Practical Observations about Electrical Cables for Container Cranes

A PEMA Information Paper

This information paper provides commentary and practical guidance about the selection of electrical cables for container cranes.

It aims to help reduce the problems and costs associated with cable installations and operation of rail mounted cranes.

PORT EQUIPMENT MANUFACTURERS ASSOCIATION

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INTRODUCTION

DOCUMENT PURPOSE

This paper is intended to give specifiers and purchasers of crane cable practical guidance about the selection, storage, transport, and installation of these cables.

The Paper's goal is to improve quality of electrical cable installations and the resulting operation of rail mounted cranes.

Over time, PEMA will further develop this guidance based on industry feedback.

For further information about this paper or to provide feedback, please contact the PEMA Secretariat at info@pema.org.

ABOUT THIS DOCUMENT

This document is one of a series of Information Papers developed by the Equipment Design and Infrastructure Committee (EDI) of the Port Equipment Manufacturers Association (PEMA).

The series is designed to provide those involved in port and terminal operations with advice on standards and their application to the design of port equipment, together with guidance on issues related to equipment design and equipment interfaces with port infrastructure.

This document does not constitute professional advice, nor is it an exhaustive summary of the information available on the subject matter to which it refers.

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The comments set out in this publication are not necessarily the views of PEMA or any member company.

1. EXECUTIVE SUMMARY

Electrical cables are a key part of a large container handling crane, and their proper selection and installation are fundamental to a reliable operation.

On container cranes there are fixed cables, which are not significantly different from those installed in buildings or other applications, and moving cables, which are subject to significant mechanical loads and environmental conditions.

This paper provides guidance about the proper selection, storage, handling, installation and use of electric cables on container handling cranes. A detailed discussion provides guidance about the suitability of particular cables for particular applications on cranes.

Picture A: fixed cable installation inside a crane portal beam

2. BACKGROUND

The operation of a container crane depends on the correct functioning of a large number of electric cables, and their correct functioning depends on their proper selection, handling and installation.

There is a great deal of cabling on a container crane. The cables vary from small control cables to heavy medium voltage gantry cables with built in fibre optic. Many of the cables are fixed and less critical for the performance of the crane. But the gantry, trolley and spreader on a container crane move regularly and must be supplied by a reliable cable, designed for movable applications.

A properly designed, accurate and durable electrical cable installation is critical to the reliable long term performance of large cranes. Such an installation depends on many pieces fitting together properly and many things can go wrong.

Typical cable problems include:

- The selection of the correct size and type according to the particular application.
- Accidental damage and deterioration in storage.
- Incorrect handling during installation.
- Installation not in compliance with the good practices of the specific energy supply system (Reel, festoon, cable chain, etc.).
- Twisting and torsion due to misalignment of cable guides and reels.
- Mechanical damage such as abrasion, crushing and impacts.
- Excessive constant and dynamic tension.
- Bending beyond the recommended minimum cable bending radius (Rmin).
- Overheating and current overloading.
- Failure to anchor cables to ensure the distribution of tensile forces over a sufficiently large area.

3. CABLE SELECTION

When selecting electrical cables, the primary consideration is safety of operation. This means that the product does not present an unacceptable risk of danger to life or property while being used in its intended manner. Unsafe cables can result in fire, electric shock and other unacceptable outcomes.

The life of a cable depends on the type of use, the installation, and the characteristics of the electrical equipment. All selection factors mentioned should be considered in combination, not separately.

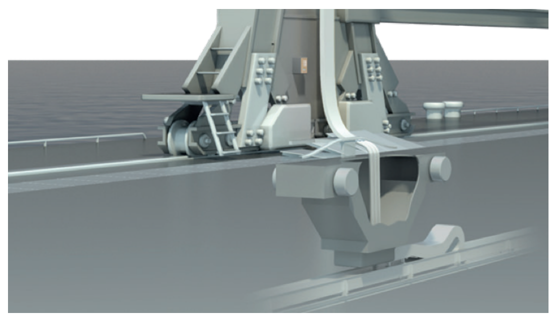
Cable selection should be made by skilled and experienced professionals, taking into account the mechanical and electrical requirements. The cables should be used solely for their designated purpose.

Conductors and cables should be suitable for their operating conditions. Consideration should be given to voltages and currents, protection, grouping with other cables and local derating factor rules.

External influences such as ambient temperature, mechanical stresses, presence of water or chemicals and fire hazards as well as method of installation, exposure to sun and weather and accessibility are also important.

Picture B: STS crane MV gantry cable reel system with a belt and plate lifiting device

Flexible electrical cable should be used for connections to all mobile equipment and should be selected with the application and operating conditions in mind.



Picture C: STS crane MV gantry cables running inside a cable chain in a trench

3.1 Applicable standards

For applicable local and international standards please refer to upcoming PEMA papers on the topic crane electrical systems/safety.

3.2 Voltage

The rated voltage of a cable is the reference voltage for which it is designed.

The rated voltage of a cable in an alternating current system is expressed by the combination of two values. In ports, two type of voltage ratings can be found, depending on the electrical protection system used:

U_0/U (U_m), expressed in volts, where

U_0= the rms value between any insulated conductor and "earth" (the metal covering of the cable, or the surrounding medium).

U= the rms nominal value between any two phase conductors of a multicore cable or of a system of single core cables. For 3-phase: U=√ U_0 .

(U_m) = according to IEC, U_m is the maximum permissible operating voltage.

*For 3-phase: U_m = 1.2*U*

Typically, these cables are used in solidly earthed systems.

Or,

U/U, expressed in volts, where

U= the rms value between any two phase conductors of a multicore cable

These cables are typically used in systems that are not effectively earthed. They are not intended for continuous operation with one phase earthed.

In alternating current systems, the rated voltage of a cable or cord should be at least equal to the nominal voltage of the system for which it is intended. This condition applies to the values of both *Uo* and U.

3.3 Current-carrying capacity

The cross-sectional area of every conductor should have a current-carrying capacity which is not less than the maximum sustained current which will normally flow through it. The limiting temperature, to which the current-carrying capacity is related, should not exceed the cable's insulation or sheathing capability..

Cable current-carrying capacity is affected by the method of installation, cable supplier rules and the selected cable type. Correction factors are available for particular conditions, such as ambient temperature, cable grouping, overcurrent protection type, dynamic installations, cable spacing, electrical frequency of supply and harmonic effects.

Or in other words, the cross sectional area of a conductor should not be based on current-carrying capacity alone. Thermal effects, electrical shock, overload and short-circuit currents, voltage drop and mechanical strength are additional factors that must be considered.

