VITALink® MC

2 Hour Fire Rated Cable
UL FHIT 120/ULC S139 FHITC 120

Installation Manual

VITALink®
Circuit Integrity Cable

RSCC®
World Class Engineered Cable

VITALink® MC
Installation Manual
Technical Manual 2015
Issue 3

Table of Contents

Section **Page**

1. Introduction

This manual covers installation, and termination recommendations for *VITAL*ink® MC cable. It is assumed that the cable has been properly sized and the installation properly designed. Since this manual is only a guide and all situations cannot be covered, please call the RSCC Engineering Department for special installations.

There are nine sections to this manual, starting with this introduction. 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 UL System 120/ULC S139 FHITC 120, as well as general recommendations follow. Post installation activities are then discussed. The last two sections contain a glossary of terms and references.

*VITAL*ink® MC

NEC Fire Rated Applications:
The NEC recognizes critical electrical circuits which, in the event of a fire, must continue to perform their intended functions. NEC Article 695 and Article 700 address **"Fire Pump"** and **"Emergency System"** applications respectively. Both require a minimum of a 2-hour fire resistance rating which can be achieved through various methods. This requirement is applicable to the following:

- Fire Pump Feeders
- Emergency Generator Feeders
- Emergency Exhaust Fans
- Emergency Lighting
- Exit Signs
- Firemen's Elevators

Fire Resistive Cable Issues:
One of the options available to designers was to specify a cable system which was qualified to meet the fire endurance requirements of the code. Mineral Insulated (Type MI) cables emerged as the only available technology to meet this stringent requirement.

Although these cables did fulfill the code requirements, they suffered from many inherent problems which manifested in end user difficulties. *Installation problems such as cable stiffness, special mounting procedures, susceptibility to moisture, custom connectors, and termination difficulties forced installers to expend time, labor and resources to overcome these hurdles. Designers had to deal with product limitations that included severe length restrictions and very narrow product offering with respect to size and cable configuration.*

These issues have led to a reluctance by both installers and designers to utilize fire resistive cables. They have pursued costly alternatives such as rerouting, fire proof coating & wrapping systems, and embedding cable in concrete.

The *VITAL*ink® MC Solution:
*VITAL*ink® MC is a "user friendly" fire resistive cable which incorporates the ease and familiarity of Type MC with a 2 hour fire endurance rating. This is accomplished through the use of our revolutionary Fire-Roc™ insulation material. This proprietary thermoset inorganic insulation is applied through the use of a conventional extrusion process, allowing for long lengths and a wide product array typical of standard Type MC cables.

VITALink® MC allows designers to specify without the burden of product limitations; while enabling installers to reap the benefits of Type MC convenience.

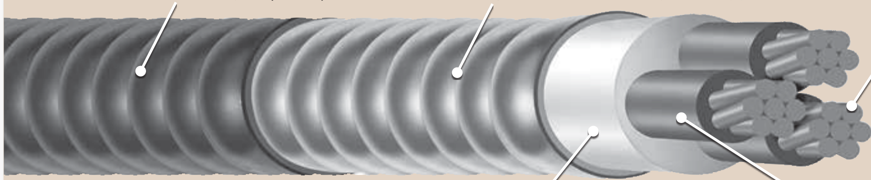
Termination Simplicity

Tools required
to terminate
*VITAL*ink® MC.

Tools required
to terminate
Type MI.

VITALink®
www.vitalinkcable.com

VITALink® MC Transit
2-Hour Fire Rated Power Cable



90°C*, 600 Volt
NEC Type MC
UL Listed
UL Electrical Circuit Integrity System (FHIT 120)

Features

- 2-hour fire rating
- Available as a VFD cable with segmented grounds
- Low smoke, halogen free design
- Simple to terminate with commercially available brass or stainless steel MC connectors
- Printed number coding allows for easy circuit identification
- Uses conventional tools for terminating
- Available in long lengths
- Welded armor forms an impervious barrier
- Armor is impact & crush resistant
- Fire-rated splice available (FHIT 120)

Scope

VITALink® MC Transit is a 600 volt power cable with a 2-hour fire-rating when installed in accordance with the VITALink Installation Manual and Installation Guide. This cable meets the requirements of UL 2196 Fire Resistive Cable Standard as a 2-hour "Electrical Circuit Integrity System". It was specifically designed to meet both the electrical and fire-resistive cable requirements of NFPA 130 and NFPA 502 for Emergency Communications, Emergency Lighting & Emergency Ventilation.

* Rated 90°C for normal operation, 130°C for emergency overload conditions, and 250°C for short circuit conditions.

Applications

Emergency circuits:

- Ventilation
- Lighting
- Communications

Performance Standards

- UL listed, NEC Type MC in accordance with UL Standard 1569
- UL listed as 2-hour fire rated in accordance with ANSI/UL 2196, maximum 480 volts under fire conditions
- Electrical Circuit Integrity Systems (FHIT) — System No. 120 of the UL Fire Resistance Directory
- Meets and exceeds fire rated cable requirements in NFPA 130 for Transit applications and NFPA 502 for Highway Tunnel applications
- Rated FT-4 / IEEE 1202 Vertical Flame test; ST1, limited smoke
- For use in wet locations to 90°C
- Armored with copper sheath that exceeds the NEC requirement for equipment grounding conductor
- Complies with NFPA 130 and NFPA 502 for total smoke released and low toxicity

Construction

Conductor: Annealed copper, Class "B" strand per ASTM B-170 & B-8
Insulation: Thermoset, low smoke zero halogen silicone rubber
Circuit Identification: Printed numbers per ICEA Method 4
Inner Jacket: Thermoset, low smoke zero halogen silicone rubber
Armor: Continuously welded and corrugated copper
Outer Jacket: Black low smoke, zero halogen polyolefin (colors available on request)

RSCC® World Class Engineered Cable

MARMON
Marmon Engineered Wire & Cable LLC
A Berkshire Hathaway Company

Consult factory for availability and minimum quantity requirements

Product Code	Size (AWG kcmil)	Number of Conductors	Nominal Core Diameter (In)	Nominal Armor Diameter (In)	Nominal Cable Diameter over Outer Jacket (In)	Approximate Net Weight (Lbs/1000 ft)
VM02014-200	14	2	0.49	0.82	0.92	490
VM03014-200	14	3	0.52	0.82	0.92	510
VM04014-200	14	4	0.57	0.89	0.99	580
VM02012-200	12	2	0.53	0.82	0.92	522
VM03012-200	12	3	0.56	0.89	0.99	599
VM04012-200	12	4	0.62	0.94	1.04	670
VM02010-200	10	2	0.58	0.89	0.99	604
VM03010-200	10	3	0.61	0.94	1.04	685
VM04010-200	10	4	0.67	1.00	1.10	767
VM03008-200	8	3	0.72	1.04	1.14	838
VM04008-200	8	4	0.80	1.16	1.26	977
VM03006-200	6	3	0.80	1.16	1.26	1,020
VM04006-200	6	4	0.89	1.22	1.32	1,158
VM03004-200	4	3	0.91	1.24	1.34	1,246
VM04004-200	4	4	1.01	1.35	1.45	1,510
VM03003-200	3	3	0.97	1.30	1.40	1,410
VM04003-200	3	4	1.07	1.41	1.51	1,700
VM03002-200	2	3	1.04	1.41	1.51	1,649
VM04002-200	2	4	1.15	1.50	1.60	1,940
VM03001-200	1	3	1.20	1.59	1.71	1,990
VM04001-200	1	4	1.33	1.73	1.85	2,550
VM011X0-200	1/0	1	0.65	1.00	1.10	920
VM031X0-200	1/0	3	1.29	1.67	1.79	2,350
VM041X0-200	1/0	4	1.43	1.82	1.94	2,750
VM012X0-200	2/0	1	0.70	1.04	1.14	1,030
VM032X0-200	2/0	3	1.38	1.80	1.92	2,757
VM042X0-200	2/0	4	1.54	1.95	2.07	3,320
VM013X0-200	3/0	1	0.75	1.08	1.18	1,189
VM033X0-200	3/0	3	1.50	1.92	2.04	3,321
VM043X0-200	3/0	4	1.68	2.12	2.25	3,950
VM014X0-200	4/0	1	0.80	1.16	1.26	1,360
VM034X0-200	4/0	3	1.62	2.04	2.16	4,007
VM044X0-200	4/0	4	1.82	2.26	2.38	4,680
VM01250-200	250	1	0.89	1.22	1.32	1,620
VM03250-200	250	3	1.81	2.26	2.38	4,380
VM04250-200	250	4	2.01	2.46	2.61	5,470
VM01350-200	350	1	0.99	1.35	1.45	2,000
VM03350-200	350	3	2.03	2.48	2.63	6,242
VM04350-200	350	4	2.26	2.71	2.86	7,050
VM01500-200	500	1	1.12	1.48	1.58	2,575
VM03500-200	500	3	2.31	2.82	2.97	7,721
VM04500-200	500	4	2.58	3.13	3.30	9,520
VM01750-200	750	1	1.33	1.73	1.85	3,455

