



VITALink[®] MC/RC90

**General Handling, Storage,
& Installation Manual**



VITALink[®]

Circuit Integrity Cable

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Edited By Robert Schmidt



Installation Manual

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Table of Contents

1. Introduction.....	1
2. Handling and Storage.....	3
3. Precautions.....	7
4. Installation Equipment.....	9
5. Installation Setup.....	10
6. Pulling the Cable and Securing.....	15
7. Cable Termination, Splicing, Testing.....	17
8. Cable Limits & Pull Calculations.....	23
9. Materials, Tools, and Connectors.....	28
10. Glossary of Terms.....	29
11. References.....	31
12. Appendix 1.....	32

1 Introduction

This manual covers general storage, handling, installation, and termination recommendations for RSCC's Metal Sheathed cables.

In order to be compliant to RSCC's fire rated 2 hour System 120, 1 hour System 60, their variants, or other VITALink fire resistive systems, please see individual instruction manuals for each system. These are available upon request.

It is assumed that the cable has been properly sized and the installation properly designed. Since this manual is only a guide and not all situations can be covered, please call the RSCC Engineering Department for special installations.

There are twelve sections to this manual, starting with this introduction. Sections 2 and 3 discuss handling, storage, and precautions to take. Information on Installation Equipment, Installation Setup, Pulling, and Terminations are found in Sections 3 through 7. An overview of calculations that should be performed prior to installation, including pulling tension, bend radius and cable fill are detailed in Section 8. The last sections contain information on connectors and tools, a glossary of terms, references, and armor size equivalencies in Appendix 1.

VITALink® MC/RC90

In the USA, this armored cable is categorized as Type MC cable in the NEC and can be used and installed as allowed by the code for Type MC.

Canada categorizes this armored cable as Type RC90 in the CEC and can be used and installed as allowed by the code for Type RC90.

Contact RSCC for a full list of cable listings.

The cable is recognized as VITALink MC or VITALink RC90, they are one and the same but the geographical location and code language dictates how the cable is described. This document will describe the cable as VITALink MC for NEC applications, VITALink RC90 for CEC applications, and VITALink MC/RC90 where distinction is not required.

USA Fire Rated Applications

The NEC (NFPA 70) recognizes critical electrical circuits which, in the event of a fire, must continue to perform their intended functions. NEC Article 728 addresses "Fire-Resistive Cable Systems". Articles 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 but not limited to the following:

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

Canada Fire Rated Applications

The National Building Code of Canada (3.2.7.10) makes reference to emergency systems requiring conformance to ULC S139 where appropriate. Note, ULC S139 is now harmonized with UL 2196.

These systems include:

- Fire Alarms
- Emergency Lighting
- Emergency Equipment
- Fire Pumps
- Areas of Refuge

NFPA 130 and NFPA 502 are other standards. The applications listed above are not exhaustive lists.

MI Cable Issues

One of the options available to designers is to specify a cable system, which is qualified to meet the fire endurance requirements of the code. Originally, 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 solution to that is VITALink MC/RC90.

The VITALink® MC/RC90 Solution

VITALink® MC/RC90 is a user friendly, fire resistive cable which incorporates the ease and familiarity of Type MC/RC90 with a 2 hour fire endurance rating. Compared to type MI, the concerns of terminating this cable in wet environments, vibration, ingress of moisture, heavy investment in specialized labor for installation, and the other hurdles outlined above have been eliminated. 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/RC90 cables. In addition RSCC offers a 2-hour UL fire rated splice.

VITALink® MC/RC90 allows designers to specify without the burden of product limitations; while enabling installers to reap the benefits of Type MC and Type RC90 convenience.

In order to be compliant to RSCC's 2 hour System 120 120A, 1 hour System 60, or other VITALink fire resistive systems, please see individual instruction manuals for each system. These are available upon request.

Termination Simplicity



Tools required to
terminate
VITALink® MC/RC90

2 Handling and Storage

VITALink® MC/RC90 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.

2.1 Handling

Cables should only be handled or installed within suitable temperature limits (see *Minimum Installation Temperature* in Section 3). 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 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 and past 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. Minimum drum diameters shall be 20X the diameter over the armor. 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, but several cable diameters is preferred. 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 re-reeling or installation. Appropriate precautions for reeling and unreeling should be followed (see *Cable Reels* in 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.

2.2 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.

Handling shall be in a manner that prevents deterioration of and physical damage to the reel and to the cable. Reels shall be stored upright on their flanges, not stacked (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.

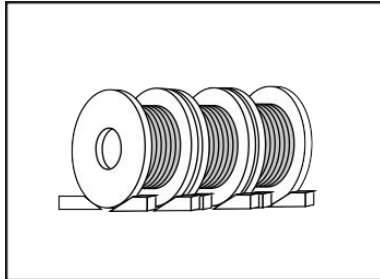
For definitions of reel components see *Figure 2*.

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.

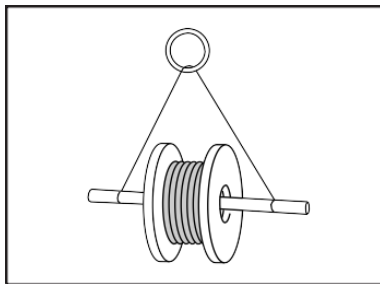
Both ends of the cable on a reel should be securely fastened to the reel flange and sealed to prevent entrance of moisture. When shipped, the exposed ends of RSCC cables are protected by shrinkable, molded polyolefin end caps. These caps are weatherproof and should adequately seal the cable against moisture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

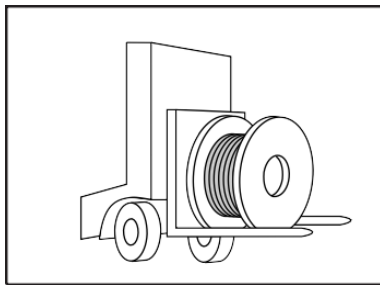
How to Handle Cable Reels



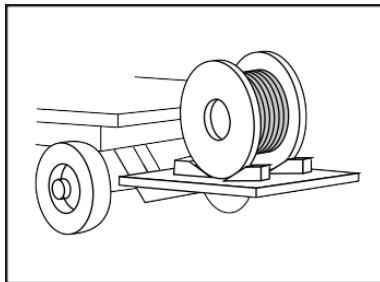
Always load and store reels upright on their flanges and block securely.



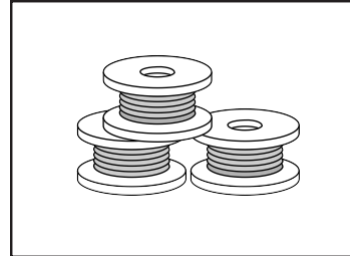
Reels can be hoisted with a properly secured shaft extending through both flanges.



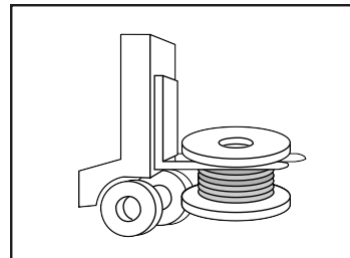
Cradle both reel flanges between fork tines.