Other influences may arise in a particular installation. For example, the type of spool on reeling systems will generate extra derating factors, which may or may not include the ambient derating factors. The reeling system maker should be able to advise on such rules. Current ratings and correction factors can be derived from corresponding rules and obtained from the respective cable manufacturer.

3.4 Ambient temperature considerations

The maximum continuous operating temperature limits of the individual types of cable can be found in the applicable standard or by contacting the cable manufacturer. The values given should not be exceeded by the combination of the heating effect of current in the conductors and the ambient conditions.

3.5 Mechanical stress

Cable selection must consider the working environment and the mechanical loads that cables will be subject to in daily operation. Tensile loads on cables should not exceed 50 N/mm2 during installation for flexible cables under static stress and local and manufacturer rules should be followed. If flexible cables will be subjected to a variable mechanical loading during operation (including loads induced by reeling operation), the permissible tension and fatigue life shall be agreed between the design engineer and the cable manufacturer. Cables should not be exposed to tensile loads exceeding the permissible tensile load of 15 N/mm² main core nominal cross section (according to VDE 0298 part 3, section 7.1).

The table below provides some guidance about cable bending radii, yet, supplier rules have to be considered.

MINIMUM CABLE BENDING RADIUS (D = Cable Diameter)

Operating Voltage	Application							
	Fixed	Festoon	Cable Reel	Basket	Cable chain	Tender system	Guide Pulley System	Delivery drum
Up to 1000V and 20mm OD	4xD	4xD	5xD	15xD	7.5xD	4xD	7.5xD	5xD
Up to 1000V over 20mm OD	4xD	5xD	6xD	15xD	7.5xD	5xD	7.5xD	6xD
Over 1000V	4xD	10xD	12xD	-	10xD	10xD	15xD	7xD

Table 1: Recommend minimum bending radii (Rmin) for cable

The above stated values are general guidelines and the minimum cable bending radii (Rmin) stated by the cable or cable management system provider should be followed. Composite cables require a larger bending radii, such as when an optical element is included in the cable design.

4 SPECIAL CRANE APPLICATIONS

The following sections discuss the required characteristics of special cables used on moving parts of container handling cranes.

4.1 Design considerations

4.1.1 Conductors

Conductors in cables for such applications are typically manufactured from annealed copper. Standards contain a number of different classes of conductor to suit the application for which the cable will be used. The most popular classes for flexible applications being Class 5 and Class 6.

The individual wires may be plain or metal coated depending upon the environment conditions in the particular application.

Although small conductors may be manufactured as a single bunch of small diameter wires, larger conductors are typically manufactured as multiple stranded, circular flexible conductors (rope stranded) the design of which can be tailored to suit the application eg resist torsion, resist crushing, have the greatest flexibility.

4.1.2 Material compounds

See detailed applications below

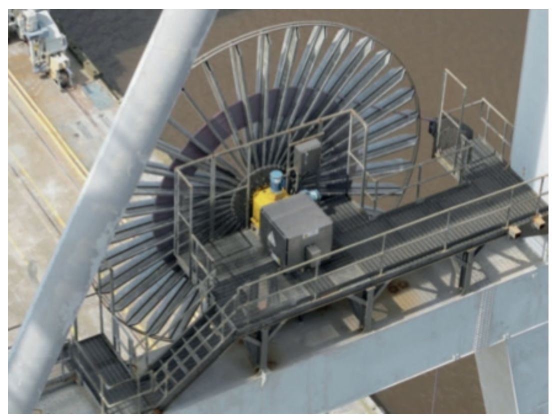
4.1.3 Metallic braids or screens

Special consideration is required when choosing metallic braids as a screen or shield. When a braid or screen is made entirely of copper wires and is bent as the cable flexes, the fine wires can work harden and break due to the continuous stretching and relaxation. Because the wires rub against each other where they cross, they will abrade each other, causing wear and eventual breakage.

For these reasons both the minimum cable bending radius (Rmin) and operating speed specified for cables containing a metallic braid or screen needs to be carefully considered.

4.2 Reeling hybrid cables for main power supply

To power a crane it is common practice to use a motor reeling system with a power cable installed to connect the crane with the port electrical supply. For modern cranes the preferred type of reel is monospiral. Some older cranes use a cylindirical reel placed in parallel to the driving direction of the crane.



Picture D: Gantry cable reel, providing the main power supply to an STS crane

4.2.1 Selection of cables for reeling systems

Low voltage (LV) power reeling cables are mainly based on polyurethane rubber (PUR) or synthetic rubber compounds for the insulation and sheathing; medium voltage (MV) reeling cables are more often only based on synthetic rubber compounds for insulation and sheathing.

Both compound types are used for high duty cycles. Synthetic rubber has an advantage when high speed reeling is expected. Polyurethane rubber (PUR) based reeling cables are usually thinner and lighter, allowing for a less weighty and more cost-effective reel designs.

On mono-spiral reels the power reeling cable is usually a round design. Flat cables can also be used, which allows the spool diameter to be reduced, however, special attention has to be given to the cable cooling calculation.

The rated AC voltage can vary between low voltage (0.6/1kV), which is often in use to power electrified RTGs and medium voltage of up to 18/30kV in use for STSs, (A)RMGs or ASCs. The operating voltage is defined by the port operator.

A power reeling cable typically has three phase conductors and an earth conductor. The cross-section of the power cores is defined by the electrical load and operating voltage. The cross-section of the earth conductor must be a minimum half cross-section of one power conductor or, if different, comply with local regulations.

For low voltage applications the power cable can be designed with three power cores and one full earth conductor (e.g. 4x25mm²) or with three power cores and a split earth conductor (e.g. 3x70+3x35/3).

For an optimized cable diameter and greater flexibility in operation, the earth conductor, especially on medium voltage power cables, is typically split into three parts and laid in the interstices of the power core assembly (e.g. 3x50+3x25/3).

Nowadays, the majority of applications require fibre optics integrated into the power cable. In this case the earth conductor is split in two parts laid up in two interstices, whilst the fibre optic element is placed in the third interstice. To limit the risk of attenuation, it is recommended not to integrate more than 24 fibres into the power cable. Typically, fibres are either multi-mode G50/125µ and G62.5/125µ or single mode E9/125µ. Further it is possible to integrate bus pairs or control cores. (e.g. 3x50+2x25/2+1x(18E9/125µ))

Picture E: Typical MV power reeling cable design with integrated fibre optics

Mechanical parameters such as the maximum permissible pulling force or gantry travel speed are defined by the manufacturer of the cable. For high-speed applications beyond 240m/min special design features may apply.

