properly sized and the installation properly designed. The RSCC catalog of products contains additional information on cable weights, diameters, constructions and applications that are intended to supplement this document. Since this manual is only a guide and all situations cannot be covered, please call the RSCC Engineering Department for more specific information.

There are nine sections to this manual, starting with this introduction and a brief overview of Gardex® products. The second section provides material recommendations, with detailed information in Appendix 1. Handling and storage information is presented in section three. An overview of calculations that should be performed prior to installation, including pulling tension, bend radius and cable fill are then presented. Pre-installation information, including minimum installation temperature, precautions, installation equipment, setup, pull tension monitoring, and cable attachment methods are next. Installation recommendations for tray, in earth and in free air, as well as general recommendations follow. Post installation activities are then discussed. The last two sections contain a glossary of terms and references.

Gardex®

Gardex® is a completely self-contained conduit/wire system with a continuous, impervious corrugated armor/sheath that provides a positive gas and moisture barrier. The term sheath and armor can be used inter-

changeably in this construction since the metallic component forms a sheath around the cable of high strength, thereby acting as an armor. This sheath can serve as electrical shielding for many applications, including control cables in substations. Aluminum is primarily used for the armor/sheath, but other materials including copper may be used for special constructions. The Gardex® wire system can be installed indoors or outdoors and is highly impact and crush resistant.

Jacketed Gardex® is available for the following application:

- PVC for direct burial or embedment in concrete
- PVC, Neoprene or CSPE for corrosive environments
- RSCC Arctic Grade, PVC and Neoprene for severe low temperature applications

Gardex® is UL listed and NEC recognized for the following hazardous locations:

- Class I, Division I
- Class I, Division 2
- Class II, Division 2
- Class III, Division 1 & 2 (Type MC only)

Gardex® is easy to install, flexible and available in long continuous lengths. The wire system's flexibility allows the cable to be formed around obstructions, saving valuable installation time and the cost of associated conduit fittings. Installation costs can also be cut dramatically where the use of long continuous lengths are required, such as for the petroleum and petrochemical industry, pulp and paper plants, utilities and other industrial applications.

A full range of sizes is available for Gardex® power, control and instrumentation cables, ranging from 18 AWG through 750 kcmil. Table 1 provides product drawings for typical Gardex® constructions. For special constructions please consult a RSCC representative.

Power: Gardex® used for 600 to 5000 volt power circuits installed in cable trays provides an economical installation that is recognized by the National Electrical Code. Gardex® 5000 volt nonshielded cable is approved for use under NEC Article 310.60, and is approved for direct burial under NEC Articles 330.10.

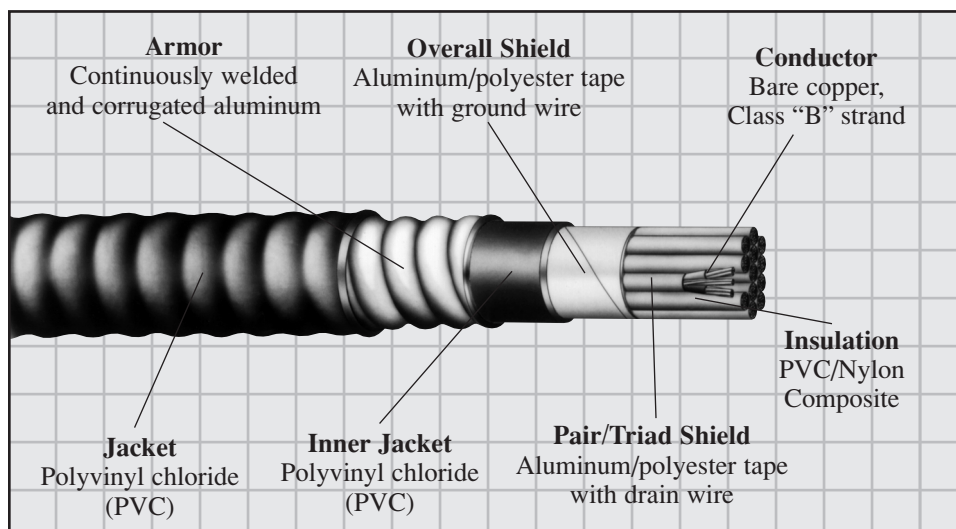
Control: Gardex® is available with large numbers of conductors in a single armor that provides an ideal method of wiring for major control circuits in hazardous areas.

Instrumentation: Gardex® offers a variety of conductor combinations consisting of shielded and nonshielded pairs or triads, overall shielding, etc. Various insulation and shielding materials are available for specific requirements.



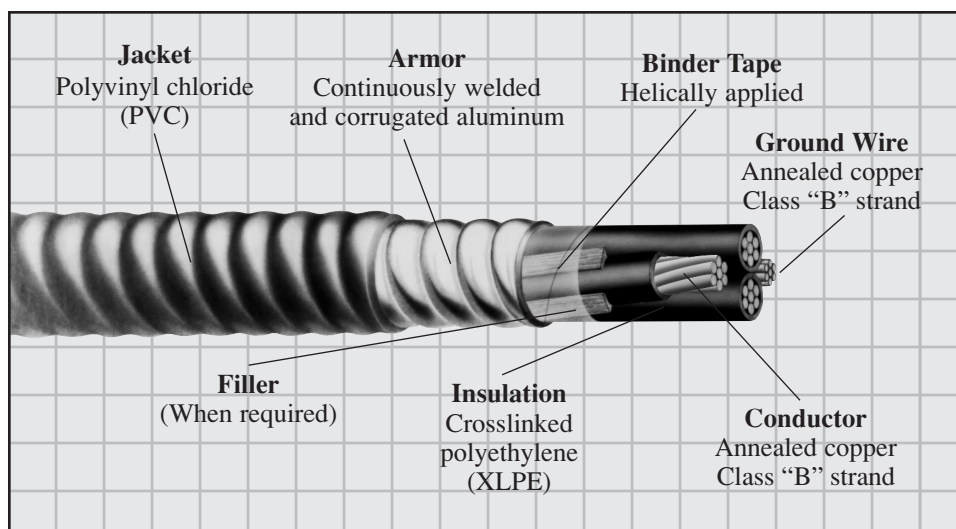
Gardex® Pulp and Paper Plant Installation

Table 1. Product Drawings



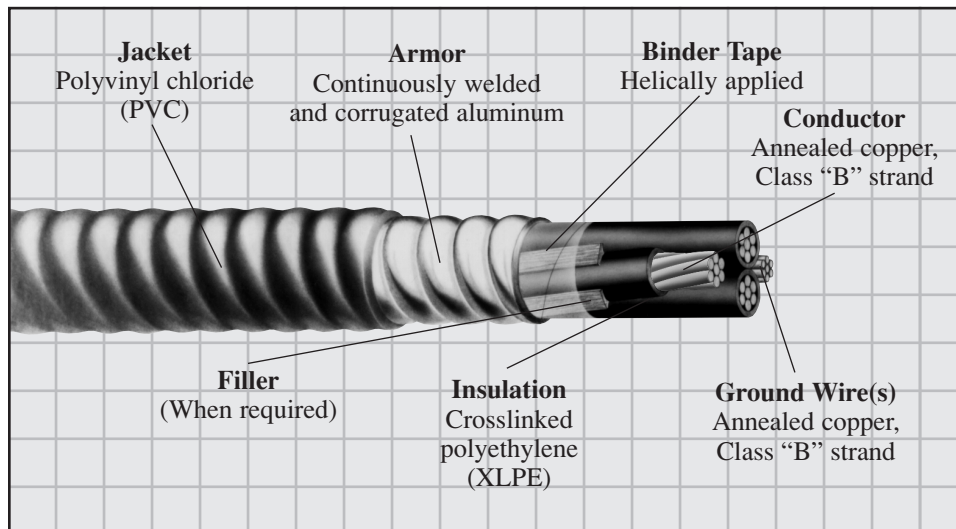
Gardex® CC **Armored Instrumentation Cable**

PVC/Nylon Insulation
Aluminum Armor
PVC Outer Jacket
UL Listed
90°C, 600 Volt
NEC Type MC-HL
UL Type CWC MC
UL1309/CSA C22.2 No.245
Marine Shipboard Cable
Spec. RSS-8-016



Gardex® CC **Armored Control Cable**

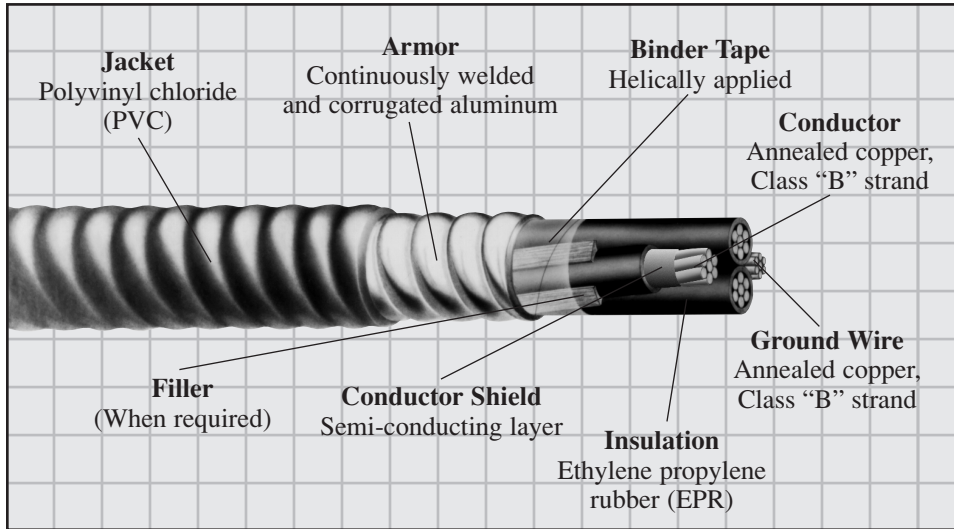
XLPE Insulation
Aluminum Armor
PVC Outer Jacket
UL Listed
90°C*, 600 Volt
NEC Type MC-HL
UL Type CWC MC
UL1309/CSA C22.2 No.245
Marine Shipboard Cable
Spec. RSS-8-001



Gardex® CC **Armored Power Cable**

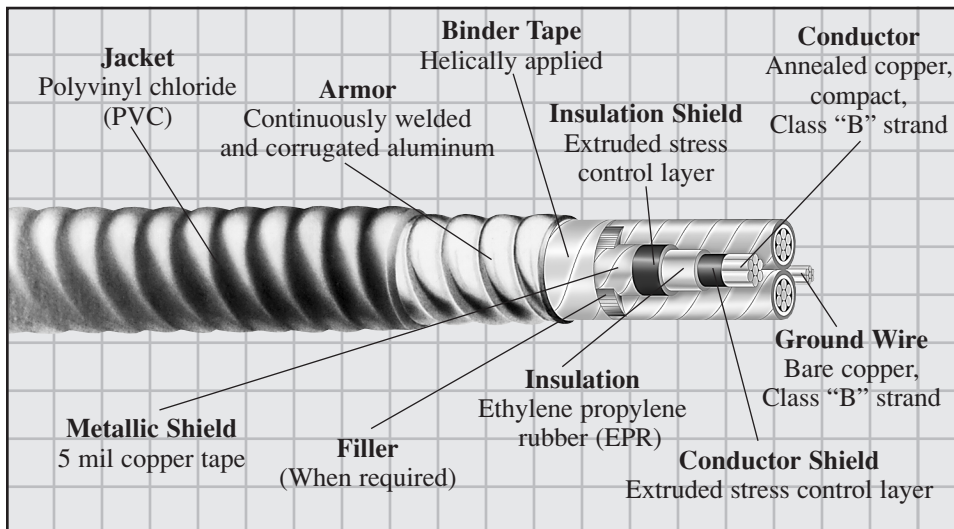
XLPE Insulation
Aluminum Armor
PVC Outer Jacket
UL Listed
90°C*, 600 Volt
NEC Type MC-HL
UL Type CWC MC
UL1309/CSA C22.2 No.245
Marine Shipboard Cable
Spec. RSS-8-001

Table 1. Product Drawings (Continued)



Gardex® CC **Armored 5kV** **Power Cable**

EPR Insulation
Aluminum Armor
PVC Outer Jacket
UL Listed, 90°C*
5000 Volt, Non-Shielded
NEC Type MV 90
and Type MC-HL
UL Type CWC MC
UL1309/CSA C22.2 No.245
Marine Shipboard Cable
Spec. RSS-8-014



Gardex® CC **Armored 5kV** **Shielded Power Cable**

EPR Insulation
Aluminum Armor
PVC Outer Jacket
105°C*, UL Listed
5000 Volt, Shielded
NEC Type MV 105 and
Type MC-HL
UL Type CWC MC
UL1309/CSA C22.2 No.245
Marine Shipboard Cable
Spec. RSS-8-023

2. Materials

When planning an installation, careful consideration should be given not only to the initial cost of materials and construction, but also to the long-term costs. These long-term costs include maintenance, replacement, and in the case of power feeders, the long-term operating cost over the life of the system. By using the next larger conductor than that required for ampacity and voltage drop considerations, the reduction in I^2R losses may more than offset the additional cost of installing the larger size

conductor. The design should also allow additions, replacements, and other changes to be made easily, at minimum cost, and with minimum interruption of service.