Note: For other sizes and configurations not shown above please consult RSCC Customer Service Representative.

RSCC World Class Engineered Cable

Marmon Engineered Wire & Cable LLC
A Berkshire Hathaway Company

2. Materials

Recommendations for fittings and other materials for use with *VITAL*ink MC are shown in Appendix 1. Other commercially available materials may work as well. It is suggested that the manufacturer be contacted for recommendations and instructions on the use of their products.

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

3. Handling and Storage

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

Storage

Cables shall 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 shall be stored upright on their flanges, not stacked (see Figure 1). See Figure 2 for definitions of reel components. Handling shall 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 covering 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.

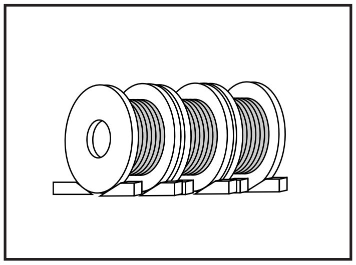
Both ends of the cable on a reel should be securely fastened to the reel flange, and sealed to prevent entrance of moisture. When shipped, the exposed ends of RSCC cables are protected by shrinkable, molded polyolefin end caps. These caps are weatherproof and should adequately seal the cable against 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.

Handling

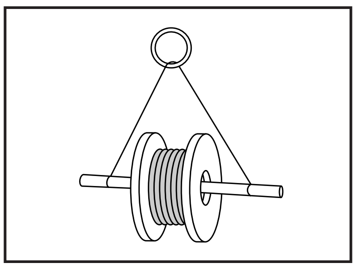
Cables should only be handled or installed within suitable temperature limits (see Section 5, Minimum Installation Temperature). Cable reels should be handled utilizing equipment designed for that purpose. Reels of cable must not be dropped from any height, particularly from

How To Handle Cable Reels

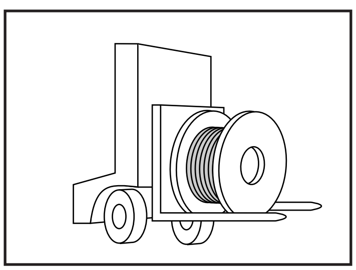
YES



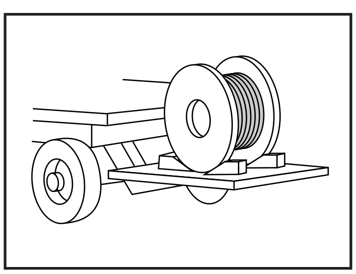
Always load and store reels upright on their flanges and block securely.



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

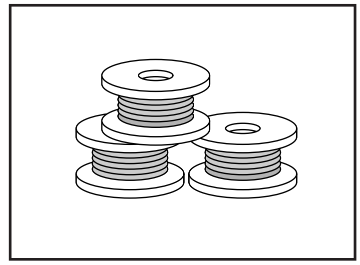


Cradle both reel flanges between fork tines.

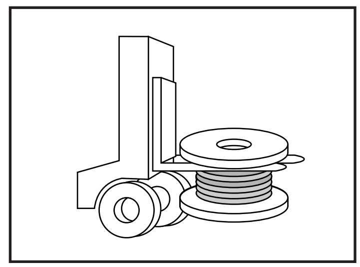


Lower reels from a truck using a hydraulic gate, hoist or fork lift. LOWER CAREFULLY.

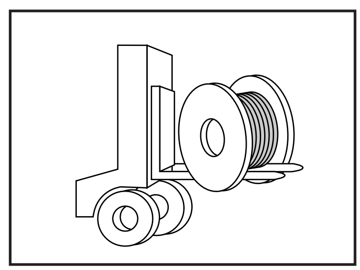
NO



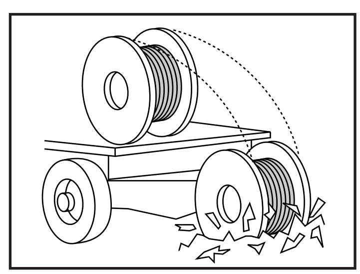
Upended heavy reels will often be damaged.



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



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



Never drop reels.

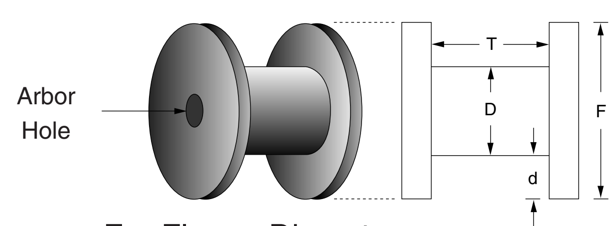
Figure 1. Reel Handling

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 shall 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 shall 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 1 provides capacities of standard RSCC shipping reels. If a cable is transferred to another reel, the drum diameter of the reel shall be equal to, or greater than the original reel drum diameter, as shown in Table 2. 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 shall have an adequate weight capacity. Care shall 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 shall be transferred to the new reel using a permanent marking method.

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



F = Flange Diameter
T = Inside Traverse Width
D = Drum Diameter
d = Depth

Figure 2. Reel Components

Roll reel in the direction indicated by the arrow.