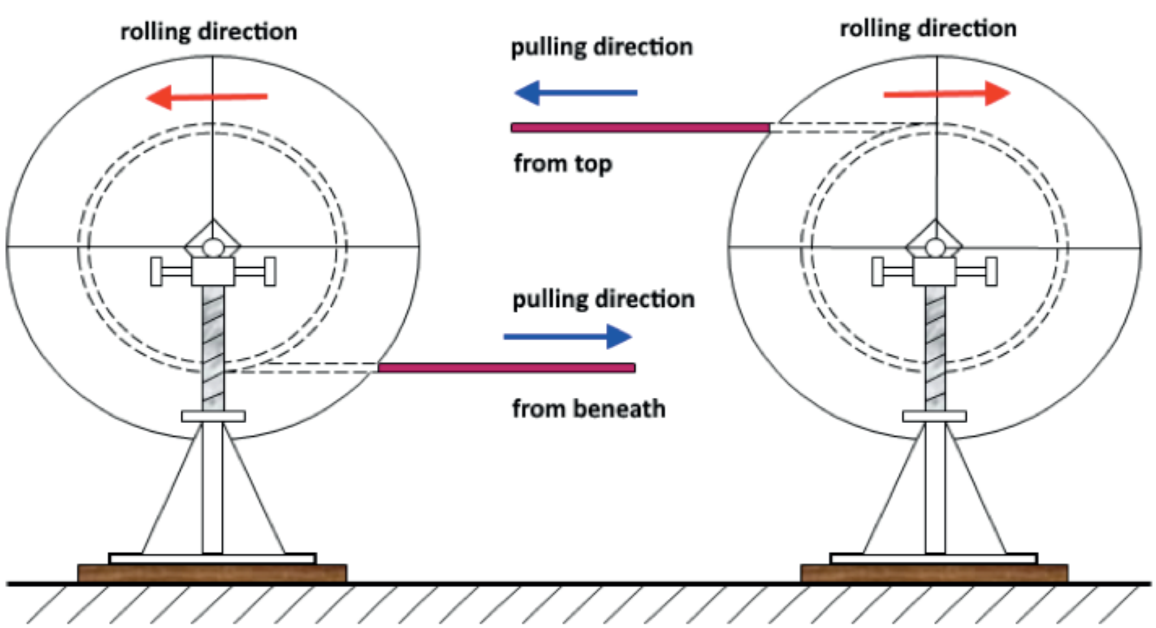
On mono-spiral reels the power reeling cable can be a flat design.

In this case, the three power cores are in a parallel arrangement and the earth conductor is split and concentrically distributed around each power core. This is in order to avoid any surface discharges and to ensure symmetric electrical and mechanical relations within the cable. Fibre optic elements can also be integrated.

The mechanical performance of flat power reeling cables is limited. The permissible tensile load is usually limited to 15N/mm² and the maximum gantry speed shall not exceed 120m/min.

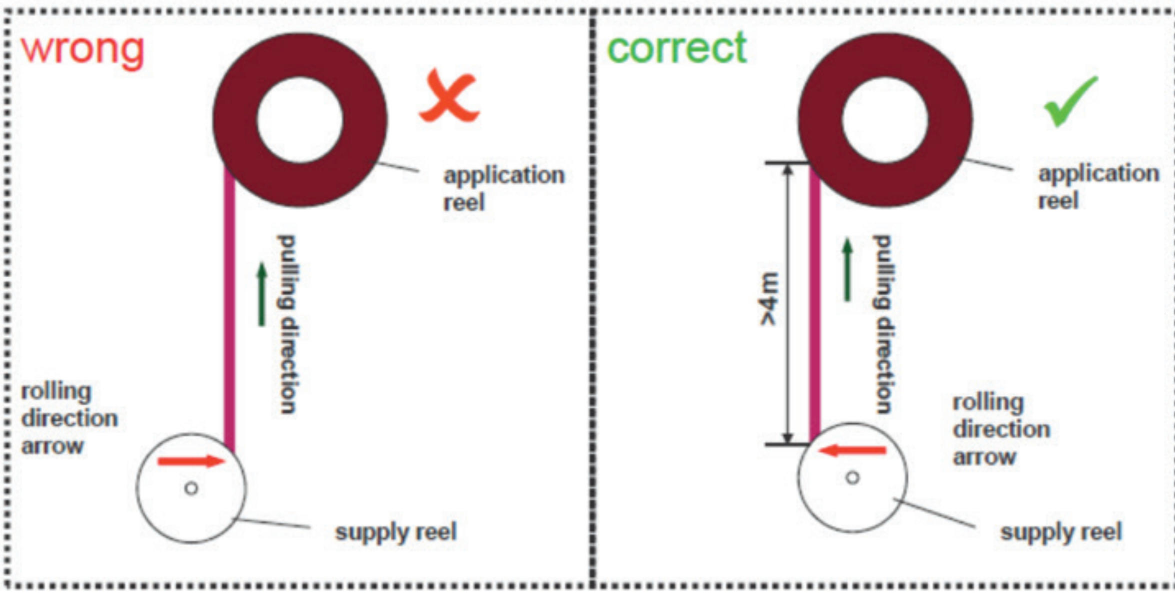
4.2.2 Installation of cables specific to reeling systems

In order to ensure best cable performance, it is very important to install the cable correctly. Overtension, reverse bending and torsion have to be avoided. When installing the cable, the direction of pulling is in the opposite direction to the rolling direction of the supply or storage drum:

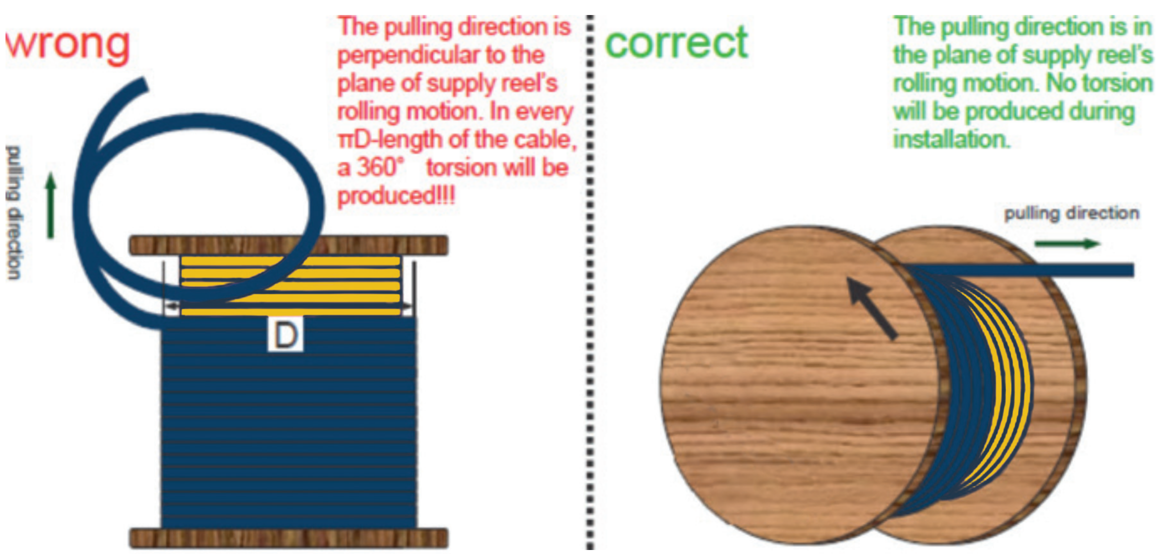


Picture F: Cable pulling direction on storage drum

Feed the cable directly from the delivery or storage drum onto the motor reel on the crane in one continuous smooth operation under constant tension. To avoid reverse bending of the internal components of the cable, both reels must rotate in the same direction and same plane. The distance between the drums must be sufficient to allow the internal components to return to their neutral position.



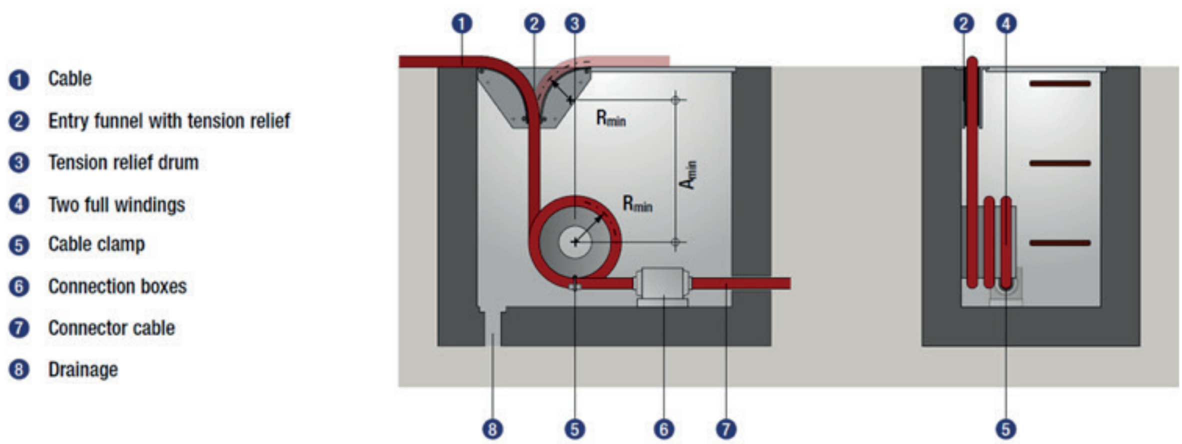
Picture G: Correct cable pulling direction vertically



Picture H: correct cable pulling direction horizontally

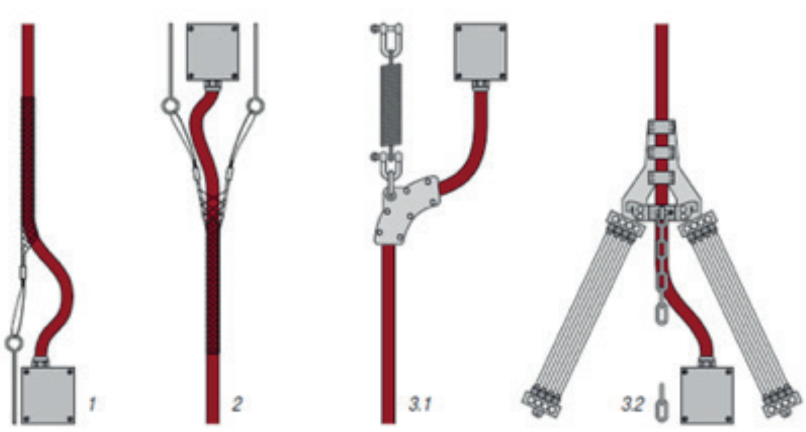
A moving reel cable, with central or end feeding, should never be operated without sufficient tension relief. The tension relief can either be achieved by using a tension relief drum or a cable mesh grip.

When using a tension relief drum, it is important to ensure that the drum and the entry funnel comply with the minimum cable bending radius (Rmin) and that relief segments (Amin) are provided. The relief segment (Amin) is the correct distance between the tension relief drum and the entry funnel (see Picture I below). It is dependent on the cable and must be defined by the cable manufacturer. At least two full windings should be in place on the cable reel and the tension relief drum.



Picture I: Cable reel tension relief drum

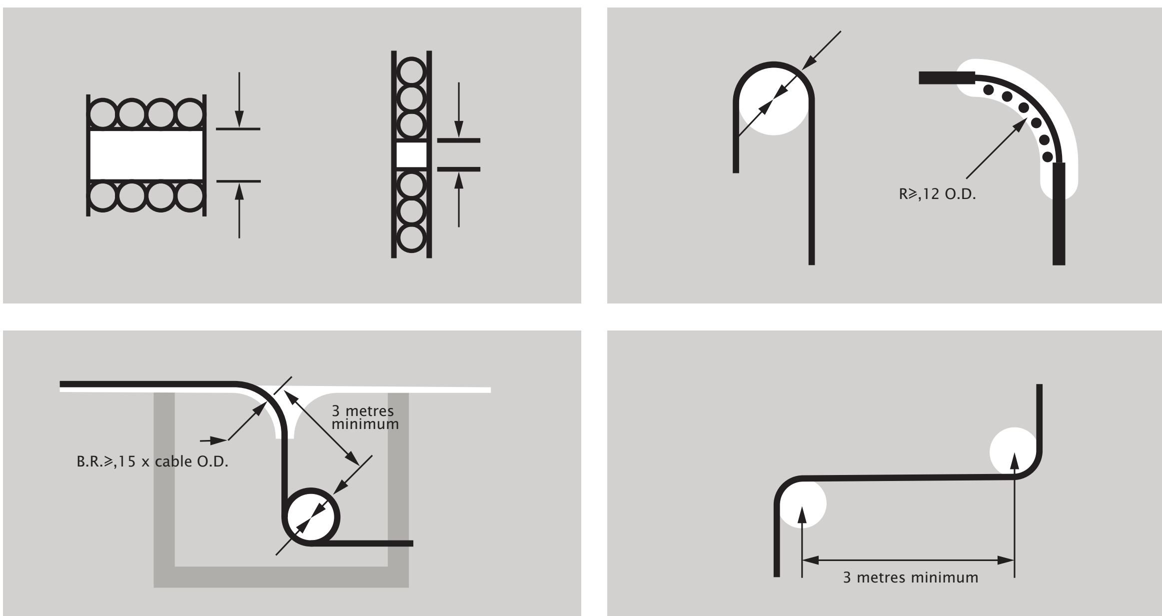
Another option for tension relief is the cable mesh grip, which avoids point stresses on the strands in stranding bundles. The correct mesh grip tension relief is selected according to the cable diameter. A mesh grip with a single fixing eye is the standard variant (version 1). For vertical applications with higher tension forces or central feeding, the use of mesh grips with two fixing eyes is recommended (version 2). For impacts or extreme tension forces (e.g. spreader applications) systems with tension relief springs (version 3.1) or bundles of rubber ropes (version 3.2) are used. Line pulling swivels should always be used to connect the cable mesh grip to the pulling line.