3. Handling and Storage

Gardex® cables are very durable, but the following general handling and storage guidelines should be observed. These sections provide prudent storage and handling measures that should be followed to minimize the possibility of cable damage.

Storage

Cables should be stored to protect them against physical damage and the environment. Protection from construction equipment, falling objects, chemical spills, and other hazards should be considered in selecting storage areas and environments. Fencing or other barriers may be used to protect cables and reels against damage by vehicles or other equipment moving about in the storage area. Reels should be stored upright on their flanges, not stacked (see Figure 1). See Figure 2 for definitions of reel components. Handling should be in a manner that prevents deterioration of and physical damage to the reel and to the cable (see Figure 1). To prevent cables from settling into soft ground and prevent reels from rotting, storage should be on a firm surface, paved if possible, or on planking in an area with good drainage. For these reasons, storage of cable should, preferably, be indoors.

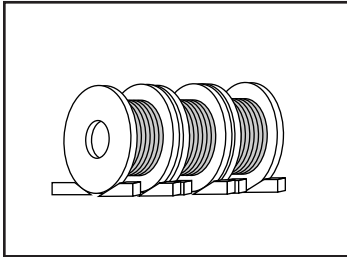
Cables are protected from the direct effects of weather with wrapping or lagging when shipped. When received, the protective cover-

ing or wrap on the cable should be inspected for evidence of shipment damage. Whenever possible, the factory applied protective cover should be left in place until removal is absolutely necessary. Additional covering should be used to protect against the effects of the environment in which the cable is stored, such as outdoors or in excessively dirty, dusty areas. The cover should be resistant to the environment and should be chosen to shield cables from the deleterious effects of the sun. If possible, ventilation should be provided to dissipate any heat buildup.

Both ends of the cable on a reel should be securely fastened to the reel flange, and sealed to prevent entrance of moisture. When shipped, the exposed ends of RSCC cables are protected by shrinkable, molded polyolefin end caps. These caps are weatherproof and should adequately seal the cable against moisture and other contaminants during shipment and storage. Whenever end seals are damaged, missing, or removed look for moisture in the cable. If moisture is found, use suitable measures to dry the cable core and rectify any deleterious effects of the moisture, such as corrosion, prior to installation. If storage is outdoors or in an environment where considerable dirt and moisture are present, protection of the exposed cable ends with shrinkable, molded polyolefin end caps or other suitable means is recommended.

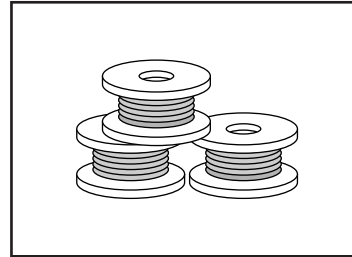
How To Handle Cable Reels

YES

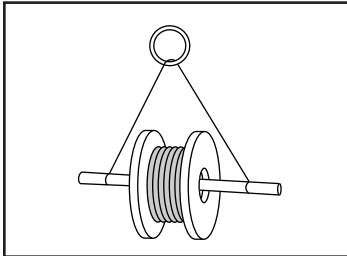


Always load and store reels upright on their flanges and block securely.

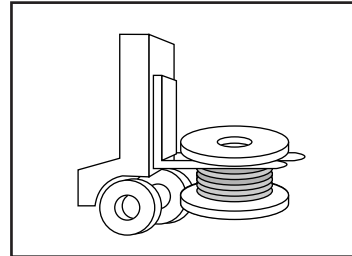
NO



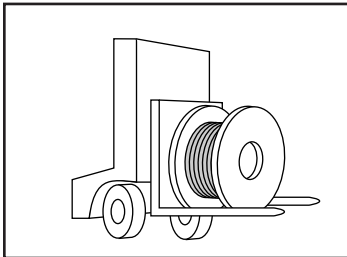
Upended heavy reels will often be damaged.



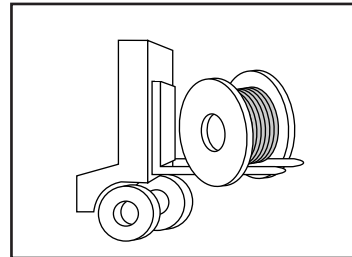
Reels can be hoisted with a properly secured shaft extending through both flanges.



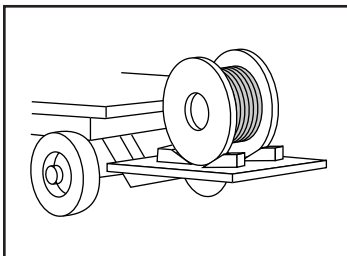
Do not lift by a single reel flange. Cable or reel may be damaged.



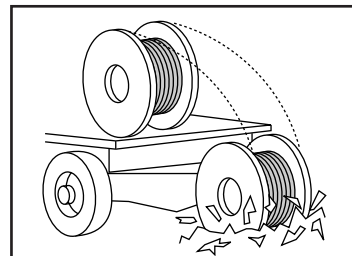
Cradle both reel flanges between fork tines.



Never allow fork tines to touch the cable surface or reel wrap.



Lower reels from a truck using a hydraulic gate, hoist or fork lift. **LOWER CAREFULLY.**



Never drop reels.

Figure 1. Reel Handling

Handling

Cables should only be handled or installed within suitable temperature limits (see Section 5, Minimum Installation Temperature). Cable reels should be handled utilizing equipment designed for that purpose. Reels of cable must not be dropped from any height, particularly from trucks or other transporting equipment. Lifting or handling of cable reels should be done in such a manner that the lifting/handling device does not make direct contact with the cable or its protective covering. Care should also be taken so that the flange of one reel does not impact cable on another reel. If any of these cases occur, the cable should be examined for damage. The following methods are recommended for lifting of cable (see Figure 1):

- A crane or boom type equipment may be used by inserting a suitable shaft, which is properly secured, through the reel arbor hole and lifting with slings. A spreader or other device should be used to minimize sling pressure against the reel flange.
- Forklift type equipment may be used to move smaller, narrower reels. Fork tines should be placed so that lift pressure is on the reel flanges, not on the cable, and must reach all the way across the reel so the lift is against both reel flanges.
- Reels may be moved short distances by rolling. Reels should be rolled in the direction that the cable is wound (see Figure 3). This will tend to tighten the cable windings, not loosen them. Surfaces over which the reels

are to be rolled should be firm, level, and clear of debris including protruding stones, stumps, and other material which may damage the cable if the reel straddles them. Make sure there are no objects in the way that could damage the cable surface by preventing the reel flanges from bearing the total weight.

Table 2 provides capacities of standard RSCC shipping reels. If a cable is transferred to another reel, the drum diameter of the reel should be equal to, or greater than the original reel drum diameter, as shown in Table 3. Reel flanges should be in good condition to prevent damage to the cable. The reel should be capable of accommodating the cable length with at least 1 1/2 inches of clearance below the top of the flange. The reel should have an adequate weight capacity. Care should be taken to assure that cable limits for bending radius are not violated and the cable is not twisted during rereeling or installation. Appropriate precautions for reeling and unreeling should be followed (see Section 5). Identification and/or marking information should be transferred to the new reel using a permanent marking method.

Cables should be handled carefully during unreeling to prevent damage due to kinking or bending to radii smaller than allowable limits. During handling, cables should not be laid on rough ground, run over, dragged over sharp objects or other such treatment that could cause damage.

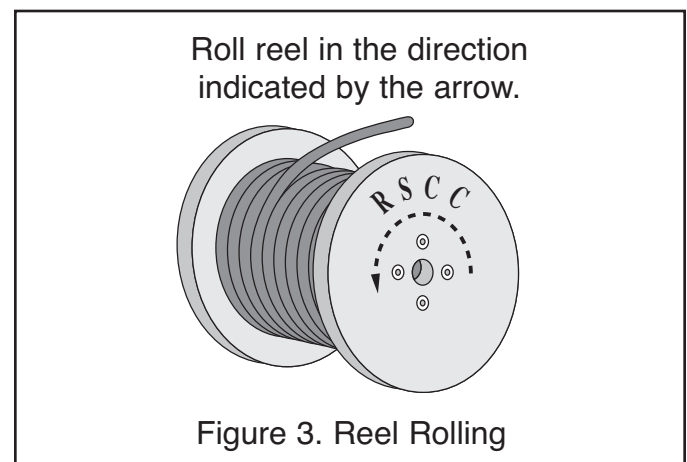
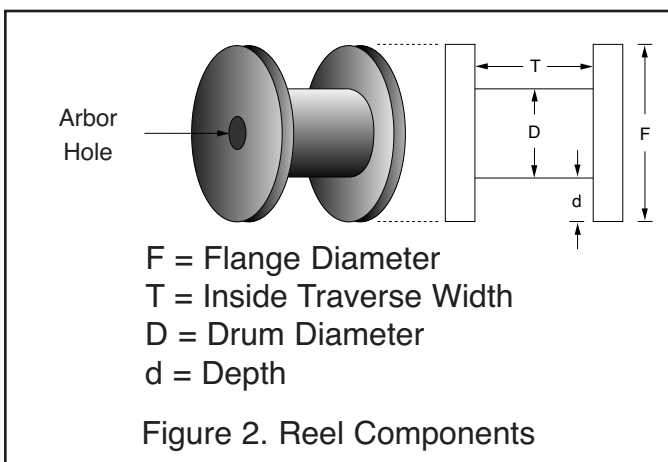


Table 2. Gardex® CC* Length Capacities On Standard RSCC Shipping Reels

Flange (Inches)	14	14	17	19	21	24	24	27	30	34	40
Traverse (Inches)	6	12	12	12	12	12	18	18	24	24	24
Drum (Inches)	6	6	8	8	10	10	12	12	14	14	16
Tare Wt: (Lbs)	3	4	5	8	10	15	25	35	50	70	95
Max. Net: (Lbs)	100	100	150	225	250	300	400	900	900	1,500	3,000
Cable Diameter	Reel Capacity In Feet										
0.150	1,983	4,018	5,470	7,756	8,997	-	-	-	-	-	-
0.200	1,124	2,286	3,020	4,248	4,927	7,414	8,458	-	-	-	-
0.250	724	1,480	1,981	2,769	3,211	4,725	5,521	8,030	-	-	-
0.300	460	944	1,292	1,787	2,073	3,267	3,568	5,561	8,904	-	-
0.400	271	562	698	1,044	1,211	1,822	2,091	3,110	5,066	7,298	-
0.500	-	-	485	677	786	1,156	1,361	1,979	3,279	4,706	6,847
0.600	-	-	-	-	505	796	877	1,367	2,093	3,216	4,600
0.700	-	-	-	-	368	541	641	932	1,608	2,353	3,464
0.800	-	-	-	-	-	-	464	709	1,245	1,708	2,616
0.900	-	-	-	-	-	-	-	-	964	1,361	1,959
1.000	-	-	-	-	-	-	-	-	741	1,084	1,596
1.100	-	-	-	-	-	-	-	-	-	-	1,300
1.200	-	-	-	-	-	-	-	-	-	-	-