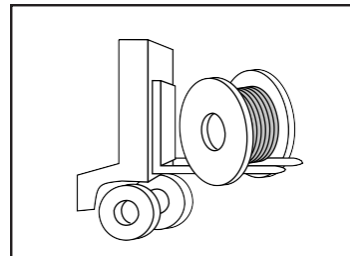
Lower reels from a truck using a hydraulic gate, hoist or fork lift. LOWER CAREFULLY.



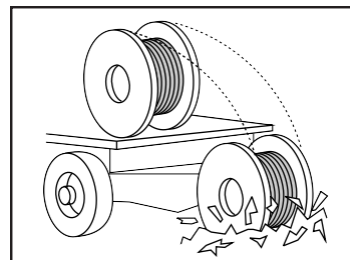
Upended heavy reels will often be damaged.



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

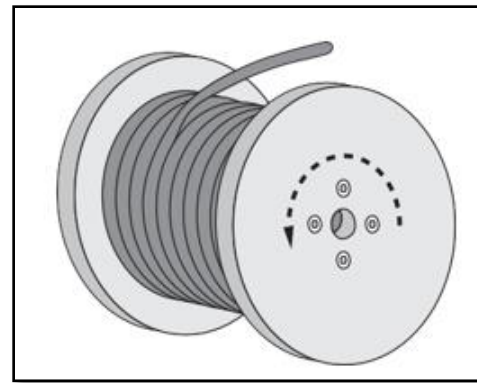
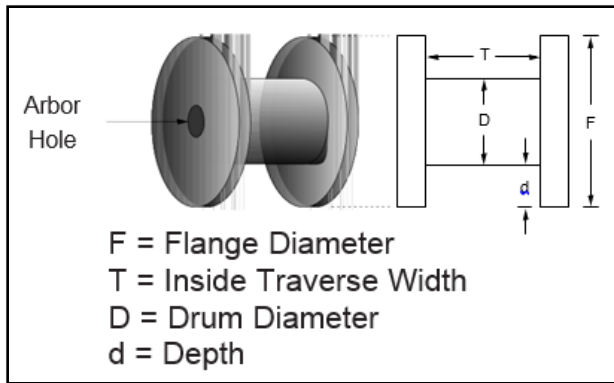


Figure 2. Reel Components

Figure 3. Roll Direction

Table 1. VITALink MC/RC90 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					
0.7	3,300	6,058	12,520	16,021	26,243	27,146
0.8	2,488	4,579	9,495	12,584	19,926	20,923
0.9	1,860	3,433	7,572	9,918	15,907	16,091
1	1,513	2,800	6,038	7,790	12,698	13,345
1.1	1,230	2,283	5,130	6,559	10,799	10,093
1.2	997	1,855	4,062	5,536	8,561	9,236
1.3	-	-	3,450	4,672	7,279	7,660
1.4	-	-	2,927	3,934	6,183	6,312
1.5	-	-	2,723	3,296	5,758	5,881
1.6	-	-	-	3,082	4,897	4,816
1.7	-	-	-	2,572	4,139	4,525
1.8	-	-	-	2,422	3,901	3,657
1.9	-	-	-	2,003	3,278	3,458
2	-	-	-	1,898	3,107	3,280
2.1	-	-	-	-	2,584	2,599
2.2	-	-	-	-	2,461	2,476
2.3	-	-	-	-	2,349	2,364
2.4	-	-	-	-	1,925	2,262
2.5	-	-	-	-	-	1,734
2.6	-	-	-	-	-	1,665
2.7	-	-	-	-	-	1,600
2.8	-	-	-	-	-	1,540
2.9	-	-	-	-	-	1,485
3	-	-	-	-	-	1,433

¹Shaded area indicates that chosen reel is too small for cable.

²Minimum drum diameter for all VITALink® MC/RC90 cables is 20X diameter over the armor.

3 Precautions

- 3.1 Preplan
- 3.2 Personnel
- 3.3 Handling and Storage
- 3.4 Cable Limitations
- 3.5 Minimum Installation Temperature
- 3.6 Equipment Ratings
- 3.7 Equipment Condition
- 3.8 Material Compatibility
- 3.9 Lubricant
- 3.10 Cable Fill
- 3.11 Cable Protection
- 3.12 Temporary Support

General

This section deals with some factors that should be considered prior to installation.

All appropriate precautions should be taken when installing cables, including following OSHA and other applicable regulations including federal, state, local, and municipal laws shall be followed. 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, at a minimum the precautions outlined in this section should be observed.

3.1 Preplan

It is highly recommended that cable installations be preplanned. Read all of the instructions to ensure the routing can be followed while staying within the bend radius, tension, and sidewall limits to prevent cable damage. These limits are described in detail in Section 8.

Understand how the cable will be supported and what equipment will be needed to achieve the cable pull.

3.2 Personnel

Personnel should be properly trained and qualified for the specific task they are performing. Take care to ensure personal protection equipment is used.

3.3 Handling and Storage

Appropriate precautions should be taken in the handling, storage, and disposal of materials (see Section 2).

3.4 Cable Limitations

Before installation, the installer should determine that the cable(s) can be installed according to the designed routing, tension/sidewall pressure limits, minimum bending radius, and minimum installation temperature requirements. The total degrees of bend between pull points should be minimized and be per the NEC or CEC where applicable.

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.

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.

3.5 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 2 may be used.

Pulling lubricants shall be capable of functioning without freezing at the installation temperature.

Table 2. Minimum Installation Temperature

Cable Jacket Material	Minimum Installation Temperature	
	(°C)	(°F)
PVC	-10	14
VITALink MC/RC90 LSZH	-18	0
No Jacket	-50	-58

3.6 Equipment Ratings

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.

3.7 Equipment Condition

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.

3.8 Material Compatibility

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.

3.9 Lubricants

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. When used, cable lubricants must be capable of functioning without freezing at the installation temperature. Polywater® LZ is recommended for compatibility with the VITALink MC/RC90 polymeric cable jacket.

3.10 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.

3.11 Cable Protection

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

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.

Special care should be exercised during welding, soldering, and splicing operations to prevent damage to cables.

Precautions should be taken when routing in close proximity to hot pipes or other heat sources because of ampacity considerations.

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.

3.12 Temporary Support

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.

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 off of a ladder tray, the cable may be damaged by the rung before connection is completed.

4 Installation Equipment

- 4.1 Pull Device
- 4.2 Pull Rope
- 4.3 Pulling Eye
- 4.4 Swivel
- 4.5 Basket Weave or Split Grip
- 4.6 Luffing Grip
- 4.7 Rollers, Pulleys, and Sheaves
- 4.8 Lubricants

General

The properly chosen installation equipment, proper setup, and understanding of the forces involved in the cable pull will prevent injury to people and damage to equipment and cable.