Picture J: Different cable mesh grip versions

To ensure a proper function of the reeling system, the following critical dimensions need to be optimized to prevent cable twisting and uneven cable wear, which will affect the life time of the cable reel cable.

The critical dimensions of the reeling system consist in the different applicable cable bending radii according to the situation, the sheaves or rollers sizes and shapes, the deviation angles and the relaxation distances. All these parameters have to be considered for best lifetime of the cable using both the specification of the cable manufacturer and the experience and knowledge of the reel maker. The cable selection and design of a reeling system should be left to an industry expert, preferably the selected manufacturer.



Max working speed 60M/MIN

In order to prevent torsion and wear

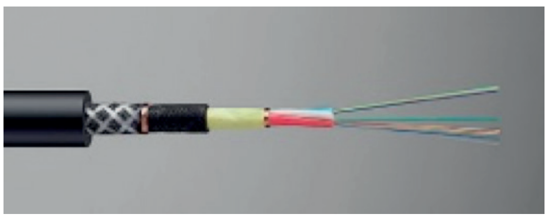
Suitable only at low speed (Max. 60 meters/Min)

Picture K: Critical bending radii dimensions of reeling systems

4.2.2.1 Hybrid reeling cables

As mentioned before, with careful thought and special design, fibre optics, bus (e.g. profibus) or control cores can be integrated into the power cable design of a cable reeling cable.

Single fibre optic cables can also be used for reeling applications, for instance to upgrade a crane with secure data transmission.



Picture L: Optical fibre cable for reeling applications

4.3 Festoon cables

Festoon cables are designed and manufactured for use in festoon systems powering moving trolleys on gantry cranes. This application subjects the cables to frequent flexing and mechanical stress. Festoon cables are unusual in that they are supplied in both round and flat constructions. This is because they are primarily designed for the use on cranes, hoists, or any other equipment, which travels with a lateral traversing motion. Flat festoon cables can be stacked and are frequently used where space is at a premium, or where extreme flexing is a requirement. These cables must be very flexible, while resistant to weathering and strong sunlight exposure.

4.3.1 Selection of cables for festoon systems

The first steps to lay out a festoon system are to prepare a list of all the required cables and their respective cross sections. Then, select the appropriate type of cable (flat or round) and the appropriate composition for your application.

Round festoon cables are the preferred choice for motorised festoon systems with speeds of 240m/min and higher. Speed limits are given by the cable manufacturer. For outdoor festoon cables for container handling it is recommended to use cables based on synthetic rubber or polyurethane rubber (PUR) compound. The rated voltage of round festoon cables is commonly 0.6/1kV. Because of their thermoplastic behaviour cables based on polyvinyl chloride (PVC) or thermoplastic elastomer (TPE) are not recommended for mechanical and environmental reasons.

Dynamic forces that occur as the festoon system moves can be partly absorbed by larger cables. Therefore whenever possible, wider cables should be used instead of multiple smaller cables (e.g. one cable of 12x1.5mm² instead of three cables of 4x1.5mm²)

A typical cable package consists of power, control, bus pairs, fibre optic and communication cables, as well as screened electromagnetic compatibility (EMC) cables. Each manufacturer typically has their own bespoken design for the core assembly of these types of cable.

Flat or round festoon cables are the preferred choice for non-motorised festoon systems with moderate speed of up to 160m/min. Again speed limits for flat or round cables are given by the cable manufacturer and validated by the integrator based on specific application parameters.

For flat outdoor festoon cables, for container handling, it is recommended that cables based on synthetic rubber or polyurethane rubber (PUR) compound are used. The rated voltage of flat festoon cables is commonly 300/500 V. Under special conditions, the manufacturer may allow the use of flat festoon cables of up to 0.6/1kV. Cables based on polyvinyl chloride (PVC) or thermoplastic elastomer (TPE) are only recommended for indoor festoon applications.

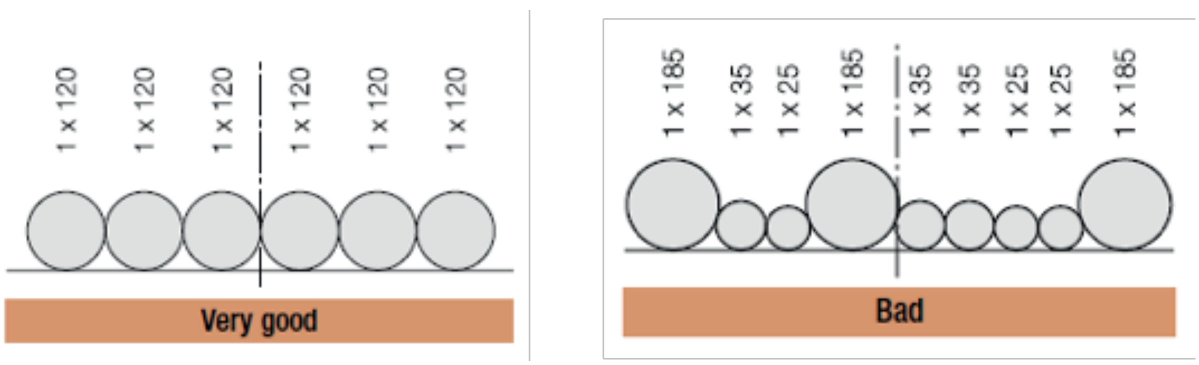
A typical flat festoon cable package consists of power, control, bus pairs and communication cables. The design of the core assembly depends on the manufacturer.