Flange (Inches)	40	40	48	50	60	66	72	78	84	84	84
Traverse (Inches)	24	24	24	32	32	32	36	36	36	48	54
Drum (Inches)	16	24	24	24	32	32	40	40	48	48	48
Tare Wt: (Lbs)	95	90	133	193	280	380	490	545	670	685	852
Max. Net: (Lbs)	3,000	3,000	3,000	6,000	6,000	9,000	9,000	9,000	10,000	10,000	12,000
Cable Diameter	Reel Capacity In Feet										
0.700	3,464	2,392	4,510	6,649	8,856	-	-	-	-	-	-
0.800	2,616	1,852	3,405	5,074	6,815	9,215	-	-	-	-	-
0.900	1,959	1,435	2,550	3,854	5,233	7,305	8,903	-	-	-	-
1.000	1,596	1,102	2,077	3,169	4,334	5,782	6,991	8,957	9,456	-	-
1.100	1,300	831	1,692	2,611	3,600	4,891	5,885	7,164	8,036	-	-
1.200	1,055	759	1,373	2,147	2,990	3,830	4,965	6,112	6,366	8,561	9,659
1.300	969	697	1,262	1,756	2,476	3,230	4,189	5,224	5,409	7,279	8,214
1.400	784	516	1,021	1,625	2,037	2,990	3,526	4,464	4,591	6,183	6,979
1.500	728	479	948	1,323	1,895	2,529	2,953	3,809	4,272	5,758	6,501
1.600	-	447	759	1,236	1,549	2,126	2,761	3,236	3,631	4,897	5,530
1.700	-	314	711	994	1,454	1,995	2,303	3,037	3,066	4,139	4,675
1.800	-	-	-	-	1,173	1,669	2,169	2,574	2,888	3,901	4,407
1.900	-	-	-	-	1,107	1,576	1,793	2,432	2,424	3,278	3,704
2.000	-	-	-	-	1,049	1,306	1,698	2,047	2,297	3,107	3,512
2.100	-	-	-	-	829	1,239	1,382	1,944	1,908	2,584	2,921
2.200	-	-	-	-	789	1,179	1,315	1,619	1,816	2,461	2,783
2.300	-	-	-	-	-	-	1,254	1,544	1,732	2,349	2,657
2.400	-	-	-	-	-	-	1,199	1,475	1,418	1,925	2,178
2.500	-	-	-	-	-	-	956	1,412	1,358	1,844	2,087
2.600	-	-	-	-	-	-	916	1,160	1,302	1,769	2,003
2.700	-	-	-	-	-	-	880	1,114	1,250	1,700	1,925
2.800	-	-	-	-	-	-	846	1,071	1,001	1,363	1,544
2.900	-	-	-	-	-	-	-	-	964	1,313	1,488
3.000	-	-	-	-	-	-	-	-	929	1,266	1,435
3.100	-	-	-	-	-	-	-	-	896	1,223	1,386
3.200	-	-	-	-	-	-	-	-	865	1,182	1,340
3.300	-	-	-	-	-	-	-	-	837	1,144	1,297
3.400	-	-	-	-	-	-	-	-	648	886	1,005
3.500	-	-	-	-	-	-	-	-	-	-	-

* NOTE: Shaded area indicates that the chosen reel size is too small for corresponding Gardex® CC cable.

Table 3. Minimum Reel Drum Diameter

Cable Type	Cable Diameter Range (Inches)	Minimum Drum Diameter As A Multiplier Of Cable Diameter
Gardex® Continuously Corrugated	All Sizes	14 X

4. Pulling Calculations

When cables are pulled into raceways (such as trays), they are likely to be subjected to physical stresses that they will never again be required to endure. The prime cause of pulling forces is the friction of the cable against the supporting and contact surfaces. If the supporting surface is straight and horizontal, this friction is caused by the weight of the cable in contact with this surface. If the surface is not horizontal, the weight of the cable also affects the pulling load, but is dependent upon the angle of inclination. This angle may add to or lessen the total pulling force, depending upon whether the pull is up or down.

When a cable is pulled around a bend, it is in contact against the inner arc of curvature of the bend. If any substantial amount of pulling force has been developed in the cable, the friction load due to the pressure at this point will greatly surpass that due solely to the weight of the cable. Thus, bends in the run increase the pulling load significantly.

Factors that should be considered prior to installation, to minimize the possibility of cable damage, are as follows:

- Tensile strength of the conductors
- Method of attachment to the cable
- Sidewall pressure
- Estimated pulling tension
- Force required to pull the cable off the reel
- Coefficient of friction between the cable and adjacent surfaces
- Percentage of raceway area filled
- Bend radius

Each of these items is discussed in the following sections starting with tension calculations. Two tension calculations are required for each cable installation. The first calculation is the “Maximum Allowable Pulling Tension” for the particular cable to be installed.

This value is dependent upon the method of attachment to the cable, the allowable sidewall bearing pressure, and the construction of the cable.

Secondly, knowing the weight of the cable and the details of the installation configuration, the “Estimated Pulling Tension” that may occur during installation can be calculated.

Maximum Allowable Pulling Tension

The maximum allowable pulling tension on the cable(s) is the lesser of the maximum allowable tension based on conductor strength (T_c), the maximum allowable tension based on sidewall pressure (T_p), and the limit based on the attachment method to the cable.

Conductor Tensile Strength

It is assumed that the method used to attach the cable to the pull rope transfers all forces to the conductor. The tensile strength of the conductor then becomes a limiting factor for the force that can be applied. Copper elongates slightly before breaking, which changes the resistance characteristics. A safety factor is used to prevent this, as well as other items. This tension is determined by the following formula:

$$T_c = K \times F \times \text{kcmil}_T$$

T_c = Maximum allowable tension based on conductor tensile strength (pounds)

K = Factor based on material strength with a safety margin;
8 for annealed copper

F = Factor to account for possible unequal tension distribution

kcmil_T = The sum of the circular mil area of all conductors in thousand circular mils (kcmil)

When all conductors are the same size, the equation becomes:

$$T_c = K \times F \times \text{kcmil} \times N$$

kcmil = Circular mil area of one conductor in thousand circular mils (kcmil)

N = Total number of conductors pulled

The tension distribution factor (F) is 1 for a single multiconductor cable, 0.8 when pulling more than one cable of equal conductor size, and 0.6 when pulling multiple cables of unequal conductor size. Ground wires and armor should not be considered in these computations. The conductor circular mil area, and the conductor strength for one and three annealed copper conductor(s) of a single cable (N=1 and 3, and F=1) using the above equation is provided in Table 4.

Cable Attachment Limit

The maximum allowable tension is also limited by the ability of the device used to connect the cable to the pull rope to withstand the forces applied. When pulling by gripping the conductors with a pulling eye or bolt, the maximum tension is usually limited to 10,000 pounds. This is dependent upon the pulling eye or bolt used and the method of application. The manufacturer's recommendations should be followed. When the conductors are gripped with a properly sized and applied basket weave grip, the limit is 2000 pounds. This is based upon the hoop stress applied with a basket grip and the cable construction.

Sidewall Pressure

When a cable is pulled around a bend, radial force is exerted on the insulation, armor, and jacket as the cable is pressed against the inner arc of the bend (see Figure 4). This is referred to as sidewall pressure and is expressed as pounds per foot of radius.

Sidewall pressure is important in cable pulling calculations for two reasons. The first is its increase in the total pulling tension due to greater pressure between the cable and the

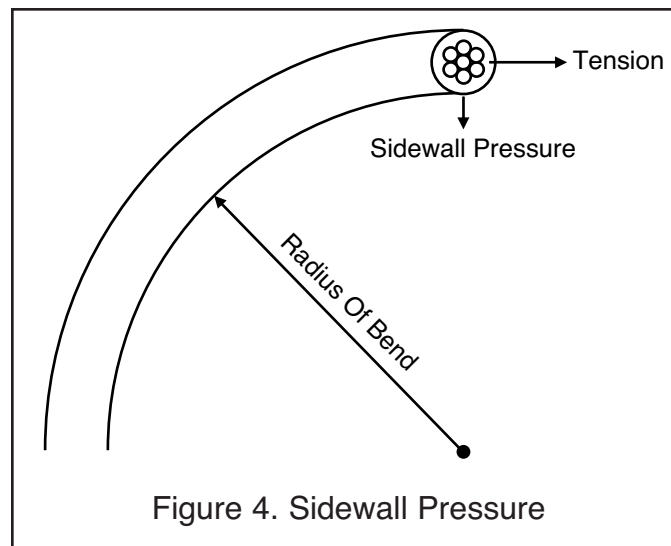


Figure 4. Sidewall Pressure

bend. The second is its crushing effect upon the cable insulation and the possibility of permanent damage to the insulation and/or the cable armor if excessive sidewall pressures are permitted. Sidewall pressure is usually the determining factor when establishing maximum allowable pulling tension for large conductor sizes.

The maximum value for sidewall pressure depends on the cable design. For Gardex® with aluminum armor it is normally 400 pounds per foot of bend, with a 10 times pulling radius multiplier. Under certain circumstances it may be necessary to reduce the bend radius multiplier to 7 times (which is provided for permanent training). For this case, the sidewall pressure should not exceed 300 pounds per foot of bend. The formula for sidewall pressure for a single cable is as follows:

$$T_p = \text{SWP} \times R$$

T_p = Maximum allowable tension which will not exceed the sidewall pressure limit in pounds*

SWP = Sidewall pressure limit in pounds per foot

R = Radius of bend in feet

* This value may be more limiting than the maximum tension T_c based on conductor strength. The lower value of the two governs.

Table 4. Maximum Tension Based On Copper Conductor Tensile Strength Limit

Conductor Size (AWG or kcmil)	Equivalent Circular Mil Area (kcmil)	1/C T_c (Pounds)	3/C T_c (Pounds)
20	1.02	8	24
19	1.29	10	31
18	1.62	13	39
16	2.58	21	62
14	4.11	33	99
13	5.18	41	124
12	6.53	52	157
10	10.38	83	249
9	13.09	105	314
8	16.51	132	396
6	26.24	210	630
4	41.74	334	1,002
3	52.62	421	1,263
2	66.36	531	1,593
1	83.69	670	2,009
1/0	105.6	845	2,534
2/0	133.1	1,065	3,194
3/0	167.8	1,342	4,027
4/0	211.6	1,693	5,078
250	250	2,000	6,000
300	300	2,400	7,200
350	350	2,800	8,400
400	400	3,200	9,600
500	500	4,000	12,000*
600	600	4,800	14,400*
750	750	6,000	18,000*

* Do not exceed cable attachment limit.

Table 5. Maximum Tension Based On SWP Limits For Various Sheave Diameters

Sheave Inner Diameter (Inches)	Maximum Tension Based On SWP Limit - T_p (Pounds)	
	SWP = 400 Pounds/Foot	SWP = 300 Pounds/Foot
10	167	125
12	200	150
15	250	188
18	300	225
20	333	250
25	417	313
28	467	350
30	500	375
35	583	438
40	667	500
42	700	525
45	750	563
48	800	600
50	833	625
55	917	688
60	1,000	750
65	1,083	813

When pulling multiple cables together, additional forces may be encountered based on cable geometry. For these cases contact the RSCC Engineering Department for additional information. Table 5 provides the

maximum tension based on sidewall pressure limits for various sheave diameters. Note that an increase in maximum allowable pulling tension can be obtained by simply increasing the radius of bend.

Estimated Pulling Tension

The installer should calculate estimated pulling tensions for all cables to be pulled, to insure that the allowable values established in the previous sections are not exceeded. The principle equations used for these calculations are as follows:

The estimated pulling tension of one cable in a straight section of raceway may be calculated from the following formula that does not consider changes in elevation:

$$T = L \times W \times K$$

T = Estimated pulling tension in pounds

L = Length of installation in feet

W = Weight of cable in pounds per foot

K = Coefficient of friction

The estimated pulling tension of a cable in an inclined section of raceway may be calculated from the following formulae, where prior tension is the tension at the beginning of the incline.