4.1 Pull Device

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.

4.2 Pull Rope

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.

4.3 Pulling Eye

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

4.4 Swivel

A swivel should be used between the pulling rope and the cable on all mechanically assisted pulls. On more difficult hand pulls, a swivel should also be used. 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.

4.5 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.

4.6 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.

4.7 Rollers, Pulleys, and Sheaves

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).

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.

4.8 Lubricants

Polywater® LZ is recommended for compatibility with the VITALink MC/RC90 LSZH polymeric cable jacket. Lubricant

for non polymeric jacketed cable shall not have any deleterious effects on the metallic armor.

5 Installation Setup

- 5.1 Cable Reels
- 5.2 Cable Attachment Methods
- 5.3 Pull Tension Monitoring
- 5.4 Supports
- 5.5 Cable Spacing
- 5.6 Raceways
- 5.7 Cable Trays
- 5.8 Concrete
- 5.9 Earth
- 5.10 Bonding/Grounding
- 5.11 Paralleling
- 5.12 Splices
- 5.13 Induced Currents in Metal Enclosures or Metal Raceways

General

In order to be compliant to RSCC's fire rated 2 hour System 120, 1 hour System 60, or other VITALink fire resistive systems, please see individual instruction manuals for each system.

This section explains how to support and install the cable. Termination of the cable is detailed in Section 7.

The rules outlined in this section apply to all areas that **DO NOT** require fire protection. Cable installed in areas that do not require fire protection may follow the adopted code rules outlined in the NEC or CEC for Type MC or Type RC90 respectively.

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.

5.1 Cable Reels

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 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.

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

1. Proper setup of the cable reel assembly (see *Figure 4*). The setup should ensure that the cable is not kinked or bent beyond the minimum pulling radius or subject to excessive twisting force. 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.
2. 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 where reel breaking equipment can be deployed.
3. 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.
4. Cable pull tension should be minimized by turning the reel and feeding the cable into the raceway or tray.

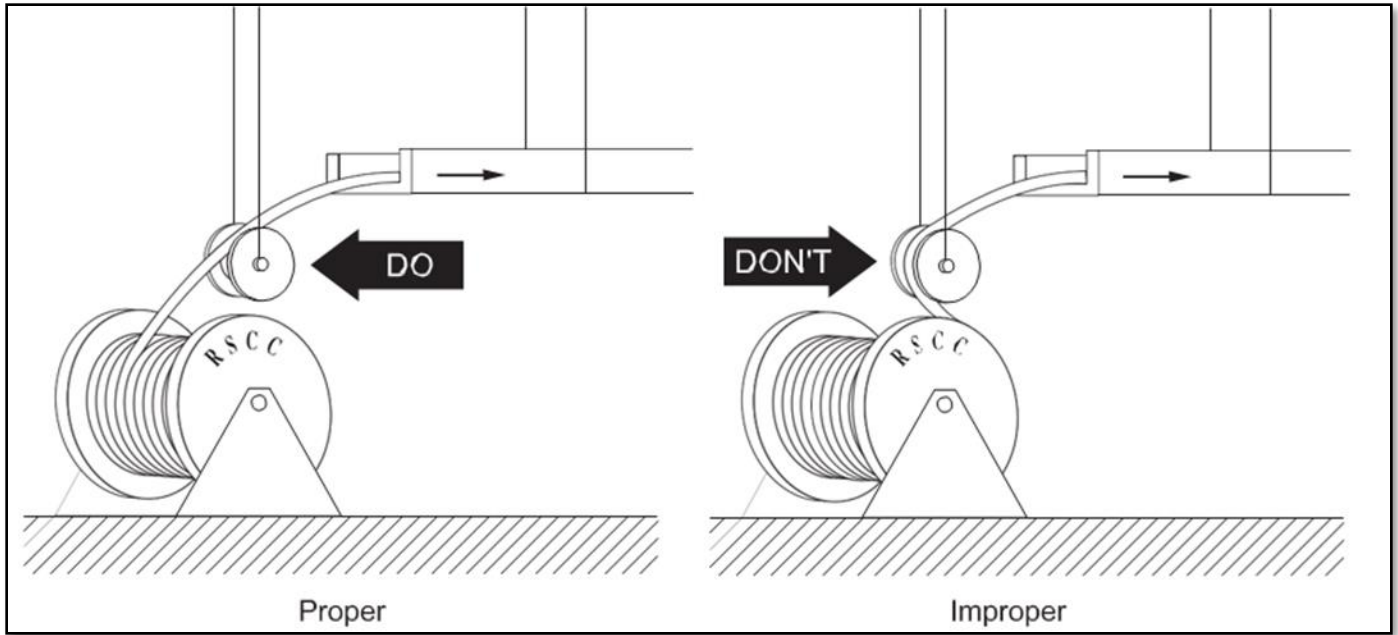


Figure 4. Reel Setup

5.2 Cable Attachment Methods

If a cable is pulled into a raceway or tray segment, the cable should be attached to a pull rope. For VITALink® MC/RC90, 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.

5.3 Pull Tension Monitoring

Cable tension should be limited to less than the maximum allowable pulling tension (see Section 8), 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 3 to obtain the true pulling tension (see Figure 5). 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 3. Multiplying Factors for Use with Dynamometer Readings

Angle	Multiplying
0	0.5
60	0.6
90	0.7
100	0.8
110	0.9
120	1

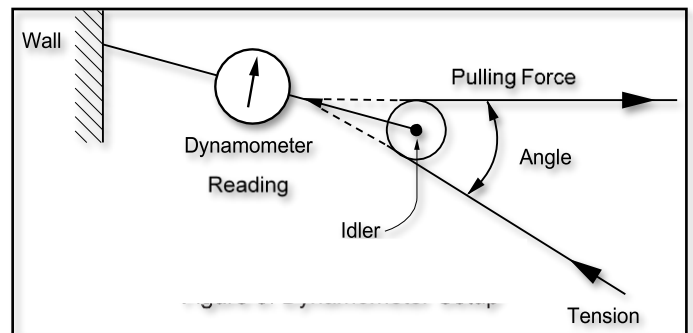


Figure 5. Dynamometer Setup

5.4 Support and Secure

Article 330 of the NEC details information on how to support the MC/RC90 cable. Some of the information is repeated here. If discrepancies exist, the NEC or CEC shall govern.

Install supporting hardware at intervals not exceeding 6 feet.

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 cables used in wet areas. Use of strut fulfills this requirement.

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.

When transitioning from a straight run of VITALink® MC/RC90 cable to a bend, use additional supports at the start of the bend and the end of the bend as shown in Figure 6.

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.

For vertical runs we recommend an S-bend every 30ft even though the cable core is self-supporting. This provides additional support for the core. Do not exceed the minimum bend radii for the cable. Support the cable on each side of the bend.