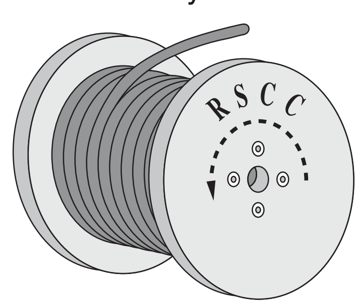


Figure 3. Reel Rolling

Table 1. *VITALink* MC* Length Capacities On Standard Shipping Reels

Flange (Inches)	48	48	66	72	84	87
Traverse (Inches)	18	32	32	40	48	60
Drum (Inches)	24	24	30	40	48	60
Tare Wt: (Lbs)	110	194	350	520	750	880
Max. Net: (Lbs)	6,000	6,000	6,000	9,000	15,000	14,000
Maximum Diameter	**Reel Capacity In Feet**					
0.700	3,300	6,058	12,520	16,021	26,243	27,146
0.800	2,488	4,579	9,495	12,584	19,926	20,923
0.900	1,860	3,433	7,572	9,918	15,907	16,091
1.000	1,513	2,800	6,038	7,790	12,698	13,345
1.100	1,230	2,283	5,130	6,559	10,799	10,093
1.200	997	1,855	4,062	5,536	8,561	9,236
1.300	-	-	3,450	4,672	7,279	7,660
1.400	-	-	2,927	3,934	6,183	6,312
1.500	-	-	2,723	3,296	5,758	5,881
1.600	-	-	-	3,082	4,897	4,816
1.700	-	-	-	2,572	4,139	4,525
1.800	-	-	-	2,422	3,901	3,657
1.900	-	-	-	2,003	3,278	3,458
2.000	-	-	-	1,898	3,107	3,280
2.100	-	-	-	-	2,584	2,599
2.200	-	-	-	-	2,461	2,476
2.300	-	-	-	-	2,349	2,364
2.400	-	-	-	-	1,925	2,262
2.500	-	-	-	-	-	1,734
2.600	-	-	-	-	-	1,665
2.700	-	-	-	-	-	1,600
2.800	-	-	-	-	-	1,540
2.900	-	-	-	-	-	1,485
3.000	-	-	-	-	-	1,433
3.100	-	-	-	-	-	-
3.200	-	-	-	-	-	-
3.300	-	-	-	-	-	-
3.400	-	-	-	-	-	-
3.500	-	-	-	-	-	-

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

Table 2. Minimum Reel Drum Diameter

Cable Type	Cable Diameter Range (Inches)	Minimum Drum Diameter As A Multiplier Of Cable Diameter
VITALink MC	All Sizes	20 X

4. Pulling Calculations

When cables are pulled into raceways or 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 shall 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 (Tc), the maximum allowable tension based on sidewall pressure (Tp), 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:

$$T_C = K \times F \times kcmil_T$$

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:

$$T_c = K \times F \times kcmil \times N$$

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 3.

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 insulated conductors are gripped with a properly sized and applied basket weave grip, the limit is 200 pounds per grip. This is based upon the hoop stress applied with a basket grip and the cable construction. Since the attachment by a grip is limited by the slip of the insulation, the insulation may be removed, and friction tape applied over the conductor to increase the pull by grip limit. For this configuration, with a properly sized and applied grip, the limit is 2000 pounds.

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.

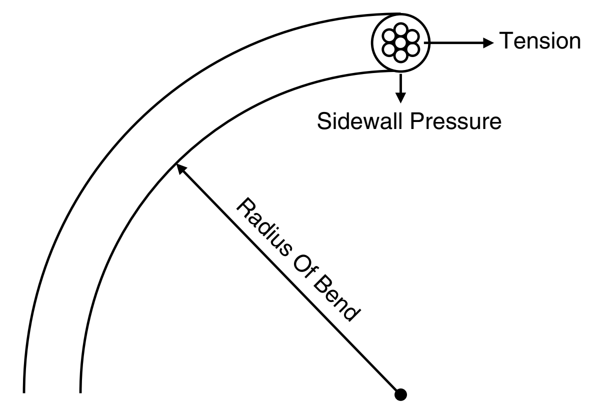


Figure 4. Sidewall Pressure

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 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 *VITAL*ink MC 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:

$$T_p = SWP \times R$$

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 Tc based on conductor strength. The lower value of the two governs.

Table 3. 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)	4/C T_c (Pounds)
14	4.11	–	99	132
12	6.53	–	157	209
10	10.38	–	249	332
8	16.51	–	396	528
6	26.24	–	630	840
4	41.74	–	1,002	1,336
3	52.62	–	1,263	1,684
2	66.36	–	1,593	2,124
1	83.69	–	2,009	2,678
1/0	105.6	845	2,534	3,379
2/0	133.1	1,065	3,194	4,259
3/0	167.8	1,342	4,027	5,370
4/0	211.6	1,693	5,078	6,771
250	250	2,000	6,000	8,000*
350	350	2,800	8,400	11,200*
500	500	4,000	12,000*	16,000*
750	750	6,000	18,000*	–

* Do not exceed cable attachment limit.

Table 4. 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
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 4 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 simplified formula, where prior tension is the tension at the beginning of the incline and the multiplying factor (M) is tabulated below.

T = L x W x M + (prior tension)

Note, short downward bends may be neglected. For riser applications, contact the RSCC Engineering Department.

Multiplying factors (M)

	Angle from horizontal in degrees					
K	**15**	**30**	**45**	**60**	**75**	**90**
0.1	0.36	0.59	0.78	0.92	0.99	1.00
0.2	0.45	0.67	0.85	0.97	1.02	1.00
0.3	0.55	0.76	0.92	1.02	1.04	1.00
0.4	0.65	0.85	0.99	1.07	1.07	1.00
0.5	0.74	0.93	1.06	1.12	1.10	1.00

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

$$T = T_1 \times F$$

T = Tension coming out of the bend in pounds

T_1 = Accumulated tension going into the bend in pounds

F = Friction factor for various values of coefficient of friction and bends as shown below.

Friction factors (F)

	Angle of bend in degrees					
K	**15**	**30**	**45**	**60**	**75**	**90**
0.1	1.03	1.05	1.08	1.11	1.14	1.17
0.2	1.05	1.11	1.17	1.23	1.30	1.37
0.3	1.08	1.17	1.27	1.37	1.48	1.60
0.4	1.11	1.23	1.37	1.52	1.69	1.87
0.5	1.14	1.30	1.48	1.69	1.92	2.19

Note, for large cables where bends close to the minimum bend radius are contemplated, additional force may be required to bend the cable.

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 and cable trays should not be loaded beyond their maximum capacity. Cable trays should not be filled above the side rails. NEC and local code requirements should be observed as required. See Article 392 of the NEC for maximum fill in cable trays. For ampacity derating consult the NEC and applicable ICEA standards. Note, for raceway installations, consult RSCC Engineering Department.

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 recommendations for pulling radii are provided in Table 6 as a multiplier of the cable or component diameter. The values for non-armored components may be used for the individual bending radius of single cables after the armor, inner jacket on multiconductor cables and separator tape are removed and the cables are separated. Table 7 provides minimum bend radius for popular sizes of *VITAL*ink MC. 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
*VITAL*ink MC	All sizes	7 X	10 X
Components	1.000 and less	4 X	8 X
Components	1.001 to 2.000	5 X	10 X