Upward:

$$T = L \times W (K \cos (a) + \sin (a)) + (\text{prior tension})$$

Downward:

$$T = L \times W (K \cos (a) - \sin (a)) + (\text{prior tension})$$

a = Angle from horizontal

To calculate the tension out of a bend, the following formula may be used:

$$T = T_1 e^{Kb}$$

T = Tension coming out of the bend in pounds

T₁ = Accumulated tension going into the bend in pounds

e = Napierian logarithm base ≈ 2.7183

K = Coefficient of friction

b = Angle of bend

Estimated Sidewall Pressure

The sidewall pressure acting upon a single cable at a bend may be estimated from the following equation:

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

P = Sidewall pressure on the cable in pounds per foot

T = Estimated tension out of the bend in pounds

R = Radius of the bend in feet

Back Tension

The force required to pull a cable off the reel is generally referred to as back tension. This is normally taken to be zero, since the cable is fed off the reel. This value may be negative, and light braking may be applied to control the flow of cable to avoid feeding at too great a rate. For downward pulls, considerable braking may be required.

Coefficient of Friction

The values used for coefficient of friction can vary from 0.1 to 0.8 depending upon many factors including the type of installation, raceway material, the type of cable jacket, and type of lubricant. For well lubricated conduit runs, the coefficient of friction can be as low as 0.3, but a value of 0.5 is generally used in calculations. For tray installations over well lubricated, properly installed sheaves, a value of 0.1 may be used to account for the tension increase as a result of cable sag between sheaves.

Cable Fill

Raceways should not be loaded beyond their maximum capacity. NEC and local code requirements should be observed as required. Cable trays should not be filled above the side rails. For ampacity derating consult the NEC and applicable ICEA standards.

Minimum Bending Radius

In establishing the minimum allowable bend radius for a cable it must be considered that two distinct cases occur. There are bends which occur during pulling (in which case the cable is under tension and is subsequently straightened after leaving the bend) and a bend made as part of the permanent training in position (in which case the cable is not under tension and is usually only bent once). Obviously, for pulling cable under tension, the radius should be as large as practical to minimize the danger of flattening the armor or other damage occurring. For permanent training, when no subsequent straightening or re-bending is required, the minimum allowable radius can be smaller. Guidelines for the minimum permissible radius of bend have been established for these conditions:

- 1) The **minimum training radius**, is used where no tension is applied to the cable (i.e., permanent training), and
- 2) The **minimum pulling radius**, is used where tension is applied to the cable.

The minimum bending radii listed in ICEA standards and the NEC are for permanent training. These values along with RSCC's recommendations for pulling radii are provided in Table 6 as a multiplier of the cable or component diameter. The values for non-shielded components may be used for the individual bending radius of single cables after the armor, separator tape, fillers, etc. are removed and the cables are separated. Twisted pairs and triads, with or without an aluminum/polyester tape, may use the bend radius values for non-shielded cables except using the diameter of the component (including any coverings or jacket). For cases not shown please call the RSCC Engineering Department. Note, bend radius is measured from the inside portion of the cable.

Table 6. Minimum Bend Radius

Cable Type	Cable Diameter Range (Inches)	Minimum Training Radius	Minimum Pulling Radius
Gardex® continuously corrugated	All sizes	7 X	10 X
Non-shielded components	1.000 and less	4 X	8 X
Non-shielded components	1.001 to 2.000	5 X	10 X

The minimum training radius requirements of splices and terminations should comply with splice and termination manufacturer's instructions.

The effective diameter of rollers, sheaves or other pulling devices should be equal to or greater than those specified in Table 7 when the cable(s) is under tension. Note, the sheave diameter is 2 times the sheave radius (see

Figure 5). Rollers, sheaves or other pulling devices that the cable does not pass over (only the pull rope) are not required to meet these requirements. The minimum effective sheave diameter is the minimum diameter that the cable will follow (see Figure 6). It is advantageous to use a sheave with a diameter as large as possible to minimize sidewall pressure constraints.

Table 7. Minimum Effective Sheave Diameter

Minimum Effective Sheave Diameter (Inches)	
Cable Diameter (Inches)	Gardex® Continuously Corrugated
0.50	10
0.75	15
1.00	20
1.25	25
1.50	30
1.75	35
2.00	40
2.25	45
2.50	50*
2.75	55*
3.00	60*
3.25	65*

* A 48 inch diameter sheave may be used if the sidewall pressure does not exceed 300 pounds per foot.

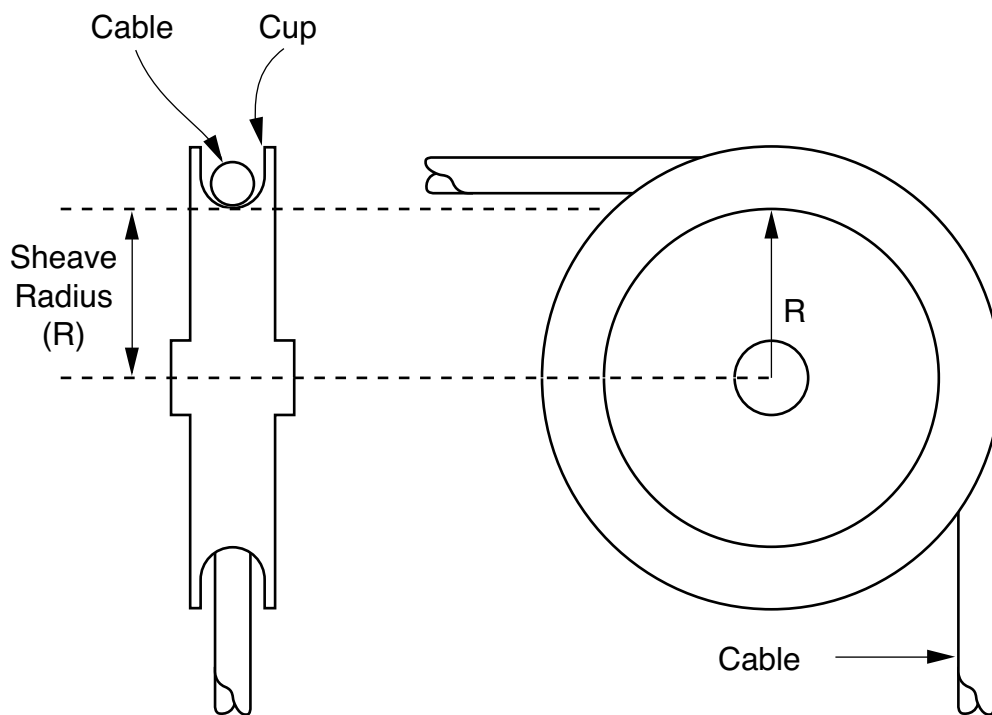


Figure 5. Single Sheave

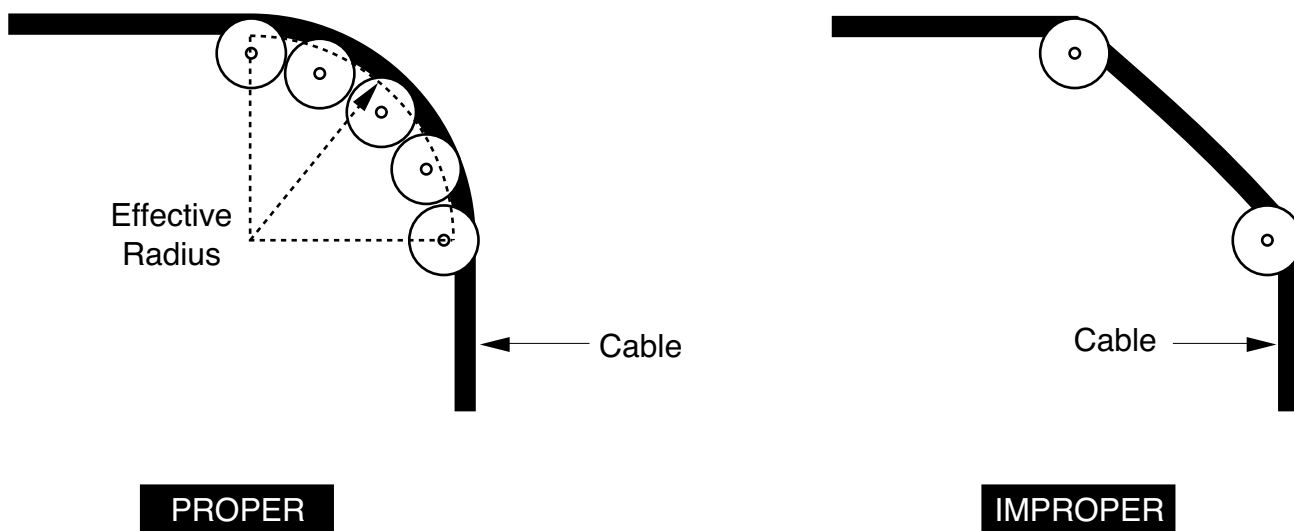


Figure 6. Typical Multiple Sheave Arrangement

5. Pre-Installation

This section deals with factors that should be considered prior to installation. It is highly recommended that cable installations be preplanned. Personnel should be properly trained and qualified for the specific task they are performing. All applicable rules and regulations including federal, state, local, and municipal laws should be followed.

Minimum Installation Temperature

Handling or pulling cables in extremely low temperatures can cause damage to the cable shielding, jacketing, or insulation. To prevent damage of this nature, cables should not be removed from reels or coils, handled, or pulled, without first warming in a heated area (at least 50°F/10°C) for at least 24 hours prior to installation. Cable should be installed as quickly as possible after warming. Minimum installation temperatures will vary depending upon the type of insulation and jacket material used on the cable.* A value of -10°C (14°F) is typically recommended for all cables because this will allow for a considerable degree of rough handling. In cases where this is not possible, the values shown in Table 8 may be used.

*When used, cable lubricants must be capable of functioning without freezing at the installation temperature.

Table 8. Minimum Installation Temperature

Cable Jacket Material	Minimum Installation Temperature (°C)	Minimum Installation Temperature (°F)
PVC	-10	14
Arctic Grade PVC	-40	-40
Neoprene	-20	-4
Arctic Grade Neoprene	-40	-40
CSPE	-20	-4

Precautions

All appropriate precautions should be taken when installing cables, including following OSHA and other applicable regulations. Improper installation procedures can significantly damage or impair the operation or performance of electrical cables. While different cable constructions may have varying degrees of resistance to physical damage, there is no technology that will guarantee a damage-proof cable. Therefore, in addition to observing standard safety practices, the following precautions should be observed:

Ensure that the cable reel is properly secured prior to cable installation. Pulling devices and the pull rope should be used within their rating to prevent breaking of the rope or devices under tension. Appropriate measures should be taken to protect personnel should breakage of the pull rope occur. Personnel should not stand in line with a pull rope that is under tension.

Pull ropes should be stored clean, dry, out of direct sunlight, and away from extreme heat. Some synthetic rope, particularly polypropylene, polyethylene, and aramid (which are not properly treated) may be weakened by prolonged exposure to ultraviolet (UV) rays. Pull ropes should be checked before each pull for signs of aging or wear, including frayed strands and broken yarns. A heavily used rope will often become compacted or hard indicating reduced strength. If there is any question regarding the condition of the rope, it should not be used. No type of visual inspection can accurately and precisely determine residual strength.

Most commercial cable lubricants are water based. Appropriate precautions should be taken when working around energized cables and equipment. Any cable lubricant spilled on the floor should be cleaned up or covered immediately.

Cables should not be pulled around corners that have sharp edges such as corners in cable trays, conduit bodies or other obstructions. Cables may be hand fed around such corners or the use of cable sheaves of the proper radius or other suitable devices may be employed, provided the minimum allowable cable pulling radius and cable sidewall pressure is not violated. The mechanical stresses placed upon a cable during installation should not be such that the cable is excessively twisted, stretched or flexed.

During the time that the cables are exposed and during cable pulling activities, they should be protected from nearby or overhead work to prevent damage to the cable jacket/insulation (e.g., do not step on or roll equipment over cables, etc.). Take care to ensure that cables are not left exposed in high traffic areas where the potential for inadvertent damage is significant. Care should also be taken to protect existing cables, splices and/or terminations from damage when installing new cables through enclosures.

When cable pulling is completed or when cable is partially pulled, the portion of cable not yet routed to its final destination should be coiled and supported to keep the cable off the floor and prevent damage. The coil should be tied in at least two separate locations or a saddle or similar support should be used so that the cable does not support the coil. Train the cable with as large a radius as practical and not less than the minimum allowable. The cable should be protected so the ties do not damage the cable jacket. If coil location requires additional protective measures, a protective cover or protective fire blanket should be provided.