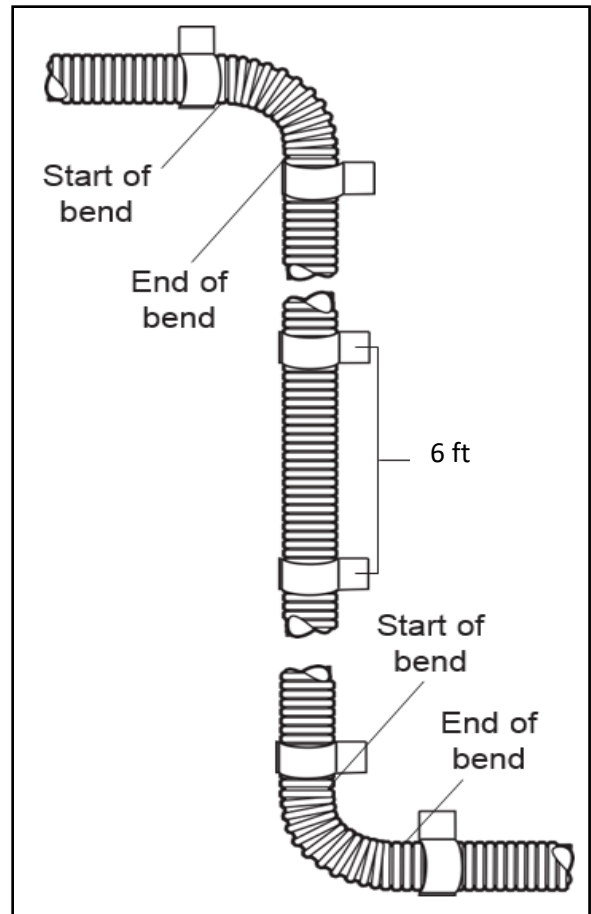


Figure 6. VITALink MC/RC90 Cable Bends

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.

5.5 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. The NEC and CEC addresses the specifics for this.

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

5.6 Raceways

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

5.7 Cable Trays

When installing in cable trays, follow the NEC, CEC, or other governing code. Some considerations are listed below.

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

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 in accordance with the manufacturers instructions

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.

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 ensure 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.

5.8 Concrete

VITALink MC/RC90 may be installed in conduit in concrete or earth. Minimum burial depth should be per Table 300.5 of NEC or as applicable CEC requirement.

VITALink MC/RC90 may also be embedded in concrete. Consult the RSCC Engineering Department for further information on these methods of installation.

5.9 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.

5.10 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.

5.11 Bonding/Grounding

Metal raceways, cable armor, and, other metal enclosures for conductors shall be metallicity 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.

VITALink MC/RC90 copper armor is listed for use as an equipment ground. See Table 12 in Appendix 1 for a list of armor ground size equivalents.

Note, per the NEC, that increases in non-grounded conductor size due to voltage drop will warrant an increase in ground size proportionately.

5.12 Splices/Terminations

Non fire rated splices shall follow practices outlined in governing code. Fire rated splices shall follow the instructions sheets for the fire resistive system being installed.

For 14, 12, and 10 AWG conductor sizes, cable shall be secured within 12 inches of boxes, cabinets, fittings or other cable terminations.

5.13 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, or brass plating sufficiently large for all of the conductors of the circuit. Non-ferrous boxes are available.

6 Pulling the Cable and Securing

- 6.1 Reels
- 6.2 Trays
- 6.3 Bends
- 6.4 Monitoring
- 6.5 Lubricants
- 6.6 Firestop

General

Cable pulling should occur after all of the supporting hardware has been installed and the installation setup is complete. Raceways and cable trays should be examined for acceptability prior to pulling activities.

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.

Maintain a slow but steady speed of up to 25 feet per minute, avoiding stops and starts as much as possible. Adjust the pulling speed to eliminate galloping (surging), if necessary.

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

6.1 Reels

The cable should be pulled straight off of 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. The cable has a tendency to unwind itself as it is pulled off of the reel. The inner most cable end may detach from the reel and swing up and over causing personal injury or damage to the cable. Before pulling ensure the inner most part of the cable is secured to reel by wrapping a rope tightly around the cable end. Use tape to ensure it does not slide off and secure it to the reel by wrapping the rope to the flange by passing it through the penetration in the reel flange.

6.2 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.

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.

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.

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).

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.

6.3 Bends

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.

6.4 Monitoring

In addition to pull tension monitoring, 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.

6.5 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.

6.6 Firestop

Through opening in wall or floor shall be firestopped using an approved firestop system. See Through-Penetration Firestop System (XHEZ) category for presently classified firestop systems. The firestop system shall not have any deleterious effects on the cable.

7 Cable Termination, Splicing, Testing

7.1 Cable Terminating

7.2 Switchgear

7.3 Jacket Removal

7.4 Armor Removal

7.5 Inner Jacket Removal

7.6 Cable Splicing

7.7 Cable Test

General

The following section provides general information on cable terminating, splicing, and testing.

Prior to final termination, the capped cable ends should be inspected to see that they were intact and have not been damaged.

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.

7.1 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.

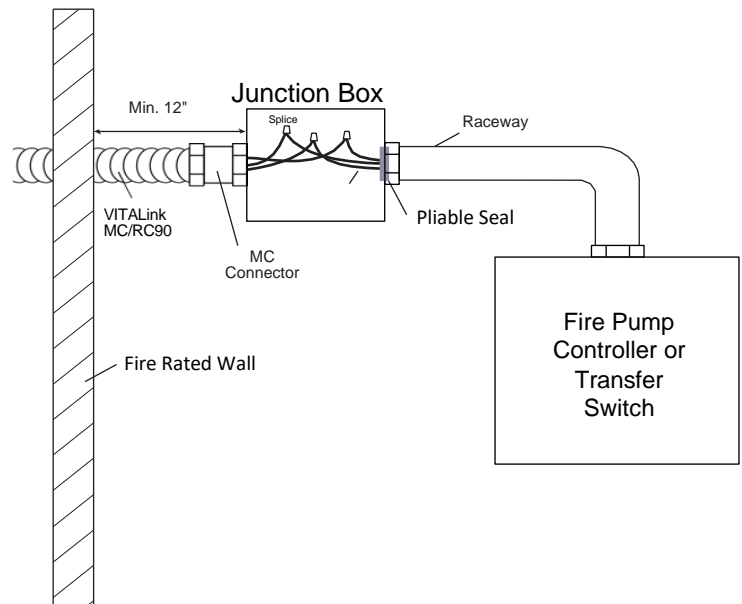
- Use proper hardware and tightening torque to connect the terminal lugs.