Table 7. *VITALink* MC — Minimum Bend Radius

Product Code	No. of Conductors	Conductor Size (AWG/Kcmil)	Normal Armor Diameter (Inches)	Min. Bend Radius (Inches)	
				Training	Pulling
VM02014-100	2	14	0.78	5.5	7.8
VM03014-100	3	14	0.82	5.7	8.2
VM04014-100	4	14	0.89	6.2	8.9
VM02012-100	2	12	0.82	5.7	8.2
VM03012-100	3	12	0.89	6.2	8.9
VM04012-100	4	12	0.94	6.6	9.4
VM02010-100	2	10	0.89	6.2	8.9
VM03010-100	3	10	0.94	6.6	9.4
VM04010-100	4	10	1.00	7.0	10.0
VM03008-100	3	8	1.04	7.3	10.4
VM04008-100	4	8	1.16	8.1	11.6
VM03006-100	3	6	1.16	8.1	11.6
VM04006-100	4	6	1.22	8.5	12.2
VM03004-100	3	4	1.24	8.7	12.4
VM04004-100	4	4	1.35	9.5	13.5
VM03003-100	3	3	1.30	9.1	13.0
VM04003-100	4	3	1.40	9.8	14.0
VM03002-100	3	2	1.38	9.7	13.8
VM04002-100	4	2	1.50	10.5	15.0
VM03001-100	3	1	1.59	11.1	15.9
VM04001-100	4	1	1.73	12.1	17.3
VM011X0-100	1	1/0	1.00	7.0	10.0
VM031X0-100	3	1/0	1.67	11.7	16.7
VM041X0-100	4	1/0	1.82	12.7	18.2
VM012X0-100	1	2/0	1.04	7.3	10.4
VM032X0-100	3	2/0	1.80	12.6	18.0
VM042X0-100	4	2/0	1.95	13.7	19.5
VM013X0-100	1	3/0	1.08	7.6	10.8
VM033X0-100	3	3/0	1.92	13.4	19.2
VM043X0-100	4	3/0	2.13	14.9	21.3
VM014X0-100	1	4/0	1.16	8.1	11.6
VM034X0-100	3	4/0	2.04	14.3	20.4
VM044X0-100	4	4/0	2.26	15.8	22.6
VM01250-100	1	250	1.22	8.5	12.2
VM03250-100	3	250	2.26	15.8	22.6
VU04250-100	4	250	2.46	17.2	24.6
VM01350-100	1	350	1.35	9.5	13.5
VM03350-100	3	350	2.48	17.4	24.8
VM04350-100	4	350	2.71	19.0	27.1
VM01500-100	1	500	1.48	10.4	14.8
VM03500-100	3	500	2.82	19.7	28.2
VM04500-100	4	500	3.13	21.9	31.3
VM01750-100	1	750	1.73	12.1	17.3

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 8 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 8. Minimum Effective Sheave Diameter

	Minimum Effective Sheave Diameter (Inches)
Cable Diameter (Inches)	***VITAL*ink MC**
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.

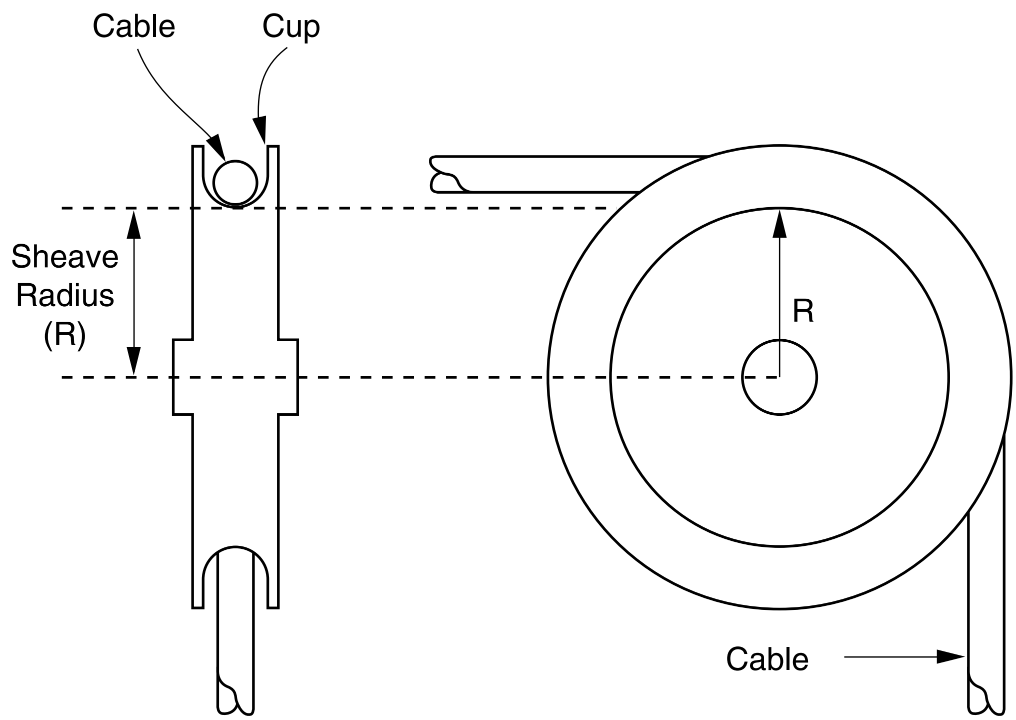


Figure 5. Single Sheave

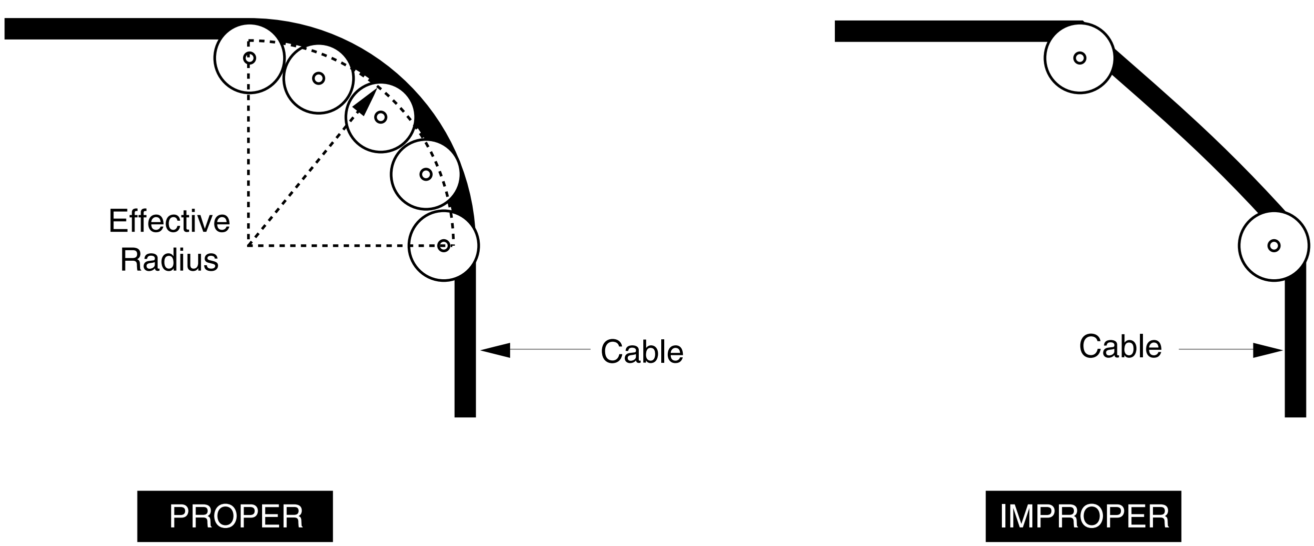


Figure 6. Typical Multiple Sheave Arrangement

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 shall 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 9 may be used.

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

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

Table 9. Minimum Installation Temperature

Cable Jacket Material	Minimum Installation Temperature (˚C)	Minimum Installation Temperature (˚F)
PVC	-10	14
LSZH	-18	0
No Jacket	-50	-58

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, 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 should be provided. Special care should be exercised during welding, soldering, and splicing operations to prevent damage to cables. 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. Precautions should be taken when routing in close proximity to hot pipes or other heat sources because of ampacity considerations. The total degrees of bend between pull points should be minimized and be per the NEC or CEC where applicable.

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

Cable should only be pulled into clean raceways or cable trays. 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.

Prior to final termination, the ends of cables located outdoors, in other wet locations, or where contamination is possible, should be capped to prevent the entrance of water or other contaminants. After installation and prior to final termination, the capped 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.