Special care should be exercised during welding, soldering, and splicing operations to prevent damage to cables. If necessary, cables should be protected by fire resistant material. These fire resistant materials should be removed before cable operation unless the cable ampacity has been suitably modified.

Appropriate precautions should be taken in the handling, storage, and disposal of materials.

Installation Equipment

Where mechanical assistance is required, pulling equipment of adequate capacity such as a winch that provides a steady continuous pull on the cable should be used. The pulling equipment should be size based on the maximum allowable tension plus a safety margin. The unit should also be capable of developing the maximum speed required with adequate margin.

Pull rope diameter and length will depend on the pull to be made and construction equipment available. If a pull rope is used it should be sized to have a breaking strength not less than the maximum allowable tension times a safety factor. This is a safety precaution to help ensure that the pull rope does not break during the installation. Pull ropes should be chosen with minimum stretch to reduce the possibility of galloping. All cable monitoring equipment should be calibrated before use.

A swivel should be used between the cable pulling device and the pull rope on all mechanically assisted pulls. On more difficult hand pulls, a swivel may also be advantageous. The primary purpose of the swivel is to prevent damage to the cable from possible twisting forces imparted when pulling the cable. Swivels should be selected that will swivel under anticipated load conditions. Swivels that do not swivel under high load conditions should never be used.

Cable rollers and sheaves used for cable pulling should have a smooth surface, use cupped rollers of adequate size, be in good working order, be properly lubricated, and free spinning. The radius of rollers, pulleys, and sheaves should be considered when calculating estimated sidewall pressure. When using properly designed segmented sheaves (a fixed combination assembly of rollers), the cable conforms to the radius of the overall assembly with no appreciable increase in pressure from the individual rollers. So, the overall radius of the assembly, rather than the radius of the individual rollers, may be used. Typically, if these devices were used, they should be used on the feeding end where the tension is near zero, so that sidewall pressure will be very low. If not properly utilized, these devices may cause damage. Therefore, segmented sheaves should be exposed to allow for inspection. Take care to avoid exceeding the cable pulling radius with pulling equipment (especially at sheaves and rollers).

Setup

Before installation, the installer should determine that the cable(s) can be installed according to the designed routing and minimum bending radius requirements. Cables should not be routed in close proximity to hot pipes or other heat sources. As a general rule, the total degrees of bend between pull points should not exceed 360 degrees.

Raceways should be examined for acceptability prior to pulling activities. Permanent supports should be properly installed to ensure the rigidity of the raceway so neither the raceway nor the cable will be subjected to damage during the pulling process. Cables should not be installed in raceways that are utilized to carry or support equipment, piping, instrument tubing, or other facilities.

Cable should only be pulled into clean raceways. Prior to installing cable, all debris should be removed. Any abrasions or sharp edges that might damage the cable should be removed. Bushings and dropouts should be installed as required.

The ends of cables located outdoors, in other wet locations, or where contamination is possible, should be sealed prior to, during and after installation to prevent the entrance of water or other contaminants. It is also good practice to seal the ends of all cables during and after installation, when the cables are not immediately spliced or terminated, to preclude moisture or other contaminants from entering. After installation, the sealed cable ends should be inspected to see that they were intact and have not been damaged.

Cable reels should be supported so that the cable may be unreeled and fed into the raceway with light braking, so as not to subject the cable to a reverse bend or overruns as it is pulled from the reel.

The amount of tension necessary to pull a cable should be minimized. The required pulling tension may be reduced by:

- Proper setup of the cable reel assembly (see Figure 7). The setup should ensure that the cable is not kinked or bent beyond the minimum pulling radius or subject to excessive twisting force.
- Pulling in the proper direction. Where practical, a cable pull should begin nearest the end having the greater degrees of bends and exit the end having the least degrees of bends. Also, where vertical sections are encountered, a downward pull is preferred.

- The number and degrees of bends the cable is pulled around under tension should be minimized. This may be accomplished in tray installations by setting up at a bend and pulling the cable straight past any bends at the far end of the installation and feeding additional cable off the reel at the bend. The cable may then be hand fed around the bend(s) at either end.
- Cable pull tension should be minimized by turning the reel and feeding the cable into the raceway.

An experienced cable pulling observer should be stationed at the pulling end and be in contact (visually, by radio or by phone) with the other members of the crew. A suitable guide device should be used to protect and guide the cable from the cable reel into the raceway. The radius of the feeder device should not be less than the minimum bending radius of the cable. Cables exiting the raceway should be protected by similar means.

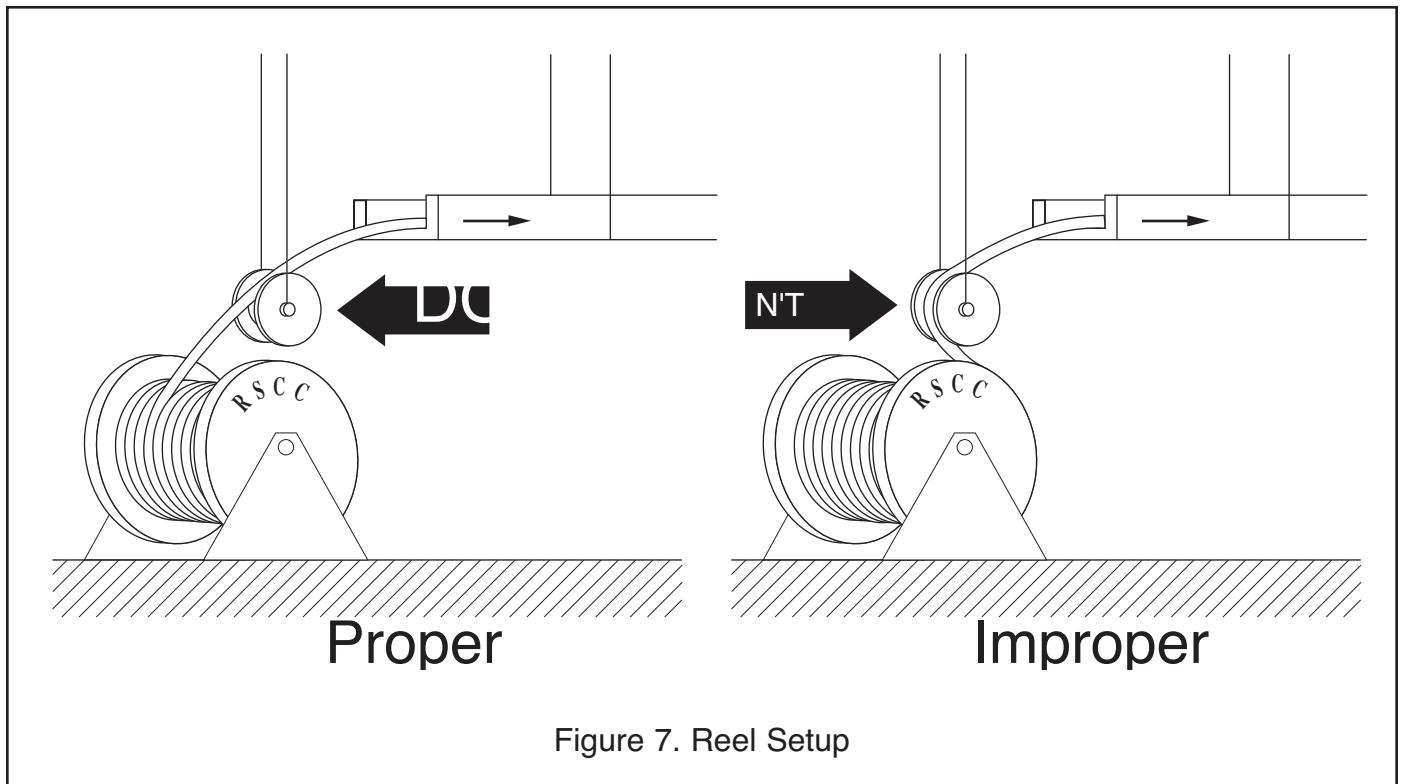


Figure 7. Reel Setup

Pull Tension Monitoring

Cable tension should be limited to less than the maximum allowable pulling tension, to help ensure that the installation process does not damage the cable. This may be accomplished by one of the following two methods:

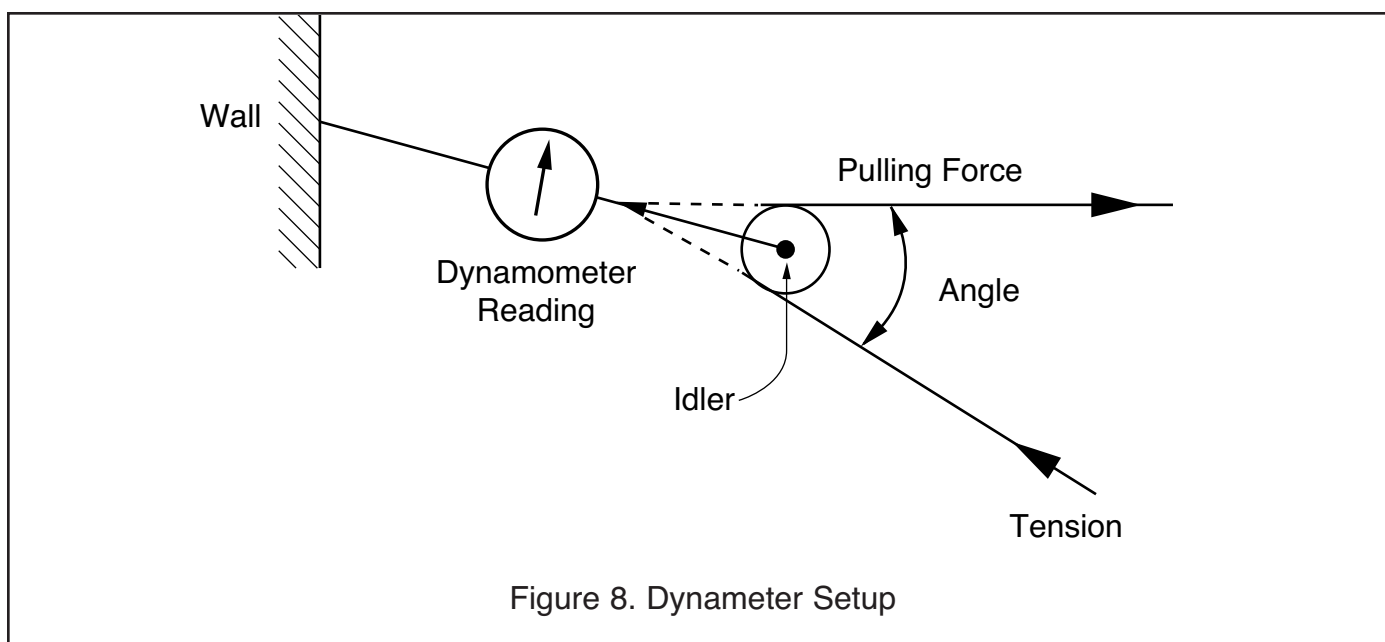
1. Limiting the amount of tension available by use of a properly sized breakaway link.
 - Breakaway links should be sized to be less than the maximum allowable pulling tension.
 - If the maximum allowable tension is excessive, then a breakaway link should not be used unless an estimated tension calculation is performed which indicates the tension to be well within allowable limits.
2. Monitoring the actual tension applied using a tension measuring device.
 - The pull force should be monitored for all high tension pulls (such as mechanical pulls, tuggers, etc.).
 - It is highly recommended that estimated tension calculations be performed for all high tension pulls.

If possible, a direct reading tension measuring device should be used. When this is not

Table 9. Multiplying Factors For Use With Dynamometer Readings

Angle (Degrees)	Multiplying Factor
0	0.5
60	0.6
90	0.7
100	0.8
110	0.9
120	1

possible, and a dynamometer is used that is not placed in direct line with the cable pull, the reading must be multiplied by the appropriate multiplying factor from Table 9 to obtain the true pulling tension (see Figure 8). When the angle falls between two tabulated values, the multiplying factor should be assumed to be the value for the larger angle. If the angle is greater than 120 degrees please contact the RSCC Engineering Department for assistance.