7.2 Terminating at Switchgear/Equipment

When entering an electrical room or other protected area for termination on equipment/cabinets, a junction box is required on the end of the fire rated cable in the fire rated room per the following:

1. Once the cable enters the fire rated room, a minimum of 12 inches, terminate the VITALink® MC/RC90 cable into the appropriate size junction box per NEC or applicable CEC. Use a listed MC/RC90 connector suitable for a corrugated copper sheath, a 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.
2. Using the appropriate raceway for the specified area, connect the junction box to the equipment.
3. Install appropriate thermoset wiring between the junction box and the equipment. RSCC's Firewall® LSZH (NFPA 130 and NFPA 502 complaint) may be used.
4. Splice VITALink® MC/RC90 to the wire using an approved method. Note a transition splice may be required based on ampacity considerations.
5. 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: All wiring methods and installation procedures shall comply with NEC /CEC and local amendments. NEC Article 110.14 should be considered in regard to the temperature limit of the wiring to the equipment. The VITALink® MC/RC90 cable may be sized at 90°C if so desired. CEC requirements shall be observed as applicable.



Contact RSCC Engineering department for other types of installations.

7.3 Jacket Removal (when provided)

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 7)



Figure 7

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 8)



Figure 8

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 9)



Figure 9

7.4 Armor Removal

1. Mark where the armor is to be cut. 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. As the cutter revolves around the cable into the depth of a corrugation and out, slight tightening and loosening of the tool is required. Do not try and cut the armor in one pass. Let the tool do the work. (Figure 10)



Figure 10

2. If required, mildly flex the cable until the sheath parts at the cut. Make sure the armor does not cut through the inner jacket. (Figure 11)



Figure 11

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 12)

For longer lengths, armor may be removed in sections. Contact RSCC Engineering for more information.



Figure 12

7.5 Inner Jacket Removal

1. It's recommended to attach the cable connector and install into box prior to removing the inner jacket as it provides protection.

Use a knife to longitudinally cut into the cable end about an inch. **DO NOT** score the inner jacket (as shown in Figure 13) because there is a possibility that the insulation underneath will get cut. Leave inner jacket on where possible for additional protection. An adequate length of free conductor should be provided per NEC/CEC.



Figure 13 – Incorrect Method

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 14). The cut provides a path for the jacket to be removed as tension is applied. Use a conductor to help peel the jacket back. Be aware of bend radius limits.



Figure 14 – Correct Method

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 15)



Figure 15

7.6 Cable Splicing

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 that is part of a listed system is required in an area without fire protection. For areas with fire protection, a box may be used with an approved splicing system. Please call the RSCC Engineering Department for additional information and to request the following fire rated splice publications in pdf format:

Fire Rated Splices

- VITALink® MC/RC90 Taped Splice Kit — Pig Tail
- VITALink® MC/RC90 Taped Splice Kit — Two-Way
- VITALink® MC/RC90 Block Splice Kit
- VITALink® MC/RC90 Fused Block Splice Kit

Contact RSCC for other splices.

7.7 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.

Table 4. Box Size per NEC 314.28

Minimum Box Length for Straight Through Splice (Inches)					
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 Length for Angle Splice (Inches)					
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

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

8 Cable Limits & Pull Calculations

- 8.1 Conductor Tensile Strength Limits
- 8.2 Cable Attachment Limits
- 8.3 Minimum Bend Radius Limits
- 8.4 Sidewall Pressure Limits
- 8.5 Estimating Pull Tension
- 8.6 Estimating Sidewall Pressure

General

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 (T_c), the maximum allowable tension based on sidewall pressure (T_p), and the limit based on the attachment method to the cable.

8.1 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. This tension is determined by the following equation:

Equation 1. Tensile strength of one conductor

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

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

K = Factor based on material strength with a safety margin; 0.008 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:

Equation 2. Tensile strength of multiple same size conductors

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

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 multi-conductor 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 maximum allowable pull tensions for one, three, and four annealed copper conductor(s) of a single cable ($N=1, 3, \text{ and } 4, \text{ and } F=1$) using the above equation is provided in Table 5 below.

Table 5. Maximum tension based on copper conductor tensile strength limit

Conductor Size (AWG or Kcmil)	Equivalent Circular Mil Area (Kcmil)	1/C Tc (Pounds)	3/C Tc (Pounds)	4/C Tc (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.

8.2 Cable Attachment

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.

Pulling Eye

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.

Basket Weave

The attachment by a basket weave grip is limited by the slip of the insulation. When the properly sized basket weave grip is applied over the insulation, the limit is 200 pounds per grip. This is based upon the hoop stress applied with a basket grip and the cable construction. Alternatively, the insulation may be removed, and friction tape applied directly over the conductor to increase the pull by grip limit. For this configuration, with a properly sized and applied grip, the limit is 2,000 pounds.

8.3 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 and IEEE 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 non-polymeric jacketed armor diameter 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 multi-conductor cables and separator tape are removed and the cables are separated. Table 7 provides minimum bend radius for popular sizes of VITALink® MC/RC90. For cases not shown please call the RSCC Engineering Department. Note, bend radius is measured from the inside portion of the cable going through the bend.

Table 6. Minimum Bend Radius OD Multiplier

	Cable Diameter Range (Inches)	Minimum Training Radius	Minimum Pulling Radius
VITALink 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. Minimum bend radius for common sizes

Conductor Size (AWG/kcmil)	No. of Conductors	Nom. Armor Diameter (Inches)	Min. Bend Radius (Inches)	
			Training	Pulling
14	2	0.78	5.50	7.80
14	3	0.82	5.70	8.20
14	4	0.89	6.20	8.90
12	2	0.82	5.70	8.20
12	3	0.89	6.20	8.90
12	4	0.94	6.60	9.40
10	2	0.89	6.20	8.90
10	3	0.94	6.60	9.40
10	4	1.00	7.00	10.00

Conductor Size (AWG/kcmil)	No. of Conductors	Nom. Armor Diameter (Inches)	Min. Bend Radius (Inches)	
			Training	Pulling
8	3	1.04	7.30	10.40
8	4	1.16	8.10	11.60
6	3	1.16	8.10	11.60
6	4	1.22	8.50	12.20
4	3	1.24	8.70	12.40
4	4	1.35	9.50	13.50
3	3	1.30	9.10	13.00
3	4	1.40	9.80	14.00
2	3	1.38	9.70	13.80
2	4	1.50	10.50	15.00
1	3	1.59	11.10	15.90
1	4	1.73	12.10	17.30
1/0	1	1.00	7.00	10.00
1/0	3	1.67	11.70	16.70
1/0	4	1.82	12.70	18.20
2/0	1	1.04	7.30	10.40
2/0	3	1.80	12.60	18.00
2/0	4	1.95	13.70	19.50
3/0	1	1.08	7.60	10.80
3/0	3	1.92	13.40	19.20
3/0	4	2.13	14.90	21.30
4/0	1	1.16	8.10	11.60
4/0	3	2.04	14.30	20.40
4/0	4	2.26	15.80	22.60
250	1	1.22	8.50	12.20
250	3	2.26	15.80	22.60
250	4	2.46	17.20	24.60
350	1	1.35	9.50	13.50
350	3	2.48	17.40	24.80
350	4	2.71	19.00	27.10
500	1	1.48	10.40	14.80
500	3	2.82	19.70	28.20
500	4	3.13	21.90	31.30
750	1	1.73	12.10	17.30

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 two times the sheave radius (see Figure 16). 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 17). 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

Cable Diameter (Inches)	Minimum Effective Sheave Diameter (Inches)
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.