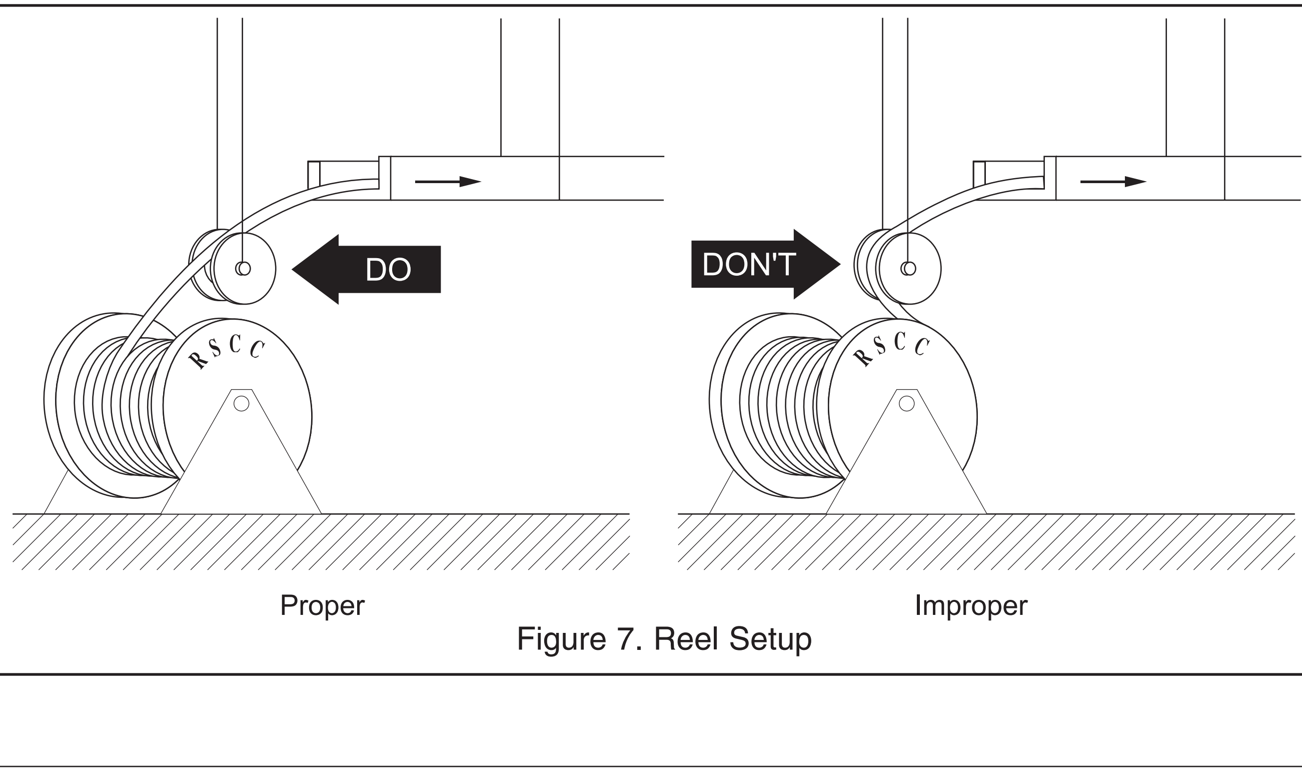


Figure 7. Reel Setup

- 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 or tray.

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 or tray. The radius of the feeder device should not be less than the minimum bending radius of the cable. Cables exiting the raceway or tray should be protected by similar means.

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 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 10 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.

Table 10. 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

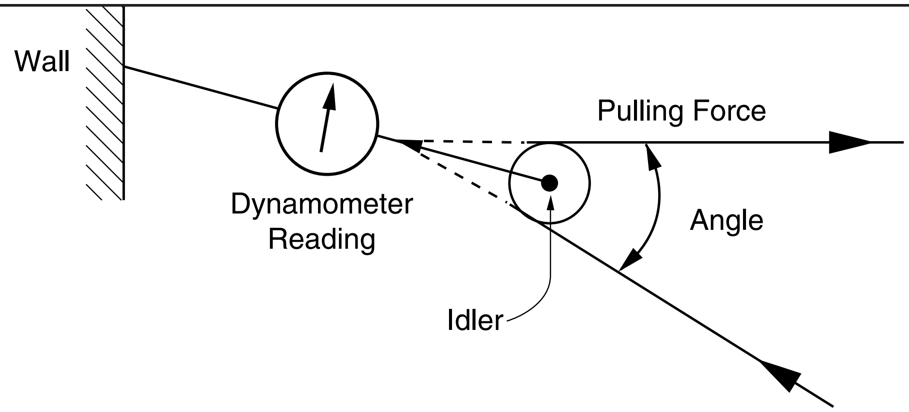


Figure 8. Dynameter Setup

Cable Attachment Methods

If a cable is pulled into a raceway or tray segment the cable should be attached to a pull rope. For *VITAL*ink MC, 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. Be sure to cut off this section a sufficient distance behind the nails prior to terminating.

Short lengths of 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 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 *VITAL*ink MC cables and proceeds with more detailed information based on the type of installation.

General

*VITAL*ink MC is installed and supported in much the same manner as other armored cables whether surface mounted, suspended, in cable tray or direct buried. The requirements of UL System 120/ULC S139 FHITC 120 should be followed as applicable.

Where independent circuits are required or desired, proper separation and segregation should be maintained from other electrical circuits.

All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors shall be contained within the same raceway, or cable tray, unless otherwise permitted in accordance with the NEC or CEC as applicable. These requirements shall apply separately to parallel circuits.

Where subject to physical damage, conductors shall be adequately protected.

Metal components and cable armor shall be of materials suitable for the environment in which they are to be installed. Conservatively, a cable jacket may then be used in direct burial installations, and embedment in concrete.

Metal raceways, cable armor, and, other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be connected to all boxes, fittings, and cabinets so as to provide effective electrical continuity. Equipment grounding conductors smaller than 6 AWG shall be protected from physical damage by a raceway or cable armor except where run in hollow spaces of walls or partitions, where not subject to physical damage, or where protected from physical damage.

Cable Support

Install supporting hardware at intervals not exceeding 6 feet for nonfire rated areas. For fire rated areas, see limits for UL System 120/ ULC S139 FHITC 120 (4ft).

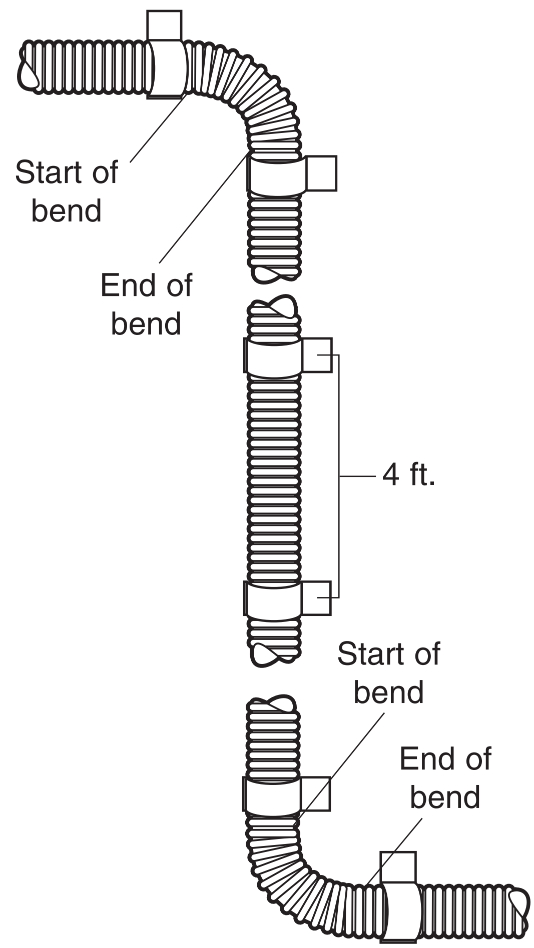


Figure 9: VITALink MC cable bends

When transitioning from a straight run of VITALink MC cable to a bend, use additional supports at the start of the bend and the end of the bend as shown in Figure 9.