Cable Attachment Methods

If a cable is pulled into a raceway segment the cable should be attached to a pull rope. For Gardex®, both the armor and conductors should be gripped simultaneously. Cables may be gripped with a basket weave device, by gripping the conductors with a pulling eye or similar device, or by a combination of these methods.

At the start of each pull, check that there is no movement of the cable core pulling out of the armor. If any movement is noted, it may be necessary to reinforce the grip between the armor and the core. One method that can be used is to drive three or four nails about two inches apart and around the circumference of the cable through the armor and into the conductor through the copper. These nails can be placed through the spaces of the basket grip weave.

Short lengths of Gardex® cable may be laid in place or pulled with a basket grip only, providing the strain does not elongate the armor beyond the conductors. Longer cable lengths should be pulled by the conductor and the armor. This may be done utilizing a pulling eye on the conductors, which is tied to the eye of a basket grip used on the armor and securing the tail end of the grip to the outside of the cable.

For high force pulls, care should be taken not to stretch the insulation, jacket or armor beyond the end of the conductor nor bend the ladder, trough or channel out of shape.

Cable grips and pulling eyes should be installed according to manufacturer's instructions. All cable connections to the pulling device should be formed in a cylindrical configuration and the leading section of the assembly should be smooth and tapered. The following general rules should be observed.

Pulling Eye

Attachment should be to the conductors only and not the insulation, shield, or other outer coverings.

Basket Weave Grips or Split Grips

Basket weave grips are installed by compressing the grip enough to insert the cable and then securely banding or taping down the trailing end. They are removed by releasing the bands or tape and again compressing the grip enough to slide it off the cable. A backup or push-pull action during the pull should be avoided, because unless securely banded, the grip could loosen enough to pull off. When pulling multiple cables with a basket grip, it may be necessary to apply friction tape between the layers of the cables to prevent differential movement.

Luffing Grips (Mares Tail)

Only luffing grips with flat surface areas should be used. The surface area should be as wide as practical. The straps of the luffing grip should be installed around the cable to form a basket along five to ten feet of the cable. This type of grip is predominantly used to provide intermediate assistance to the pull. Excessive tension, which may damage the cable, should not be applied when using these grips.

6. Installation

This section starts with general guidelines for installation of Gardex® cables and proceeds with more detailed information based on the type of installation.

General

Gardex® is installed and supported in the same manner as other armored cables whether surface mounted, suspended, in cable tray or direct buried. The requirements of NEC Article 330 should be followed as applicable.

Set up to pull as much of the cable as possible, preferably the total length. Position sheaves and pulling ropes, avoiding all obstructions so the cable will move freely during the pulling operation. Attach the pull rope to the cable by suitable means. The armor should be fastened to the pull rope and/or the conductor in order to prevent relative movement of the conductors and armor. Utilize supplementary pulling lines with luffing grips as applicable. The cable should be pulled straight off the reel. Use light back pressure on the cable reel to avoid reverse bending or overrunning as the cable leaves the reel. Back pressure can be applied by a reel brake or by wedging a two-by-four against the flanges of the reel. Maintain a slow but steady speed of up to 20 to 25 feet per minute, avoiding stops and starts as much as possible. Adjust the pulling speed to eliminate galloping (surging), if necessary.

When pulling around a bend, use as large a radius as possible, if necessary, hand feed to keep long smooth curves. Sheaves or other guiding devices can be used provided the bends are not too severe. For difficult pulls involving several bends or changes in elevation, a jacketed cable is recommended for additional mechanical protection.

Lubricants

When cables are laid in trays, pulled over rollers and sheaves, or directly buried,

lubrication is not required. When cables are pulled in contact with a stationary surface, friction at these points will cause an increase in the tension required to install the cable. Therefore, for these cases, including installation or removal from conduit or duct, lubrication is recommended. For additional information, contact the RSCC Engineering Department.

Installation In Cable Trays

When hand feeding (laying) cable in raceways having open tops or removable covers such as cable trays and cable trenches, it is recommended that:

- Personnel be positioned at corners and periodically along the route to “hand feed” the cable into the raceway, or
- Personnel be positioned to “hand feed” the cable along the side of the raceway and then lay it into the raceway.

If cable is installed by sliding it into the tray (for short distances only), a flame retardant plastic cloth should be used to provide protection. Lubrication may be necessary. The plastic cloth should be removed after cable pulling is complete.

Sheaves and rollers should be used when installing cables in trays by methods other than hand feeding. In straight runs, a sufficient number of rollers should be used to preclude the cable dragging on the tray. Sharp bends should be avoided by using a sufficient number of sheave assemblies such that the effective cable bend radius conforms to the contour of the tray bend, to insure the cable bending radius is adequate.

Cable tray manufacturers may recommend the number, type, and location of the sheaves and rollers as well as instructions for their application. When this information is not available, the following general guidelines may be used. The most economical spacing of

rollers depends on the weight of cable to be pulled. In general, the spacing of rollers should range between ten feet for cable weighing over eight pounds per foot and sixteen feet for cable weighing not more than two pounds per foot. When different size and weight cables are installed on the same cable tray, spacing should be determined for the heaviest cable used. Rollers for straight sections should be used near each raceway support assembly. Such a roller arrangement should suffice for any weight cable to be pulled in that raceway.

Cables should be placed neatly, and orderly across the full width of the tray to maintain a uniform level. The cable should be properly spaced for ampacity concerns. Cables should be segregated by voltage level (such as medium voltage and low voltage cables) and separated by function (i.e., power and instrument cables should be installed in separate trays).

During installation, where a cable rests on a tray side rail, such as at cable exit points, temporary tray edging should be used to protect cable. If, after the cable is installed, the cable rests on the side rail then permanent tray edging should be provided. Material used for tray edging should be fire retardant, have a large surface area, be compatible with the installation, and have a suitable temperature rating.

Cables installed in trays having an expansion gap or fitting (to accommodate differential movement) should be placed in the tray in such a manner that a slack section of cable is present. The expansion gap allows for free movement of the trays without damage to the cable. The cables should not be tied down within five feet of each side of the gap.

In Earth

Cable trench depth should be sufficient to provide not less than 24 inches of cover for cables rated 600 volts and less and 30 inches for cables rated 601 volts to 22 kV. Cable depth may be increased to minimize possible

disturbance from surface digging or frost. The width should be large enough to accommodate the cables to be installed with sufficient separation between cables. The bottom of the trench should be loosened and free of rocks and other rough material.

Prepare a bedding of at least 6 inches of selected backfill (finely screened dirt or sand) in the bottom of the trench for the cable to rest upon. In laying the cable on this bedding, allow it to snake slightly in the trench to allow slack when the earth settles. If several cables are to be laid in the same trench, it is desirable to keep them separated uniformly, so earth and sand can be filled in around them. Be certain there are no crossovers. Avoid bruising or distorting the cable during backfilling. Backfill material should not contain large rock, large or sharply angular substances, paving materials, cinders, scrap wood, corrosive substances or other such materials.

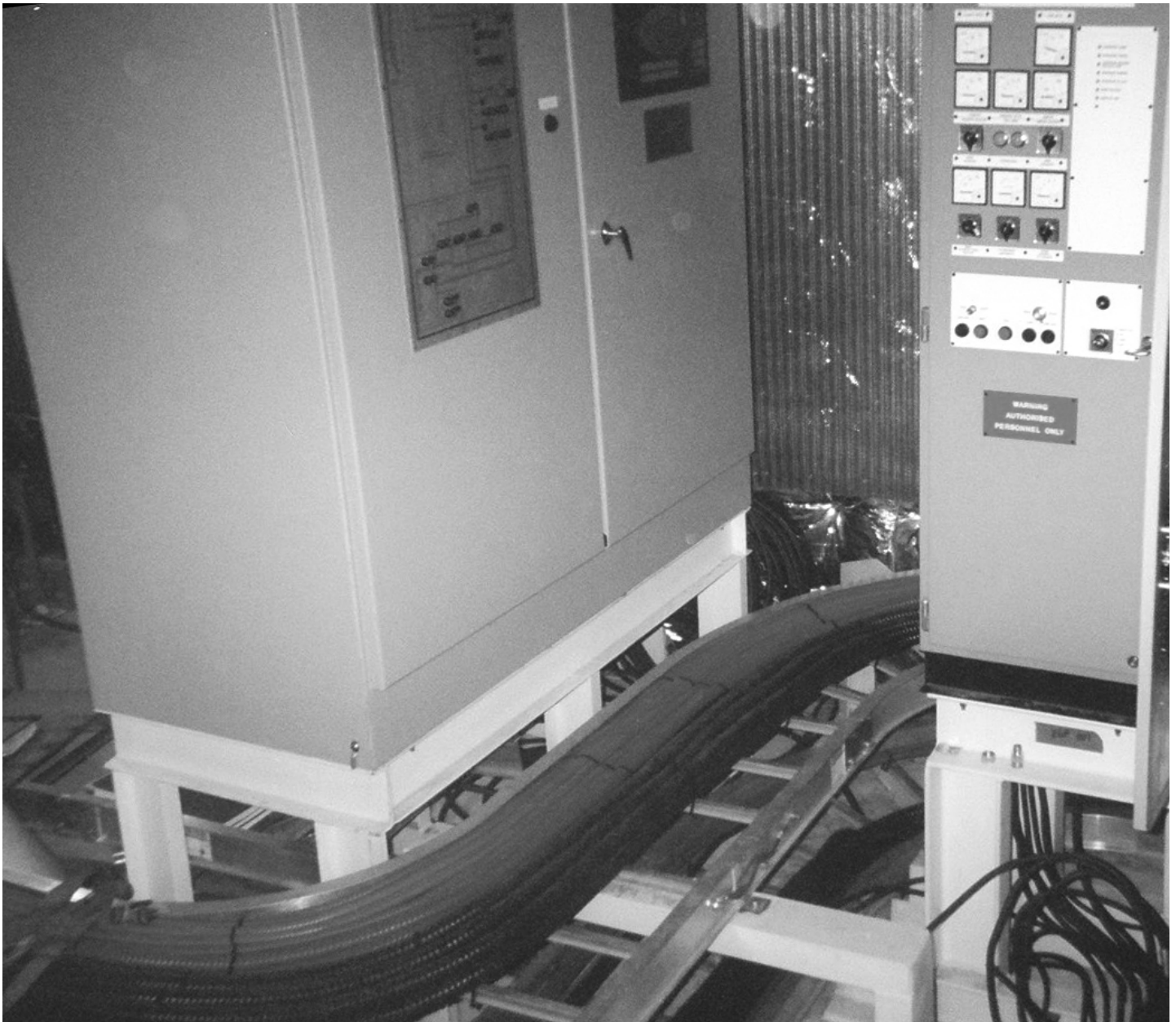
For future use, suitable as-built data of the actual location of the cable before backfilling should be recorded. In areas of heavy traffic or places where excavating is likely to occur, protective slabs should be placed over the screened dirt covering to protect the cables and warn workers of the presence of cables. Where physical protection is not required, use electrical warning tape installed not less than 1 foot above the cables.

Control cable should be separated from power cables by a minimum clear spacing of 1 foot. Crosses and contact between cables should be avoided. Additional separation may be required due to electromagnetic interference. Separation should be maintained by inert nonmetallic spacers where cables must cross. Cables should be separated from crossing pipe lines or other underground structures by a minimum clearance of 1 foot. Additional separation may be required due to ampacity considerations.

Additional protection may be required when the cables are run under roads, or as they enter or exit the ground.

Installation of Cable in Free Air

The horizontal unsupported length of installed cable should not exceed 6 feet. Vertical support should be as appropriate for the installation. A minimum of 1/4 inch clearance should be provided at the points of support between the back of the cable and the wall or supporting surface for metal clad cables used in wet areas. Jacketed cables should be used in wet locations, or other areas where corrosion is possible.



Gardex® Tray Intallation

7. Post Installation

The following section provides general information on post installation activities including, cable terminating, fastening, and testing.

General

A sufficient length of cable should be removed from the pulling end to ensure that an adequate length of undamaged cable is available for termination. Cables that are electrically paralleled for the same circuit should be cut as closely as possible to the same length prior to termination. The cable(s) should be identified with nonconductive tags on both ends of the installation.