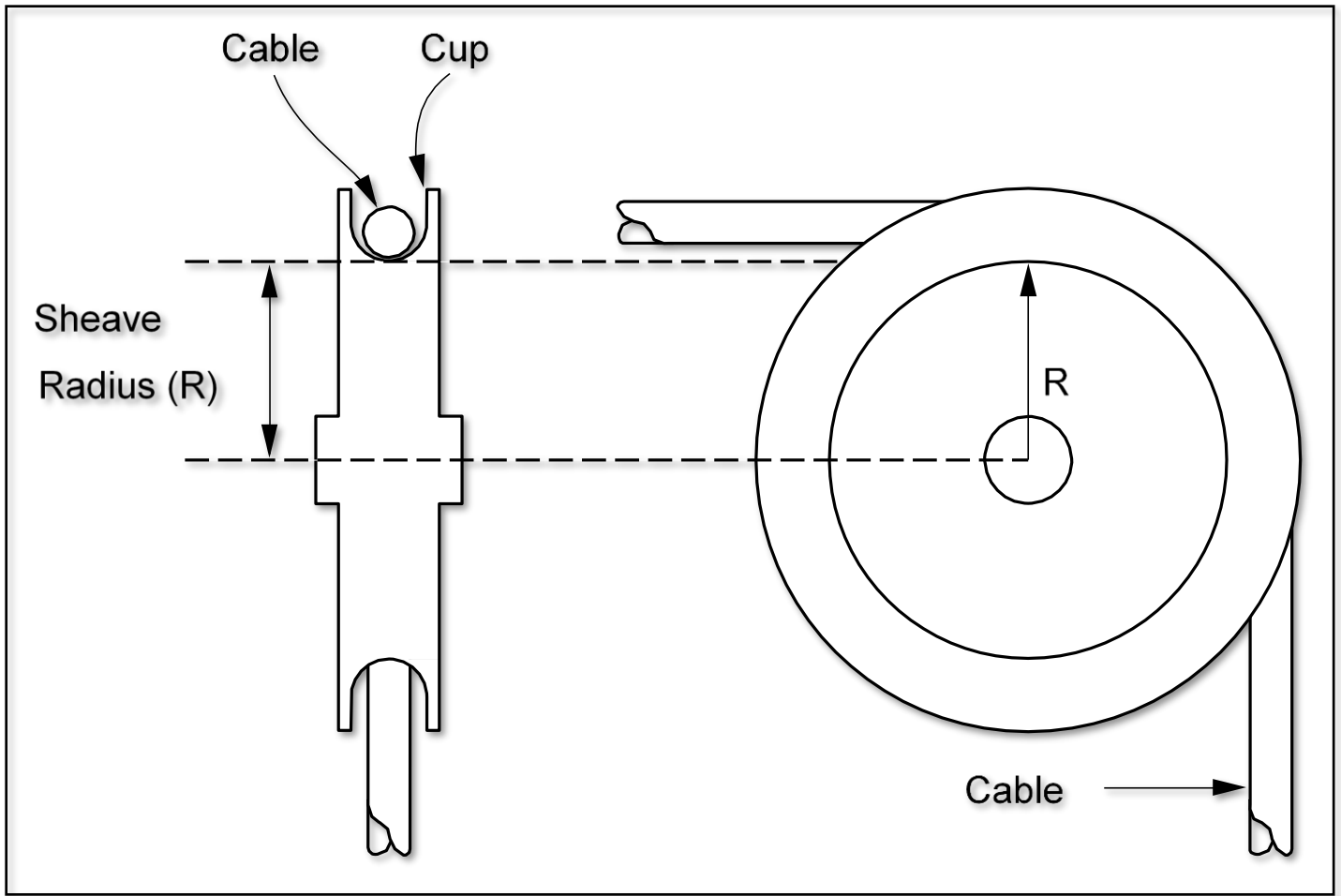


Figure 16. Single Sheave

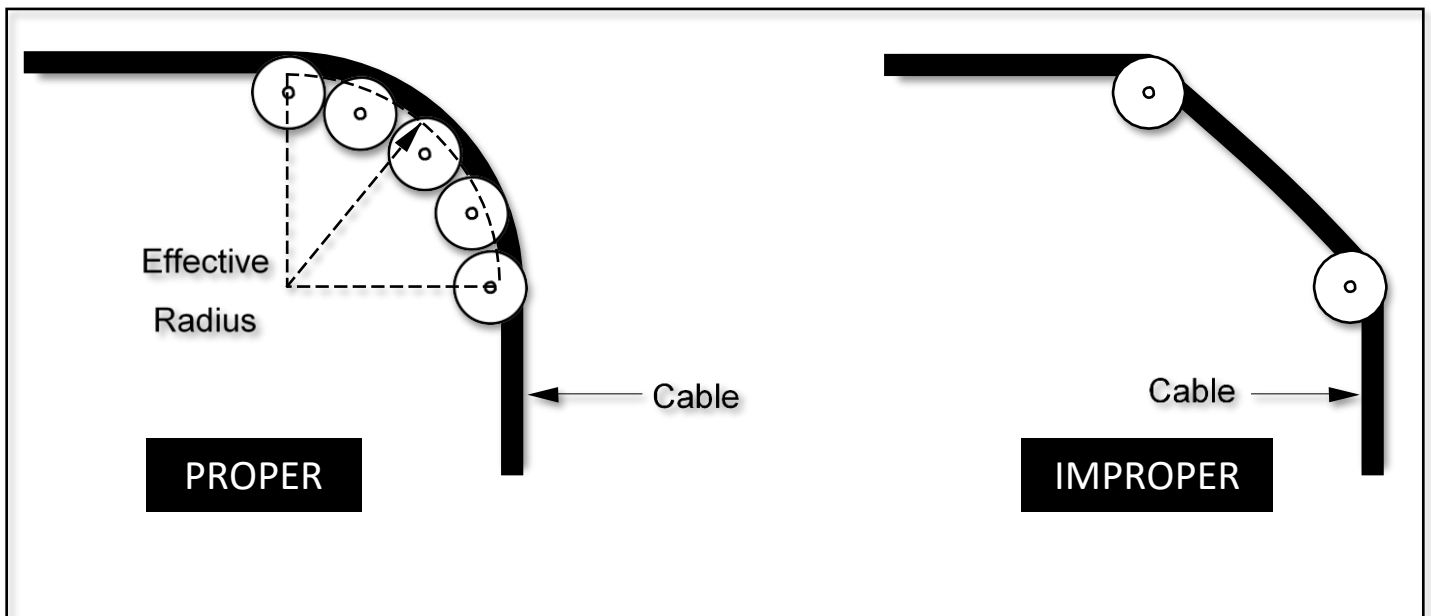


Figure 17. Typical Multiple Sheave Arrangement

8.4 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 18). This is referred to as sidewall pressure and is expressed as pounds per foot of radius.