For 14, 12, and 10 AWG conductor sizes, cable shall be secured within 12 inches of boxes, cabinets, fittings or other cable terminations. 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. Although not required, forms made from preformed PVC conduit bends cut in half may be used as a guide when forming bends. Make sure the minimum bend radius is observed.

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 Spacing

When multiple multi-conductor cables are used in the same installation, they should be appropriately spaced for ampacity considerations (generally one cable diameter apart minimum) or appropriately derated for ampacity.

When multiple single conductor cables are used, they may be laid flat, side by side as close together as possible for all cables in the same circuit. When properly designed, single conductor cables may be spaced to increase ampacity. Note, voltage drop should also be evaluated. Multiple circuits should be appropriately spaced for ampacity considerations, or appropriately derated for ampacity. Consult RSCC Engineering Department for additional design information.

For vertical support in raceway, call RSCC Engineering Department for recommendations.

Paralleling

Conductors to be joined in parallel should be 1/0 AWG or larger. See NEC Article 310.10(H) or CEC as applicable.

The paralleled conductors in each phase, neutral, or grounded circuit conductor shall

(1) Be the same length,

(2) Have the same conductor material,

(3) Be the same size in circular mil area,

(4) Have the same insulation type,

(5) Be terminated in the same manner.

Where conductors are used in parallel, space in enclosures and termination points shall be given consideration.

Where equipment grounding conductors are used with parallel conductors, they shall be sized per Article 250 of the NEC or CEC as applicable.

Induced Currents in Metal Enclosures or Metal Raceways

Where conductors carrying alternating current are installed in metal enclosures or metal raceways, they shall be arranged so as to avoid heating the surrounding metal by induction. To accomplish this, all phase conductors and, where used, the grounded conductor and all equipment grounding conductors shall be grouped together.

Where a single conductor carrying alternating current passes through metal with magnetic properties, the inductive effect shall be minimized by (1) cutting slots in the metal between the individual holes through which the individual conductors pass, or (2) passing all the conductors in the circuit through an insulating wall sufficiently large for all of the conductors of the circuit.

Pulling

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, lubrication is recommended. For additional information, contact the RSCC Engineering Department.

Electrical Circuit Integrity System

Electrical Circuit Integrity Systems consist of components and materials that are intended for installation as protection for specific electrical wiring systems, with respect to the disruption of electrical circuit integrity upon exterior fire exposure. The specifications for the protective system and its assembly are important details in the development of the ratings.

These protective systems are evaluated by the fire exposure and water hose stream test as described in UL 2196 / ULC S139. Ratings apply only to the entire protective system assembly. Individual components and materials are designated for use in a specific system(s) for which corresponding ratings have been developed and are not intended to be interchanged between systems. Ratings are not assigned to individual system components or materials.

Authorities having jurisdiction should be consulted in all cases as to the specific requirements covering the installation and use of these Classified systems.

The following instructions are for the VITALink® MC® MC UL/ULC System 120, a 2 hour fire rated cable system. This cable is only rated at 600 volts (conductor to conductor) when used for 2 hour fire resistive cables. The 1 hour splice is only rated at 480 volts (conductor to conductor) when used as a 1 hour fire resistive system.

The following instructions are for the VITALink® MC ULC S139 FHITC System 120 a 2 hour fire rated system. This cable is rated at 600 volts (conductor to conductor) when used for a 2 hour fire resistive cable.

These requirements must be followed to maintain the hourly rating in the fire area.

Open Runs/Installation of Cable in Free Air

Supports and hardware shall be per System 120 requirements and as described herein.

Exception, in a non fire rated areas, support spacing may be per the NEC/CEC.

Per the NEC/CEC, a minimum of 1/4 inch clearance should be provided at the points of support between the back of the cable and the wall of supporting surface for metal clad cables used in wet areas. Use of strut fulfills this requirement.

It is important to use the Kindorf®† J-800 Series interlocking straps and J-851 locking brackets for jacketed cable in a fire rated area. A single bolt type pipe clamp can become loose in a fire once the jacket burns off, and if on a wall, the pipe clamps can become loose and cables may slip off the support.

Installation in Raceways

Installations in raceways need special considerations, so please consult the RSCC Engineering Department.

Cable Trays

Cable trays shall have suitable strength and rigidity to provide adequate support for all contained wiring. Steel tray is required.

Each run of cable tray shall be completed before the installation of cables.

Supports shall be provided to prevent stress on cables where they enter raceways or other enclosures from cable tray systems. Tray supports should be 48 inches on center maximum. Tray supports and tray should be suitable for possible fire conditions.

In other than horizontal runs, the cables shall be fastened securely to transverse members of the cable trays. Additionally, 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 6 feet spacing. Cable ties should be installed snug, but not to a point to cause damage to the cable. The ties should be compatible with the cable and tray, and suitable for the environment (i.e., do not use plastic tiewraps in a fire rated area.)

Multiconductor cables are allowed to be installed in random configuration. For ampacity considerations, it is suggested that, where practical, cables be installed in a single layer and spaced a minimum of one cable diameter apart.

Cable Trays shall be exposed and accessible as permitted by the NEC/CEC.

Sufficient space shall be provided and maintained about cable trays to permit adequate access for installing and maintaining the cables.

Cable trays should be suitably grounded.

Installation In Cable Trays

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

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

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 tray support assembly. Such a roller arrangement should suffice for any weight cable to be pulled in that tray.

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 Concrete

*VITAL*ink MC may be installed in conduit in concrete or earth. Refer to the section on installation in raceway and installation in earth as applicable. Minimum burial depth should be per Table 300.5 of NEC or as applicable CEC requirement.

*VITAL*ink MC may also be embedded in concrete. Consult the RSCC Engineering Department for further information on these methods of installation.

Other Installations

Contact the RSCC Engineering Department for recommendations.

7. Post Installation

The following section provides general information on post installation activities including, cable terminating, splicing, 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 trays 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.

Terminating *VITAL*ink MC at Electrical Switch Gear/Equipment

A junction box is optional on either end of the fire rated cable in the fire rated room per the following (see Figure 10):

a) Once the cable enters the fire rated room, a minimum of 12 inches, terminate the *VITAL*ink MC cable into the appropriate size junction box per NEC or applicable CEC. Use UL/ULC listed MC connector suitable for a corrugated copper sheath, a UL/ULC listed lock nut and insulating bushing to terminate the cable to the box. Connector should be suitably grounded. Equipment grounding conductors should be carried through and maintained as required. Utilize a grounding hub as required.

b) Using the appropriate raceway for the specified area, connect the junction box to the equipment.

c) Install appropriate wiring between the junction box and the equipment.

d) Splice *VITAL*ink MC to the wire using an approved method. Note a transition splice may be required based on ampacity considerations.