4.3.2 Installation of cables specific to festoon systems

The correct installation of the festoon cables has to follow the instructions provided by the system integrator. In general, torsion or excessive pulling must be avoided during the installation.

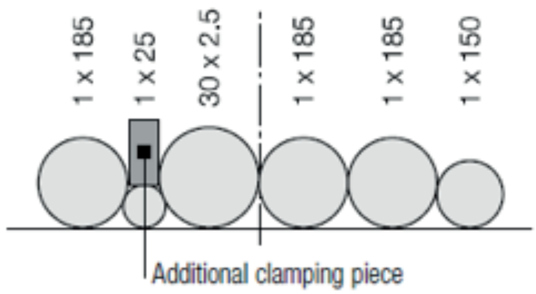
During the installation it is critical to release the cable stress by leaving the unwound cable to rest for a time before installation on the festoon trolleys.

Attention should be placed on the cable diameters when arranging round cables on the cable support. The diameters of the various cables should not vary too much, to allow for a proper clamping.



Picture M: Arrangement of round cables on the festoon cable support

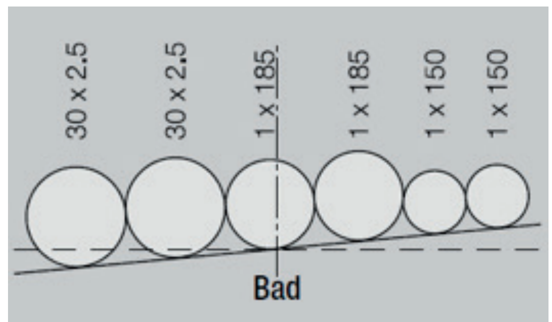
If deviations in diameter of adjacent cables are more than 15mm, the use of additional clamping pieces are required.



Picture N: Arrangement of round cables on the festoon cable support

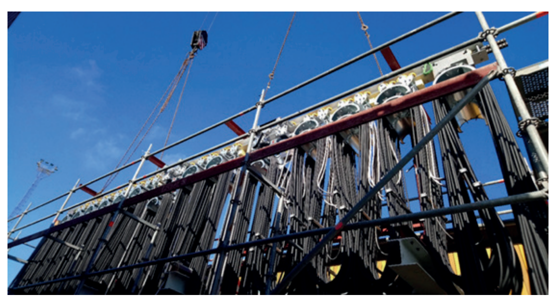
Cable clamps maintain proper spacing of the cable package within the cable loop. While outer cables are clamped, all other cables are guided in the inner windows and can move freely.

Unshielded power cables with larger cross sections should be favoured for the outer cables (e.g. 1x120mm² or 4x25mm²). A proper weight balance of the cable load on the cable supports has to be maintained.



Picture O: Balancing of round cables on the festoon cable support

Festoon systems can also be delivered pre-assembled to ensure a perfect installation and to reduce a crane's downtime.



Picture P: Pre-assembled festoon system being lifted for installation on a STS crane

4.3.2.1 Festoon motor cables

Round power cables are either single core cables or manufactured in 4-core designs with three phase conductors and one full earth conductor (e.g. 4x25mm²). For diameter reasons, it is recommended to use a three phase + split earth design for cross-sections larger than 50mm² (e.g. 3x70+3x35/3). Round cables larger than 4x50mm² on festoon systems usually require an application engineering validation to ensure system performance.

Flat power cables are manufactured in 4-core designs, with 3 phase conductors and one full earth conductor laid-up in parallel. They are more flexible than round cables, especially for sizes above 4x50mm². Because of the cable dimensions, flat power cables with a cross-section beyond 120mm² are uncommon.

Picture Q: Festoon cables to a machinery-on-hoist trolley

Cables for variable frequency drive (electromagnetic compatibility (EMC) cables) are power cables which need to be electrically symmetrical. For this reason individual screens are concentrically arranged around each power core (preferable a braid of copper wires) with a mimimum optical coverage of 80%. From the mechanical point of view, the design of a metallic screen is always critical, especially due to the tight bending in the loop of a festoon application.

Therefore and also for outer diameter limits, the use of electromagnetic compatibility (EMC) cables with cross-sections larger than 50mm² can be counter-productive.

4.3.2.2 Festoon control cables

Round control cables are usually limited to a maximum of 36 conductors, due to the cable diameter. Typical cross-sections are 1.5mm² or 2.5mm². The conductors are arranged in layers around the cable centre.

In case of screened cables, it is strongly recommended, for mechanical reasons, that these are individually screened instead of an overall screen (e.g. 24x1(C)). Individually screened cables offer better reliabilityand resistance to mechanical stresses such as tight bending.

Flat control cables are usually limited to a maximum of 42 conductors, due to cable width and height. Typical cross-sections are 1.5mm² or 2.5mm². The conductors are arranged either in parallel or in pre-assembled bundles laid in parallel.

4.3.2.3 Festoon BUS/Data cables

For bus cables, irrespective of round or flat design, best practice are cable designs with twisted shielded pairs (e.g. 6x(2x1)C). For mechanical reasons the cross-section should be a minimum of 0.5mm².

4.3.2.4 Festoon fibre optic cables (FOC)

Fibre optic cables, for reliable communication with high data rates, are also available for festoon systems.Whereby as glass fibre cables, either as multimode G 50/125 µm, G 62.5/125 µm or single mode E9/125. They are available with a synthetic rubber or PUR outer jacket and with up to 24 fibres.

Picture R: Optical fibre cable

4.4 Cables for cable chains

Chain cables should be specifically designed, manufactured and tested for the use in cable chains.