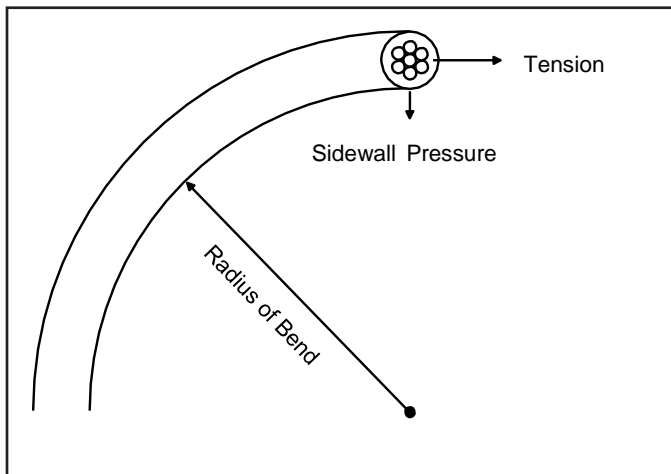


Figure 18. Sidewall Pressure

Sidewall pressure is important in cable pulling calculations for two reasons. The first reason is its increase in the total pulling tension due to greater pressure between the cable and the bend. The second reason 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 VITALink® MC/RC90 it is normally 400 pounds per foot of bend radius, 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 equation for maximum tension based on a sidewall pressure for a single cable is as follows:

Equation 3. Maximum tension for a given SWP

$$T_p = SWP \times R$$

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 T_c based on conductor strength. The lower value of the two governs the cable pull.

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 9 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.

Table 9. 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

8.5 Estimating Pulling Tensions

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:

Tension – No Incline

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

Equation 4. Estimated Pull Tension

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

T = Estimated pulling tension in pounds

L = Length of installation in feet

W = Weight of cable in pounds per foot

K = Coefficient of friction

Coefficient of Friction

The values used for coefficient (K) 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.

Tension – Incline

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) from Table 10 is tabulated below.

Equation 5. Estimated inclined tension

$$T = L \times W \times M + (\text{prior tension})$$

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

Table 10. Multiplying factors (M)

Friction Coefficient K	Angle from horizontal in degrees					
	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

Tension – Out of Bend

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

Equation 6. Estimated tension out of bend

$$T = T1 \times F$$

T = Tension coming out of the bend in pounds

T1 = Accumulated tension going into the bend in pounds

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

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

Table 11. Friction factors (F)

Friction Coefficient K	Angle from horizontal in degrees					
	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

8.6 Estimating Sidewall Pressure

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

Equation 7. Estimated sidewall pressure

$$P = T / R$$

P = Sidewall pressure on the cable in pounds per foot of bend radius

T = Estimated tension out of the bend in pounds

R = Radius of the bend in feet

9 Materials, Tools, and Connectors

Materials (firestops, paints, straps, adhesives, tapes, pulling lubrication, etc.) used with VITALink cables should not have a deleterious effect on the cable.

Recommended Pipe cutter is Rigid 152 and Reed TC4Q for larger cables

Connector manufacturers are listed below. Confirm material compatibility between the copper armor and the connector material(s). Other commercially available connectors may work as well. Information provided is believed to be accurate but it is suggested that the connector 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.

Connector Manufacturers:

American Connectors, Cooper Crouse-Hinds, Hawke Cable Glands America, Hubbell Killark Electric

American Connectors has been fully vetted for proper fitting on all VITALink MC/RC90 cables. See Table 13 in Appendix 1 for more information. Contact RSCC for constructions not listed.

NOTE: For fire rated connectors, see the FHIT/FHIT7 System installation instructions.

10 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 Gauge.

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 VITALink® MC/RC90 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 - NEC 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.

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

¹NEC - National Electrical Code.

¹NFPA - 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.

RC90 - CEC type designation for 90°C armor sheathed cables. These cable designs contain continuously welded (smooth or corrugated) copper (CEC 12-700 & CSA 22.2 No. 123).

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 2196/ULC S139 System FHIT 120/FHIT7 120 - UL electrical circuit protective system that is rated for 2 hour fire resistance in horizontal and vertical at 600 volts.

UL – Underwriters Laboratories

VITALink® MC and VITALink® RC90 - RSCC trade names 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.

11 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.

¹NEC and NFPA are registered trademarks of the National Fire Protection Agency.

12 Appendix 1

Table 12. VITALink MC/RC90 copper armor equivalents

Conductor Size (AWG/kcmil)	VITALink MC/RC90 Copper Armor Size Equivalent (AWG/kcmil)										
	1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	12C
14	-	2	2	1	1	1	1	1	1/0	1/0	1/0
12	-	2	1	1	1	1	1	1/0	1/0	1/0	1/0
10	-	1	1	1	1	1/0	1/0	1/0	1/0	2/0	2/0
8	-	1	1	1/0	1/0	1/0	1/0	2/0	-	-	-
6	-	1	1/0	1/0	1/0	2/0	2/0	-	-	-	-
4	-	-	1/0	1/0	1/0	2/0	-	-	-	-	-
3	-	-	1/0	2/0	-	-	-	-	-	-	-
2	-	-	2/0	2/0	-	-	-	-	-	-	-
1	-	-	2/0	2/0	-	-	-	-	-	-	-
1/0	1	-	2/0	3/0	-	-	-	-	-	-	-
2/0	1	-	3/0	3/0	-	-	-	-	-	-	-
3/0	1	-	3/0	3/0	-	-	-	-	-	-	-
4/0	1/0	-	3/0	3/0	-	-	-	-	-	-	-
250	1/0	-	3/0	4/0	-	-	-	-	-	-	-
350	1/0	-	4/0	4/0	-	-	-	-	-	-	-
400	2/0	-	4/0	250	-	-	-	-	-	-	-
500	2/0	-	4/0	250	-	-	-	-	-	-	-
600	2/0	-	250	-	-	-	-	-	-	-	-
750	2/0	-	-	-	-	-	-	-	-	-	-

RSCC PNs are referenced for ease of lookup for cables ending in “-100” or “-200”. For other suffixes the connector is sized off Armor OD.