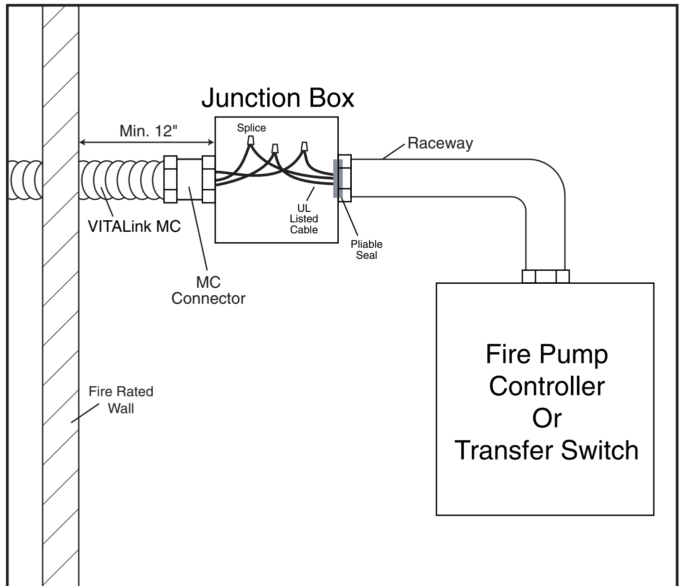


Figure 10

e) Seal the end of the raceway in the junction box to keep gases from migrating down into the equipment in the case of a fire. This may be done using a pliable compound.

Note 1: All wiring methods and installation procedures shall comply with NEC /CEC and local amendments.

Note 2: NEC Article 110.14 should be considered in regard to the temperature limit of the wiring to the equipment. The *VITAL*ink MC cable may be sized at 90°C if so desired. CEC requirements shall be observed as applicable.

Cable Terminating

General procedures for terminating are provided below. 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.

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.
- Install the connector per manufacturer's instructions. Connections to enclosures should be through the use of connectors approved for use with copper metal clad cable in the particular environment that it is installed.
- Generally, a seal should not be applied around the connector. Contact the RSCC Engineering Department for further information.
- Strip the insulation 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 terminal lugs or connectors per manufacturer instructions. When using a compression connector, a calibrated, properly sized compression tool should be used.
- 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.
- Properly terminate and ground the armor of the cable if that function is not provided by the connector.
- Utilize an insulating bushing to protect the conductors in enclosures, boxes, etc.
- Use proper hardware and tightening torque to connect the terminal lugs.

Table 11. Box Size per NEC 314.28

Minimum Box Length for Straight Through Splice					
3/C AWG/Kcmil	Conduit Size	Box Size	4/C AWG/Kcmil	Conduit Size	Box Size
8	1	8	8	1	8
6	1	8	6	1.25	10
4	1.25	10	4	1.25	10
3	1.25	10	3	1.5	12
2	1.25	10	2	1.5	12
1	2	16	1	2	16
1/0	2	16	1/0	2	16
2/0	2	16	2/0	2.5	20
3/0	2	16	3/0	2.5	20
4/0	2.5	20	4/0	2.5	20
250	2.5	20	250	3	24
350	3	24	350	3.5	28
500	3	24	500	3.5	28

Minimum Box Size for Angle Splice					
3/C AWG/Kcmil	Conduit Size	Box Size	4/C AWG/Kcmil	Conduit Size	Box Size
8	1	6	8	1	6
6	1	6	6	1.25	7.5
4	1.25	7.5	4	1.25	7.5
3	1.25	7.5	3	1.5	9
2	1.25	7.5	2	1.5	9
1	2	12	1	2	12
1/0	2	12	1/0	2	12
2/0	2	12	2/0	2.5	15
3/0	2	12	3/0	2.5	15
4/0	2.5	15	4/0	2.5	15
250	2.5	15	250	3	18
350	3	18	350	3.5	21
500	3	18	500	3.5	21

All conduit and box sizes in inches.

Based on flexible metal conduit without a ground wire, and RHW-2 conductor size per the NEC.

Jacket Removal (when provided)

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 armor. (Figure 11)

Figure 11

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 12)

Figure 12

3. Using pliers, pull the jacket away from the armor starting at the end of the cable and proceed to tear lengthwise along the score mark to the ring score. Remove the jacket. (Figure 13)

Figure 13

Armor Removal

1. Mark where the armor is to be cut by wrapping tape around the cable as a guide. Use a tubing cutter to cut the armor. 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 14)

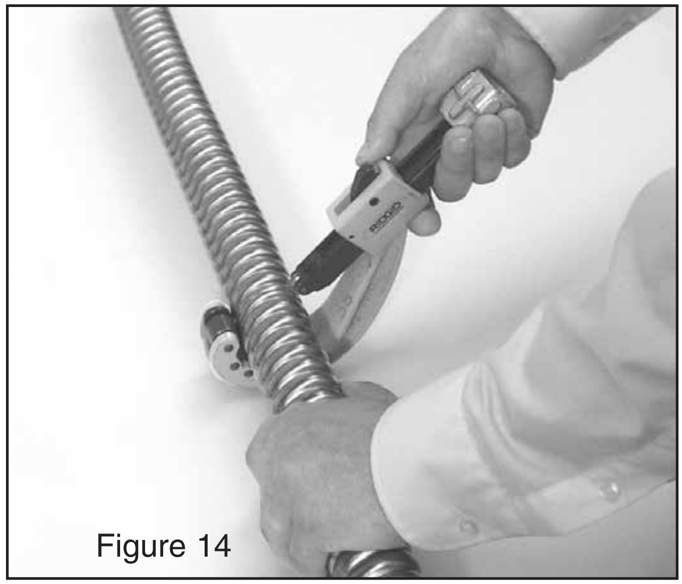


Figure 14

2. If required, mildly flex the cable until the sheath parts at the cut. (Figure 15)

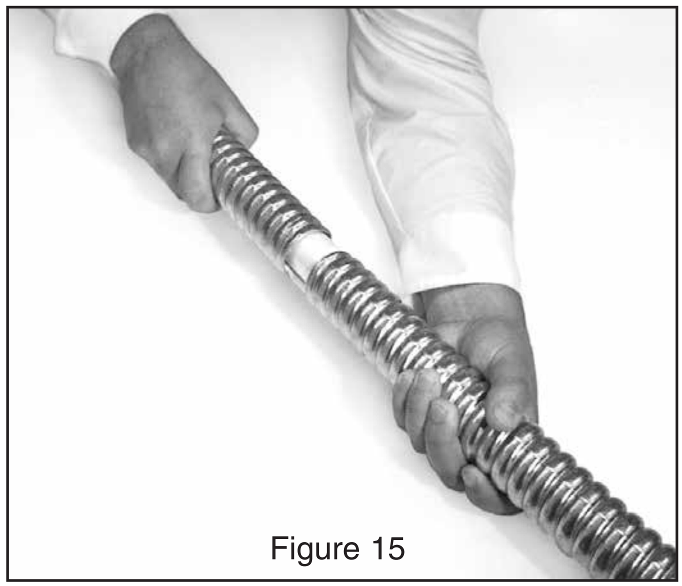


Figure 15

3. Slightly rotate sheath back and forth while pulling to remove sheath. Do not rotate completely around. If present filler cord may be entangled. When present, remove tape and filler cord. Remove any burrs. Install the connector according to the connector manufacturer's instructions. (Figure 16)

   For longer lengths, armor may be removed in sections, or armor cut longitudinally with a metal saw (such as Kett Model KS-26 AM or KS-25 AM), armor separated and peeled off. Contact RSCC Engineering for more information.