To ensure the durability inside a cable chain system, cables must :

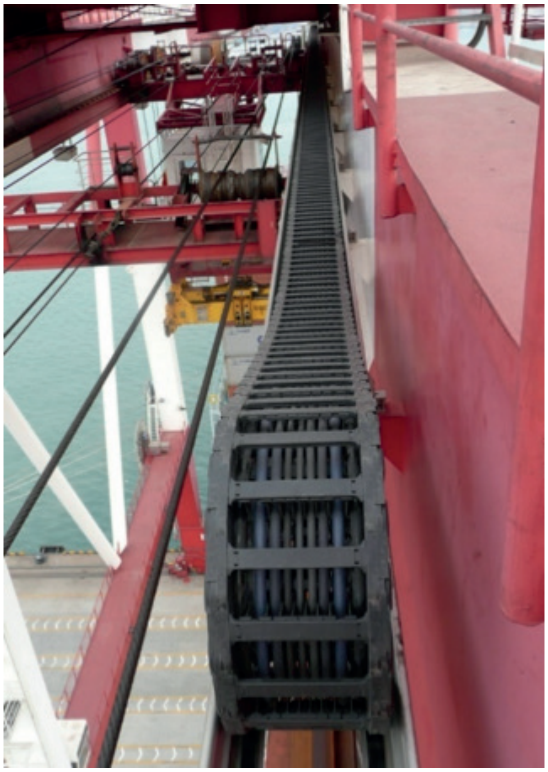
- Be twisted according to special manufacturing procedures
- Have highly abrasion resistant insulation and jacket materials, which meet the special conditions in a cable chain system
- Have high-pressure and gusset filled extruded jacket materials
- Have, a design made from tinned copper wire braid with an optical coverage of 85% in case any electromagnetic compatibility (EMC) screen applies,
- Be comprehensively tested under realistic test parameters inside an energy chain
- Be selected and installed according to manufacturer specific guidelines.

4.4.1 Selection of cables for cable chains

When selecting a cable for a cable chain, consideration should be given to so-called highly flexible cables and flat cables as they are not necessarily suitable for cable chain applications. Only cables specifically guaranteed by manufacturers as cables for cable chain applications should be selected.

The cable type is dependent on the electrical requirements (motor, control, communication, camera and so on) as well as, the available installation space in the chain or the travel distance involved.

Large cable diameters require large cable chains and correspondingly large radii, resulting in bigger space occupied by the chain system and bigger stress on the chain itself. Therefore, in cable chain systems, the use of single-core motor cables, shielded or unshielded, is highly recommended where a cable cross section is greater than 25 mm².



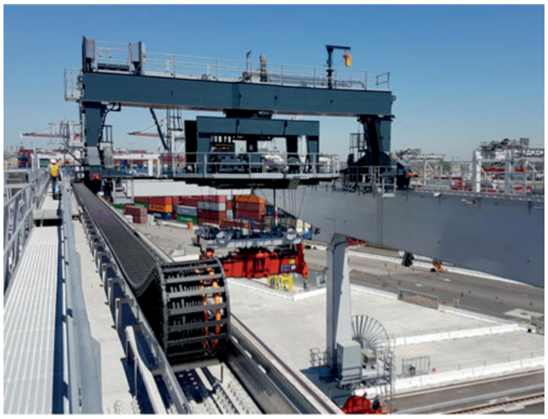
Picture S: Chain system for the cable guidance to machinery-on-hoist trolley

4.4.2 Installation of cables specific to cable chains

During the installation of cables inside a cable chain, the best practice rules listed by the manufacturer of the cable chain should be followed.

As general rules:

- Keep a level of clearance around each cable. A minimum reserve space of 10% for electrical round cables is suggested.
- In demanding long travel distance applications (travels beyond 60m, speed of more than 240m/min) where high values of the ratio between a chain's height and a chain's bending radius (>0,2) exist, placing the cables with two cables on top of each other, with same outer diameter or in one layer (without overlapping of the cables inside the cross section) is strongly recommended.
- All the cross bars should be securely closed.
- All the interior separation should be plumb and tight.
- Leave a cable loop for cable adjustment on both ends of the chain.
- In the case of cable chain systems that include a guide channel, make sure that:
    - the fixed point is in the right position foreseen by the chain OEM.
    - the chain is running on a flat surface. In case of a single chain application the supports on the extended side of the travel distance, are at the same level of the upper part of the chain on the retracted side.
    - the guide channel should be levelled, straight and aligned with the towing arm movement. In case of misalignment the use of a misalignment recovery system on the towing arm is strongly recommended.
    - the cables should be fixed on both ends of the chain with proper devices,corresponding with the bending radius of the chain, they have to run slightly outside the centre-line of the chain (cables should benot too tight or too lose inside the chain).
    - before the first movement of the moving point, there should be no obstacles on the running surface of the systems.



Picture T: Cable chain system for the cable guidance on an RMG crane

If the complete cable chain needs to be replaced, the delivery of a fully harnessed chain, with cables already inserted, ensures a fast and easy installation, keeping the crane downtime to a minimum.

Picture U: Harnessed cable chain installation

4.4.2.1 Cable chain motor cables

Many motor cables will have large cross sections and in the case of `assembled cables' (3 or 4 cores), this leads to very large cable diameters.

Large cable diameters require large energy chains and correspondingly large bending radii.

In addition, assembled cables are up to 30% heavier than corresponding single-core motor cables.

In cable chains, therefore, the use of single-core motor cables, shielded or unshielded, is recommended above a cross section of 25 mm².

Selection table for motor cables:

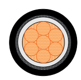
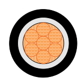
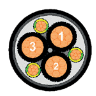
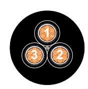
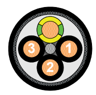
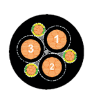
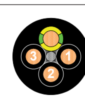
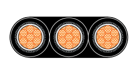
Construction	EMC evaluation	Type of mechanical application	
		Cable chain horizontal	**Cable chain vertical**
 shielded	good	optimum	optimum
 unshielded	mediocre	optimum	optimum
 shielded	good	mediocre	mediocre
 unshielded	good	mediocre	mediocre
 shielded	good	good	good
 unshielded	good	poor	poor
 unshielded	mediocre	mediocre	mediocre
 unshielded	poor	poor	poor

Table 2: motor cable selection chart

4.4.2.2 Cable chain control cables

As a rule, control cables have multiple cores. In order to avoid damage, especially in the case of highly dynamic crane applications with long travels, cables with an assembled structure (e.g. bundle assembly) that reliably prevent corkscrew damage in cable chains are preferable. Gusset-filling, extruded jackets have proven to be reliable.

Table of control cable options:

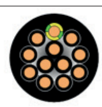
Construction	EMC evaluation	Type of mechanical application	
		Cable chain horizontal	**Cable chain vertical**
 shielded	good	optimum	optimum
 unshielded	mediocre	optimum	optimum
 shielded	good	poor	poor
 unshielded	mediocre	poor	poor

Table 3: control cable selection chart

4.4.2.3 Cable chain BUS/Data cables

BUS and data cables are used for reliable communication between a control system and the respective actuators and sensors. On the one hand, a small cross section is completely sufficient as the signals are usually transferred with low voltages and currents. On the other hand, however, maximum electromagnetic compatibility (EMC) protection shall be ensured.

A form of assembly (e.g. twisted pair) that is most appropriate for data technology purposes is just as important as a braided copper shield with an optical coverage of at least 85%.