Cable slack should be provided at transition points between non-connecting raceways or raceways, and equipment. A sufficient length of cable core should be pulled into equipment, panels and boxes to permit neat arrangement of conductors and compliance with the following:

- Cable should be trained so that the minimum bending radius for permanent training is not violated.
- Any minimum required separation distance is maintained.

Cable Terminating

General procedures for terminating and splicing Gardex® cables are provided below. Since there is a multitude of constructions in the Gardex® family, it would be nearly impossible to cover all constructions in one procedure. Be advised that RSCC cannot be responsible for the effectiveness of a termination or splice because we have no control over the fabrication of these items.

The environment should be clean and dry. Tools should be in good working order and used for the purpose that they are designed. Terminating

materials must be high quality and be compatible with the cable. Manufacturer instructions for the application of insulating and jacketing materials should be followed.

Cable Shields and Drain Wire (Instrument Cable)

- Remove the aluminum/polyester shielding tape a sufficient distance to allow separation of the conductors and drain wire.
- If the shield must extend beyond the jacket cut, wrap two turns of pressure sensitive polyester tape over the end of the shielding tape to prevent unraveling. Apply a shrinkable insulating sleeve or tape at least 1/2 inch long over the wrap to secure the end of the shield and drain wire.
- The end of the shield should be kept a sufficient distance from the terminated conductor (at least 2 inches is recommended).
- If any portion of the exposed drain wire(s) is required to be electrically isolated, insulate with an appropriate length of shrinkable insulating sleeve or tape.
- Depending upon the electrical circuitry, apply a compression or solder type terminal lug or connector to each drain wire separately or together. The drain wires are used to maintain electrical continuity of the shields as necessary.

Non-Shielded Cable (Power and Control Cable)

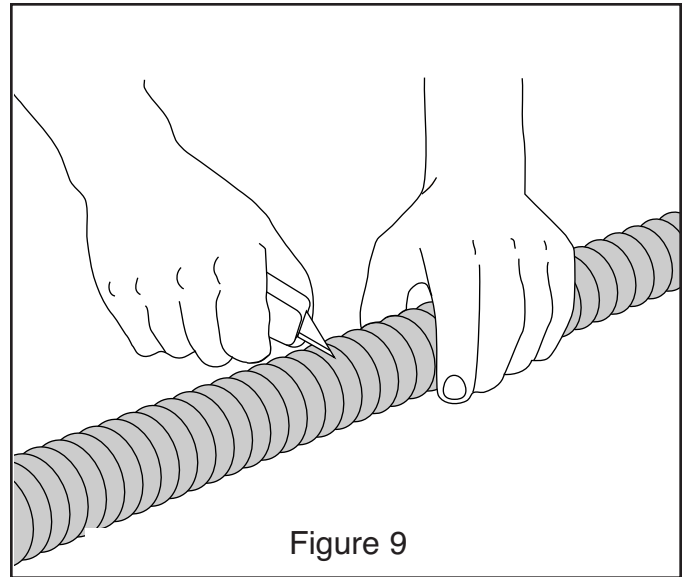
As shown in the following section, remove the outer jacket (if present) and armor from the end of the cable a sufficient distance to allow separation of the conductors, provide the necessary length to connect to the equipment being used, and provide the necessary termination creepage distance. Any underlying tapes and fillers should then be removed.

- In removing this material, care should be taken not to damage any underlying layer, particularly the cable insulation.
- Utilize rounding blocks as required to reshape the armor if distorted
- Install an anti-short bushing under the armor to protect the armor from damaging the cable.
- Install the connector per manufacturer's instructions. Connections to enclosures should be through the use of connectors approved for use with metal clad cable in the particular environment that it is installed.
- If required, a seal should be applied around the connector.
- Strip the insulation, and conductor shielding or separator tape (when present), from each conductor for a distance equal to the depth of the terminal lug plus 1/4 inch. Care should be taken to avoid cutting, nicking, or scoring of the conductor strands.
- Apply compression or solder type terminal lugs or connectors per manufacturer instructions. When using a compression connector, a calibrated, properly sized compression tool should be used. When using a solder connector, protect the insulation and utilize an appropriate flux and solder.
- Insulate the applied terminal lug with a shrinkable insulating sleeve or tape. The sleeve or tape should be of sufficient length after application to cover the connector barrel and at least 2 inches of the conductor insulation.
- Apply a non-tracking covering if required.
- Properly terminate and ground the armor of the cable if that function is not provided by the connector.
- Use proper hardware and tightening torque to connect the terminal lugs.

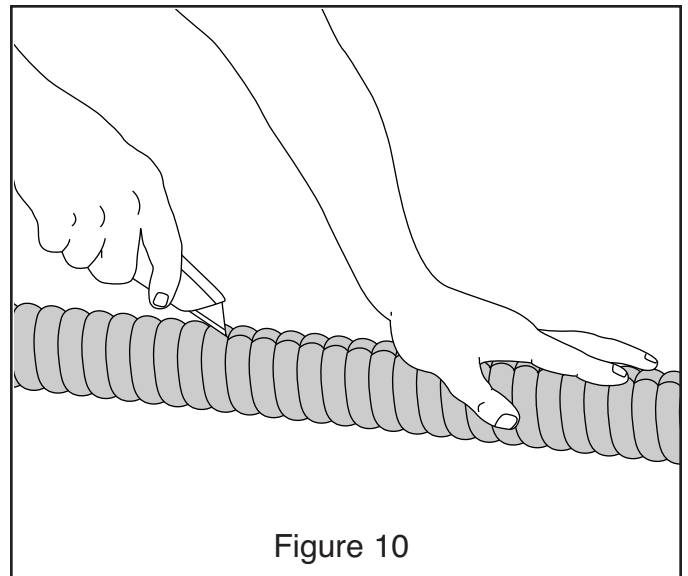
Jacket Removal

To remove the outer jacket:

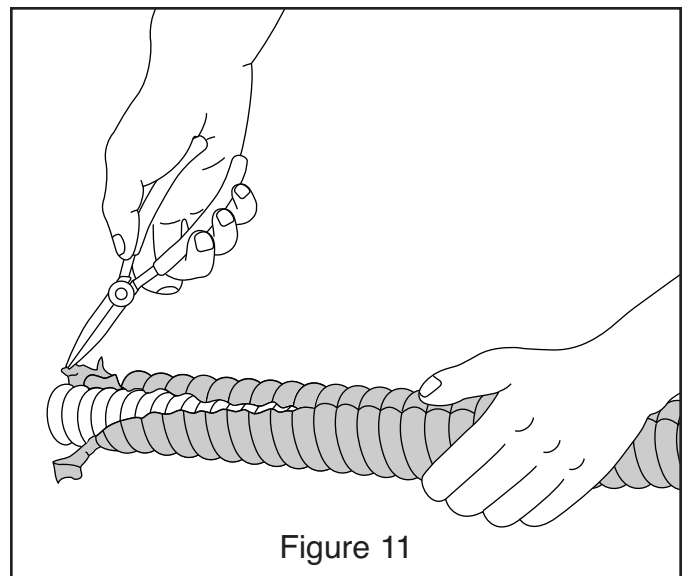
1. Measure the length of jacket to be removed and mark. With a sharp knife score around the jacket to about half its thickness. Do not score the aluminum armor. (Figure 9)



2. Starting at the end of the cable, cut the jacket completely through for the first half inch, continue scoring, but not more than half the thickness of the jacket, back to the score mark. (Figure 10)

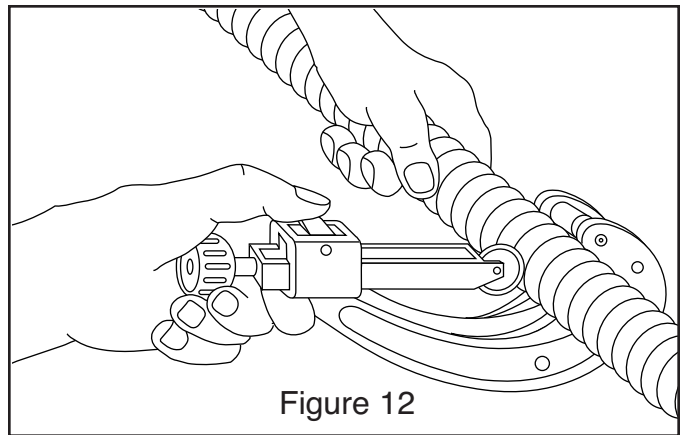


3. Using pliers, pull the jacket away from the aluminum sheath starting at the end of the cable and proceed to tear lengthwise along the score mark to the ring score. Remove the jacket. (Figure 11)

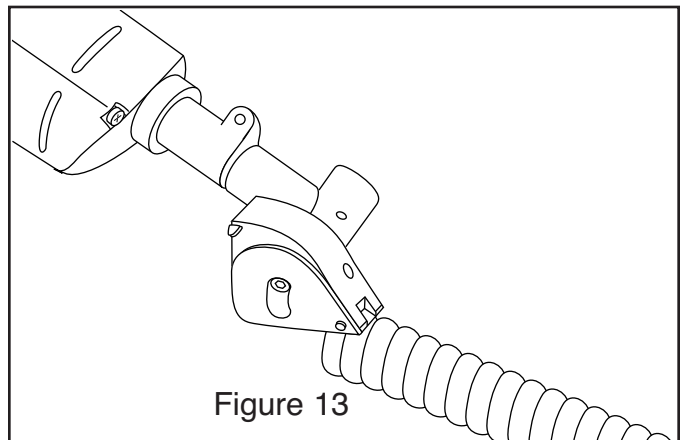


Armor Removal - Gardex[®] CC (Continuously Corrugated)

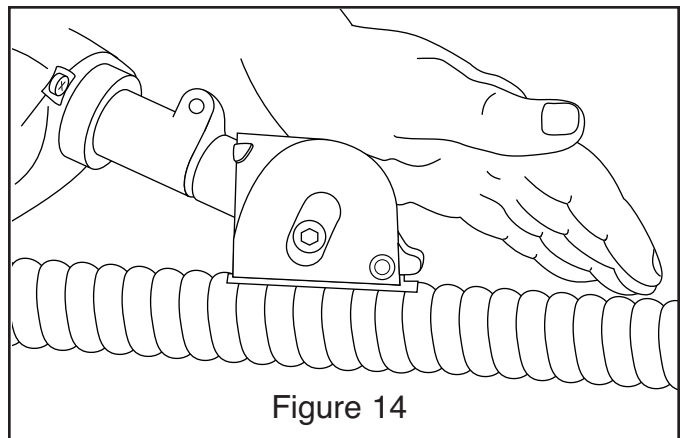
1. Mark where the armor is to be cut by wrapping tape around the cable as a guide. Use a tubing cutter or sharp knife to score the armor to about half of the armor thickness. When using a tubing cutter, the cutting wheel should be adjusted at the crest of a corrugation and rolled back and forth in ever increasing arcs while advancing the wheel until a 360 degree turn can be made without the tool wobbling off track. (Figure 12)



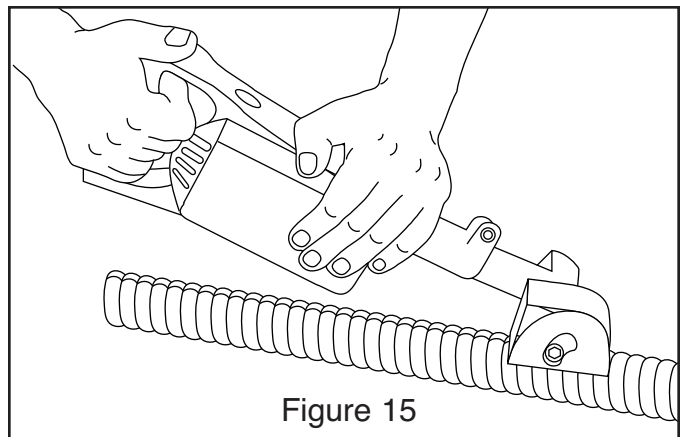
2. Set cutting blade depth to fully cut through the ridge of corrugations and score the grooves. Care should be exercised not to cut through the grooves and damage the cable core. Check blade setting on the armor at the end of the cable (see blade depth setting instructions furnished with the tool). (Figure 13)