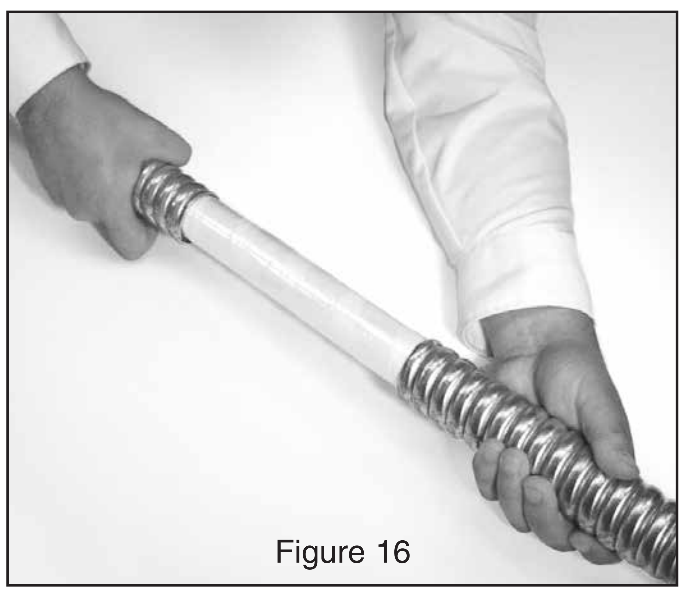


Figure 16

Inner Jacket Removal

1. Mark where jacket is to be cut by wrapping tape around the cable as a guide. Use a knife to longitudinally cut back inner jacket appropriate distance. Leave inner jacket on where possible for additional protection. An adequate length of free conductor should be provided per NEC/CEC. Only cut 50% into jacket. Be careful not to cut insulation. (Figure 17)

Figure 17

2. Cut through inner jacket at very end of the cable, then pull apart and peel back inner jacket to end of longitudinal cut. (Figure 18)

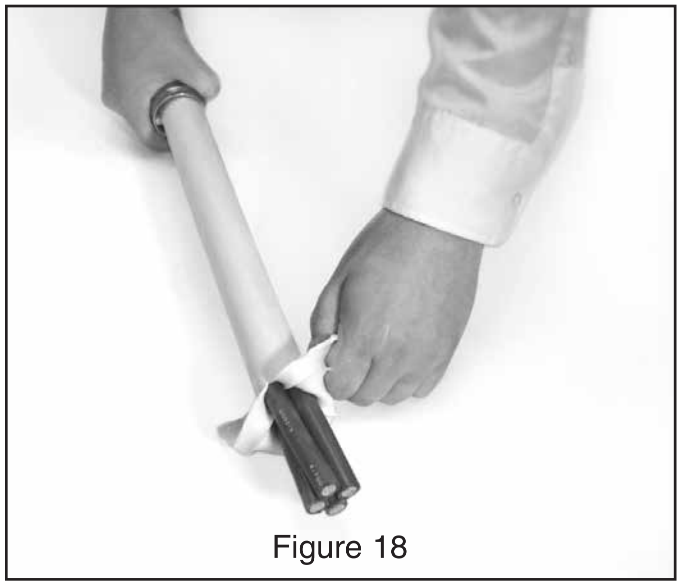


Figure 18

3. Pull inner jacket up at end of longitudinal cut while cutting in a circular manner. Pull off inner jacket. Inspect insulation for any damage. (Figure 19)

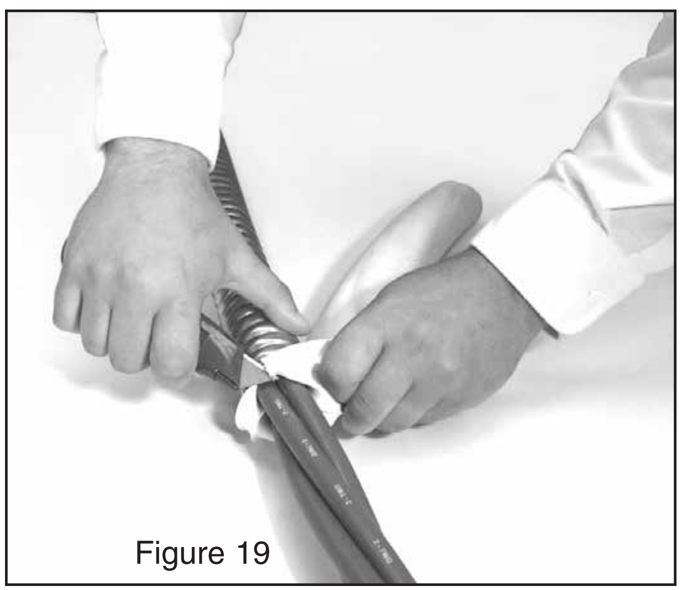


Figure 19

Cable Splicing (480 volt – 1 Hour only)

Splicing should be avoided with this construction type since the impervious nature of the armor can be compromised. Continuous lengths are best. If splices are used, they should be rated for the environment. A fire rated splice or system is required in a fire rated area. For non-fire rated areas, a box may be used with an approved splicing system. Please call the RSCC Engineering Department for additional information and to request the following publications in pdf format:

- *VITAL*ink MC Taped Splice Kit — Pig Tail Crimp
- *VITAL*ink MC Two-Way Taped Splice Kit

Cable Test

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

8. Glossary of Terms

Ampacity - The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

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.

Bonding (Bonded) - The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

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).

CEC – Canadian Electrical Code

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.

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

Fire-Roc™ - RSCC trade name for a proprietary insulation capable of passing the UL 2 hour fire test as part of a qualified system.

Fitting - An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Galloping - 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.).

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.

LSZH - Low smoke zero halogen material used as an optional jacket on RSCC *VITAL*ink MC cable.

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.

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 - An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in the NEC. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid-tight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

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.

System FHIT 120 - UL electrical circuit protective system that is rated for 2 hour fire resistance in horizontal and vertical straight through with cables listed at 600 volts. With 1-Hour horizontal splices listed at 480 volts.

UL - UL, LLC.

System FHITC 120 - ULC electrical circuit protective system that is rated for 2 hour fire resistance in horizontal and vertical straight through with cables listed at 600 volts.

***VITAL*ink MC®** - RSCC trade name for a continuously welded and corrugated metal sheath cable with a UL 2 hour fire rating for an electrical circuit protective system.

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.

9. References

AEIC G5, “Underground Extruded Power Cable Pulling Guide”.

ANSI/NFPA 70, “National Electrical Code”.

ANSI N45.2.2, “Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plants”.

ICEA P-46-426/IEEE S-135, “Power Cable Ampacities”.

ICEA P-54-440/NEMA WC 51, “Ampacities of Cables in Open-Top Cable Trays”.

ICEA S-66-524/NEMA WC 7, “Cross-Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy”.

IEEE 100, “Dictionary of Electrical and Electronics Terms”.

IEEE 400, “IEEE Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field”.

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”.

UL Subject 1724, “Fire Tests for Electrical Circuit Protective Systems”.

UL 2196, “Standard for Tests of Fire Resistive Cables”.

ULC S139, Standard Method of Fire Test for Evaluation of Integrity of Electrical Power, Data and Optical Fiber Cables.

UL Fire Resistive Directory, Volume 2.

10. Appendix 1

A list of MC connector manufacturers for *outside* of the fire zone:

Company Name	Series
Cooper Crouse-Hinds	TMC
Hawke Cable Glands America	N701
Hubbell Killark Electric	MCR
Thomas & Betts Corporation	STE

NOTE: For MC connector in the fire zone, see UL FHIT 120/ULC S139 FHITC 120.

Information provided is believed to be accurate, but company should be contacted for information on products and use.

Additional information on materials is available from the RSCC Engineering Department.

Notes:

RSCC Wire & Cable LLC

800-327-7625 ▪ Tel: 860-653-8300 ▪ Fax: 860-653-8301
www.r-scc.com

Marmon Engineered Wire & Cable LLC
A Berkshire Hathaway Company

ISO 9001/QS 9000 REGISTERED

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