Table 13 – MC Cable and American Connector XRef

Conductor Size (AWG/kcmil)	RSCC PN xxx-100 xxx-200	Nom Armor OD (In)	Nom Jacketed OD (In)	Fire Rated WT-WSE Series Stainless Steel Connector PN		Non-Fire Rated WTNI Series Nickel Coated Aluminum Connector PN	
				Non Jacketed Cables	Jacketed Cables	Non Jacketed Cables	Jacketed Cables
1 Conductor							
1/0	VM011X0	1.004	1.107	104-100-S3		104-100	
2/0	VM012X0	1.043	1.146	111-100-S3		111-100	
3/0	VM013X0	1.075	1.178	111-100-S3		111-100	
4/0	VM014X0	1.155	1.258	118-100L-S3		118-100L	
250	VM01250	1.215	1.318	125-125-S3		125-125	
350	VM01350	1.350	1.453	139-125-S3		139-125	
400	VM01400	1.410	1.513	148-150-S3		148-150	
500	VM01500	1.500	1.603	157-150-S3		157-150	
600	VM01600	1.670	1.793	166-150-S3		166-150	
750	VM01750	1.729	1.852	175-200-S3		175-200	
2 Conductor							
14	VM02014	0.820	0.923	083-075-S3		083-075	
12	VM02012	0.820	0.923	083-075-S3		083-075	
10	VM02010	0.886	0.989	090-075-S3		090-075	
8	VM02008	1.004	1.107	104-100-S3		104-100	
6	VM02006	1.075	1.178	111-100-S3		111-100	
3 Conductor							
14	VM03014	0.820	0.923	083-075-S3		083-075	
12	VM03012	0.886	0.989	090-075-S3		090-075	
10	VM03010	0.940	1.043	097-100-S3		097-100	
8	VM03008	1.043	1.146	111-100-S3		111-100	
6	VM03006	1.155	1.258	118-100L-S3		118-100L	
4	VM03004	1.235	1.338	125-125-S3		125-125	
3	VM03003	1.299	1.402	132-125-S3		132-125	
2	VM03002	1.410	1.513	148-150-S3		148-150	
1	VM03001	1.585	1.708	166-150-S3		166-150	
1/0	VM031X0	1.670	1.793	166-150-S3		166-150	
2/0	VM032X0	1.795	1.918	184-200-S3		184-200	
3/0	VM033X0	1.915	2.038	193-200-S3		193-200	
4/0	VM034X0	2.038	2.161	213-250NJ-S3	213-250-S3	213-250NJ	213-250
250	VM03250	2.258	2.412	235-250-S3		235-250	
350	VM03350	2.480	2.634	257-250-S3		257-250	
400	VM03400	2.710	2.864	285-300-S3		285-300	
500	VM03500	2.820	2.974	285-300-S3		285-300	
600	VM03600	3.128	3.302	313-300-S3		313-300	
4 Conductor							

Conductor Size (AWG/kcmil)	RSCC PN xxx-100 xxx-200	Nom Armor OD (In)	Nom Jacketed OD (In)	Fire Rated WT-WSE Series Stainless Steel Connector PN		Non-Fire Rated WTNI Series Nickel Coated Aluminum Connector PN	
				Non Jacketed Cables	Jacketed Cables	Non Jacketed Cables	Jacketed Cables
14	VM04014	0.886	0.989	090-075-S3		090-075	
12	VM04012	0.940	1.043	097-100-S3		097-100	
10	VM04010	1.004	1.107	104-100-S3		104-100	
8	VM04008	1.155	1.258	118-100L-S3		118-100L	
6	VM04006	1.215	1.318	125-125-S3		125-125	
4	VM04004	1.350	1.453	139-125-S3		139-125	
3	VM04003	1.410	1.513	148-150-S3		148-150	
2	VM04002	1.500	1.603	157-150-S3		157-150	
1	VM04001	1.729	1.852	175-200-S3		175-200	
1/0	VM041X0	1.820	1.943	184-200-S3		184-200	
2/0	VM042X0	1.950	2.073	202-200-S3		202-200	
3/0	VM043X0	2.123	2.246	213-250NJ-S3	213-250-S3	213-250NJ	213-250
4/0	VM044X0	2.258	2.412	235-250-S3		235-250	
250	VM04250	2.460	2.634	257-250-S3		257-250	
350	VM04350	2.710	2.864	285-300-S3		285-300	
400	VM04400	3.128	3.302	313-300-S3		313-300	
500	VM04500	3.128	3.302	313-300-S3		313-300	
5 Conductor							
14	VM05014	0.940	1.043	097-100-S3		097-100	
12	VM05012	1.004	1.107	104-100-S3		104-100	
10	VM05010	1.075	1.178	111-100-S3		111-100	
8	VM05008	1.215	1.318	125-125-S3		125-125	
6	VM05006	1.299	1.402	132-125-S3		132-125	
4	VM05004	1.480	1.583	157-150-S3		157-150	
3	VM05003	1.585	1.708	166-150-S3		166-150	
2	VM05002	1.670	1.793	166-150-S3		166-150	
1	VM05001	1.915	2.038	193-200-S3		193-200	
1/0	VM051X0	2.038	2.161	213-250NJ-S3	213-250-S3	213-250NJ	213-250-S3
2/0	VM052X0	2.258	2.412	235-250-S3		235-250	
3/0	VM053X0	2.460	2.614	257-250-S3		257-250	
4/0	VM054X0	2.480	2.634	257-250-S3		257-250	
6 Conductor							
14	VM06014	1.004	1.107	104-100-S3		104-100	
12	VM06012	1.075	1.178	111-100-S3		111-100	
10	VM06010	1.155	1.258	118-100L-S3		118-100L	
8	VM06008	1.299	1.402	132-125-S3		132-125	
6	VM06006	1.410	1.513	148-150-S3		148-150	
4	VM06004	1.585	1.708	166-150-S3		166-150	
7 Conductor							
14	VM07014	1.004	1.107	104-100-S3		104-100	
12	VM07012	1.075	1.178	111-100-S3		111-100	

Conductor Size (AWG/kcmil)	RSCC PN xxx-100 xxx-200	Nom Armor OD (In)	Nom Jacketed OD (In)	Fire Rated WT-WSE Series Stainless Steel Connector PN		Non-Fire Rated WTNI Series Nickel Coated Aluminum Connector PN	
				Non Jacketed Cables	Jacketed Cables	Non Jacketed Cables	Jacketed Cables
10	VM07010	1.155	1.258	118-100L-S3		118-100L	
8	VM07008	1.299	1.402	132-125-S3		132-125	
6	VM07006	1.410	1.513	148-150-S3		148-150	
8 Conductor							
14	VM08014	1.155	1.258	118-100L-S3		118-100L	
12	VM08012	1.215	1.318	125-125-S3		125-125	
10	VM08010	1.299	1.402	132-125-S3		132-125	
8	VM08008	1.500	1.623	157-150-S3		157-150	
9 Conductor							
14	VM09014	1.215	1.318	125-125-S3		125-125	
12	VM09012	1.299	1.402	132-125-S3		132-125	
10	VM09010	1.410	1.513	148-150-S3		148-150	
10 Conductor							
14	VM10014	1.215	1.318	125-125-S3		125-125	
12	VM10012	1.299	1.402	132-125-S3		132-125	
10	VM10010	1.410	1.513	148-150-S3		148-150	
12 Conductor							
14	VM12014	1.235	1.338	125-125-S3		125-125	
12	VM12012	1.350	1.453	139-125-S3		139-125	
10	VM12010	1.410	1.513	148-150-S3		148-150	

* Segmented groundwires available. Contact RSCC for connector PNs for cables with segmented groundwires.

Note: Contact RSCC for other sizes not listed.