3. Be sure blade guard is flat against the cable surface. (Figure 14)



4. Cut longitudinally along the armor with firm pressure on the blade guard of the tool. (Figure 15)



5. With pliers “peel” back the armor on each side of the cut and separate about 3 inches. (Figure 16)

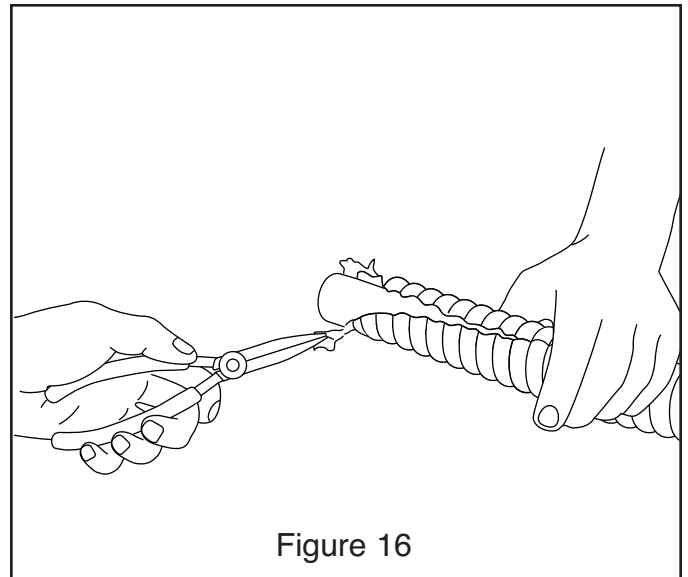


Figure 16

6. With gloves, continue to separate the armor by spreading and/or flexing the cable until the score mark is reached. (Figure 17)

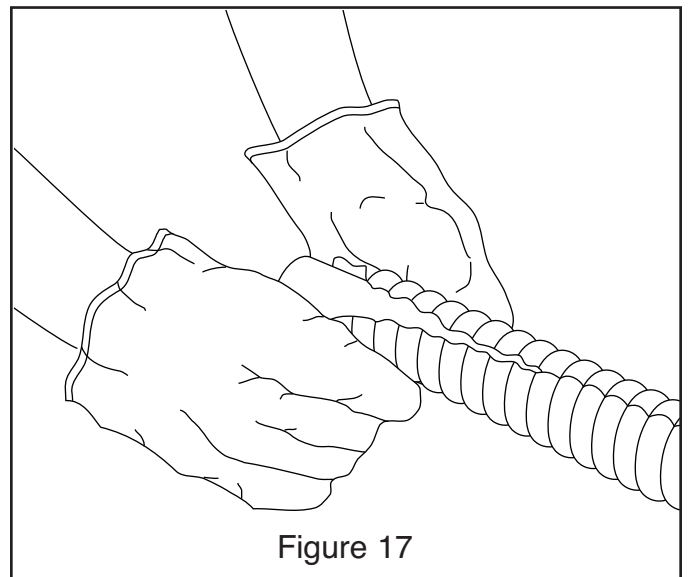


Figure 17

7. Flex cable until armor parts at the score mark. Slide the armor off. Before removing the binding tape, apply the connector per instructions furnished by the manufacturer. (Figure 18)

For larger diameter cable, or when it is necessary to remove long lengths of armor, Kett Model KS-26AM or Kett Model KS-25AM metal saw may be utilized, following the instructions provided above. For cables with a diameter of 1 inch and smaller use the Model 279-1 small cable guide. These tools may be purchased from Kett Corporation (www.kett-tool.com).

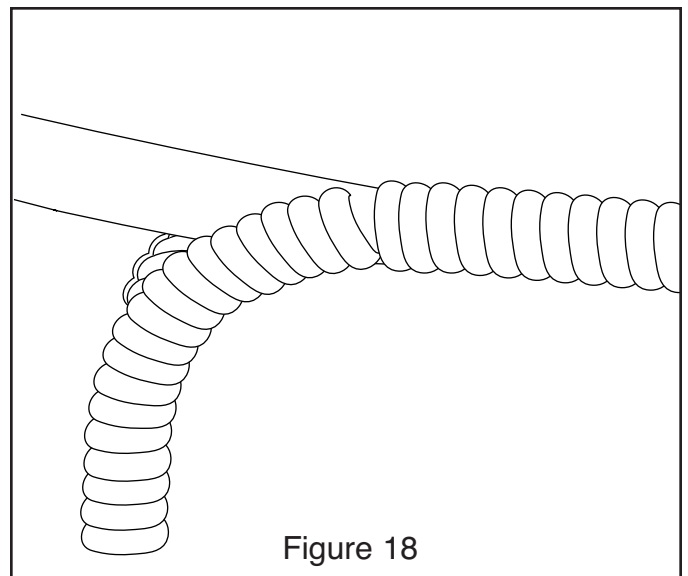


Figure 18

Cable Splicing

Splicing should be avoided with this construction type since the impervious nature of the armor can be compromised. Continuous lengths are best. For additional information, please call the RSCC Engineering Department.

Cable Ties

When required to maintain an orderly and neat arrangement of cables or to maintain spacing between power cables, cable ties should be used. Cable ties should be installed at intervals not exceeding 10 feet. Cable ties should be installed snug, but not to a point to cause damage to the cable.

Cable Support

Install supporting hardware at intervals not exceeding 6 feet. For 14, 12, and 10 AWG conductor sizes, a maximum distance of 4 1/2 feet may be required. Supports may also be required within 12 inches of boxes, cabinets, and fittings. It is recommended that support systems be completed as soon as possible after the cable is installed. Fasten the cable at the far end of the installation and work back toward the reel, straightening as you go.

Straighten by hand if possible, do not use tools such as a hammer or screwdriver, since this may deform the armor.

Bend in small increments, do not try to make the entire bend in one operation, shape into final position gradually. When bending multiple cables at the same place, shape the inner cable and form the other cables to this one. This will provide uniform curves. Do not leave long lengths of cable in a manner that will subject cable to point stresses. If a long length of cable is left hanging coming off a ladder tray, the cable may be damaged by the rung before connection is completed.

Cables should not be held under tension after installation and some slack is desirable in the region of the terminations. In open installations, the cable must be adequately supported to prevent undue strain on the cable and the termination.

Cable Test

After installation and prior to energizing, insulated power, control, and instrument cable should be tested in accordance with established procedures. All measurement and test equipment should be calibrated.

8. Glossary Of Terms

AEIC - Association of Edison Illuminating Companies.

ANSI - American National Standards Institute.

Armor - A sheath, serving or braid or other layer of metal applied over a cable to increase its mechanical protection.

ASTM - American Society for Testing and Materials.

AWG - American Wire Gage.

Breakaway Link - A device that is connected in series with the pull rope that is designed to break at a specified tension.

Cable - A cable is either an insulated conductor (one conductor cable) or a combination of conductors insulated from one another (multiple conductor cable).

Circular Mil (Cmil) - The area of a circle one thousandth of an inch (or one mil) in diameter.

Compatible - A material suitable for use with adjoining materials at the normal operating and emergency environments (i.e., proper size; similar materials, such that no adverse reaction occurs; able to withstand the temperature range, radiation, and other harmful parameters for the area; as recommended for use by the respective manufacturer).

Component - A segment of the cable, particularly pairs, triads, etc.

Conductor - A wire or combination of wires not insulated from one another, suitable for carrying an electrical current.

CSPE (Chlorosulfonated Polyethylene) - A rubbery polymer made by treating polyethylene with chlorine and sulfur dioxide.

Drain Wire - An uninsulated conductor utilized in a shielded cable in direct contact with the metallic shield. It provides shield continuity and aids in terminating.

EPR (Ethylene Propylene Rubber) - A thermoset, rubber like copolymer of ethylene and propylene with or without a third monomer. This material is primarily used as a medium voltage insulation.

Estimated Pulling Tension - The calculated pulling tension based on conduit configuration and cable construction.

FEP (Fluorinated Ethylene Propylene) - A type of high temperature thermoplastic polymer. It can be utilized for both insulation and jacket applications.

Gallop - A phenomenon that may occur when pulling cables where the cable will slide, based on the dynamic friction, then stop until tension increases to a point as to overcome the static friction. At this point, the cable slides again, and the process repeats. To minimize this effect use pulling ropes with minimal stretch (i.e. aramid, etc.).

Gardex® CC - RSCC trade name for continuously welded and corrugated aluminum armor/sheath.

Ground Wire - The conductor leading from a current consuming device to a ground connection.

ICEA - Insulated Cable Engineers Association (Formerly IPCEA).

IEEE - Institute of Electrical and Electronics Engineers (Formerly two separate organizations: AIEE and IRE).

Insulation - As applied to electrical wire and cable, insulation is the covering applied to conductors in order to isolate and confine the electrical currents which they carry. Insulation materials are of many types, i.e., plastic, rubber, etc. and are characterized by high volume resistivity.

Jacket - An extruded plastic or elastomeric material covering applied over an insulation or an assembly of components to provide protection or act as a barrier.

Kcmil - A unit of conductor area in thousands of circular mils (formerly MCM).

kV (Kilovolt) - One thousand volts.

Maximum Allowable Pulling Tension - The maximum tension that may be applied to a cable or group of cables to prevent damage due to type of grip, conductor elongation, and sidewall pressure. This value is the lesser of T_p or T_c .

Maximum Conductor Pulling Tension (T_c) - The maximum tension that may be applied to a cable or group of cables to prevent damage due to type of grip and conductor elongation.

Maximum SWP Pulling Tension (T_p) - The calculated pulling tension which can be used to pull a cable or group of cables without exceeding the cable sidewall pressure limits.

MC - UL type designation for metal-clad cables. These cable designs contain continuously welded (smooth or corrugated) or interlocked armor utilizing aluminum or steel (NEC Article 330 & UL Standard No. 1569).

Minimum Pulling Radius - The smallest radius to which the inside surface of the cable may be bent under tension. This radius should not be less than the minimum training radius.

Minimum Training Radius - The smallest radius to which the inside surface of the cable may be bent for permanent installation while not under tension.

Multiconductor - More than one insulated conductor within a single cable.

NEC - National Electrical Code.

NFPA - National Fire Protection Association.

Neoprene (Polychloroprene) - Synthetic rubber compound used for a cable jacket when thermoset materials are required.

Pull Rope - A high strength line which is attached to the cable to allow it to be pulled.

PVC (Polyvinyl Chloride) - A thermoplastic material composed of polymers of vinyl chloride that is used as an insulation or jacket.

Raceway - Any channel that is designed and used expressly for supporting wires, cables, or busbars. Raceways consist primarily of, but are not restricted to, cable trays, conduit, and ducts.

Reverse Bends - Bends opposite to the direction the cable has been wound on the cable reel.

Sheave - A wheel shaped device used in cable pulling.

Shield - Any barrier to the passage of interference causing electrostatic or electromagnetic fields, formed by a conductive layer surrounding a cable core. It is usually fabricated from a metallic tape, braid, foil, or wire serve.

Sidewall Pressure (SWP) - The radial force exerted on the insulation and sheath of a cable at a bend point when the cable is under tension.

Silicone Rubber - Various polymers in which the main polymer chain consists of alternating silicon and oxygen atoms in combination with either methyl or phenyl, or both. This is a high temperature, thermoset material primarily used for insulation.

UL - Underwriters Laboratories, Inc.

Volt - The practical unit of electromotive force. One volt is required to send one ampere of current through a circuit whose resistance is one ohm.

Voltage Rating - The maximum voltage at which a given cable or insulated conductor is designed to operate during continuous use in a normal manner.

XLPE (Crosslinked Polyethylene) - A material derived from the polymerization of ethylene gas which is crosslinked to increase temperature resistance. It can be utilized for insulation and jacket applications.

9. References

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IEEE 404, "Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5,000 V through 46,000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2,500 V through 500,000 V".

IEEE 422, "Guide for the Design and Installation of Cable Systems in Power Generating Stations".

IEEE 518, "Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources".

IEEE 525, "IEEE Guide for the Design and Installation of Cable Systems in Substations".

IEEE 576, "IEEE Recommended Practices for Installation, Termination, and Testing of Insulated Power Cables as Used in the Petroleum and Chemical Industry".

IEEE 690, "Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations".

IEEE 1185, "Guide for Installation Methods for Generating Station Cables".

NEMA WC 26, "Wire and Cable Packaging".

UL 1569, "Metal-Clad Cables".

NOTES



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