Here, it should be borne in mind that braided shield structures are clearly preferable to mere plastic film in the chain application.

Gusset-filling inner jackets also protect the assembled structure against mechanical damage.

Table of Bus/Data cable options:

Construction	EMC evaluation	Type of mechanical application	
		Cable chain horizontal	**Cable chain vertical**
 shielded	good	optimum	optimum
 shielded	mediocre	mediocre	mediocre

Table 4: Bus/Data selection chart

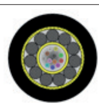
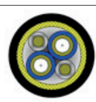
4.4.2.4 Cable chain fibre optic cables (FOC)

On cranes, fibre optic cables are ideal for reliable communication with high data rates.

Either G 50/125 µm, G 62.5/125 µm or E9/125 cclass fibre cables are recommended.

When an fibre optic cable is selected, it is important to ensure that it has a robust structure. For horizontal applications, gel-filled hollow-core types or tight-buffered core types can be used. The jacket material mixture must be stable and each fibre cable type must be tested for movement.

Selection table fibre optic cables:

Construction	EMC evaluation	Type of mechanical application	
		Cable chain horizontal	**Cable chain vertical**
 loose tube	optimum	optimum	poor
 sub cable	optimum	optimum	optimum

Tabele 5: fibre optic selection chart

Picture V: Fast running rail mounted ASC crane with cable gantry reel and cable chain system

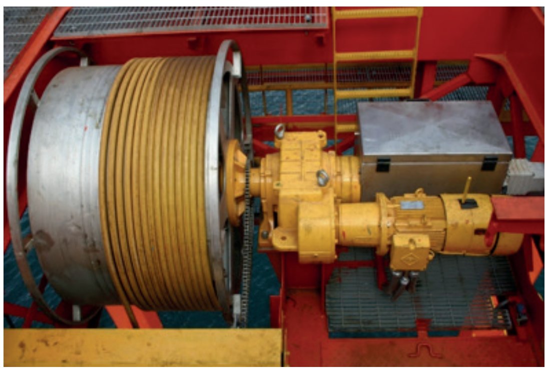
4.5 Spreader cables

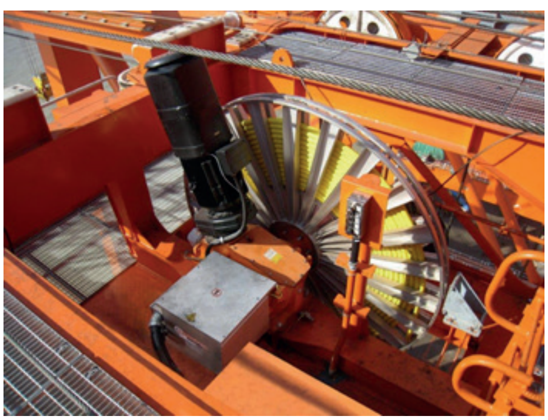
Spreader cables should be specifically designed and manufactured to withstand high hoist and trolley speeds, as well as the extreme mechanical stresses predominant on vertical systems. Hanging vertically, their design and manufacturing is special. The vertical system can be either a reeling system or a basket collector. On modern cranes, it is usual to install a spreader reeling system on cranes with a high suspension length (e.g. on STS cranes); yard cranes, with shorter suspension lengths, often use a spreader basket system (e.g. (A)RMG cranes).

4.5.1 Spreader reeling cables

The majority of vertical reeling cables for crane applications are based on synthetic rubber compound for insulation and sheathing. The capability of synthetic rubber offers best resistance to high mechanical stresses and secondary influences, and provides the best performance at varying ambient temperatures.

Two different reeling systems exist: cylindrical drum and mono-spiral reel





Picture W: Trolley mounted LV reeling drum for spreader cable for an STS crane

The rated voltage for spreader cables is typically 0.6-1kV.

Spreader reeling applications cause extreme mechanical stresses to cables. Special compounds are employed for the cable design and manufacture to increase the cable's resistance to high tensile load, torsional and bending stresses, transversal pressure and abrasion.

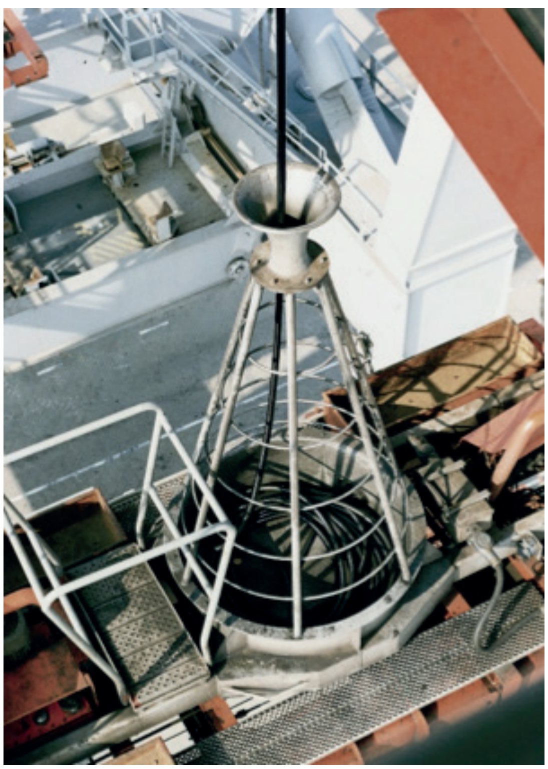
The use of special support elements to increase the permissible pulling force is especially recommended.

Spreader reeling cables are control cables with up to 56 cores typically laid up in concentric layers around the cable centre. A typical cross-section is 2.5mm². Anything smaller has lower mechanical strength while anything bigger can make the cable too stiff and the outer diameter too big.

If required, fibre optics or BUS pairs can also be integrated.

4.5.2 Spreader basket cables

Spreader basket cables should be specifically designed and manufactured to withstand the hoist speeds and stresses associated with coiling vertically into a collection basket. Although these cables have to coil uniformly under gravity into the collection basket, a basket operation means no forced cable guidance. Uncontrollable weather conditions in seaports, such as strong winds or storms, can push the cable out of the basket. Weights are sometimes added to the cable to counteract this problem.



Picture X: Spreader basket application

The use of special support elements to increase the permissible pulling force is recommended.

Spreader basket cables are control cables with up to 54 cores, typically laid up in pre-assembled units, which are laid around the cable centre. A typical cross-section is 2.5mm². Because of constraints upon size and weight, a higher number of cores is not recommended.

It is possible to integrate fibre optic or BUS pairs in a spreader basket cable.

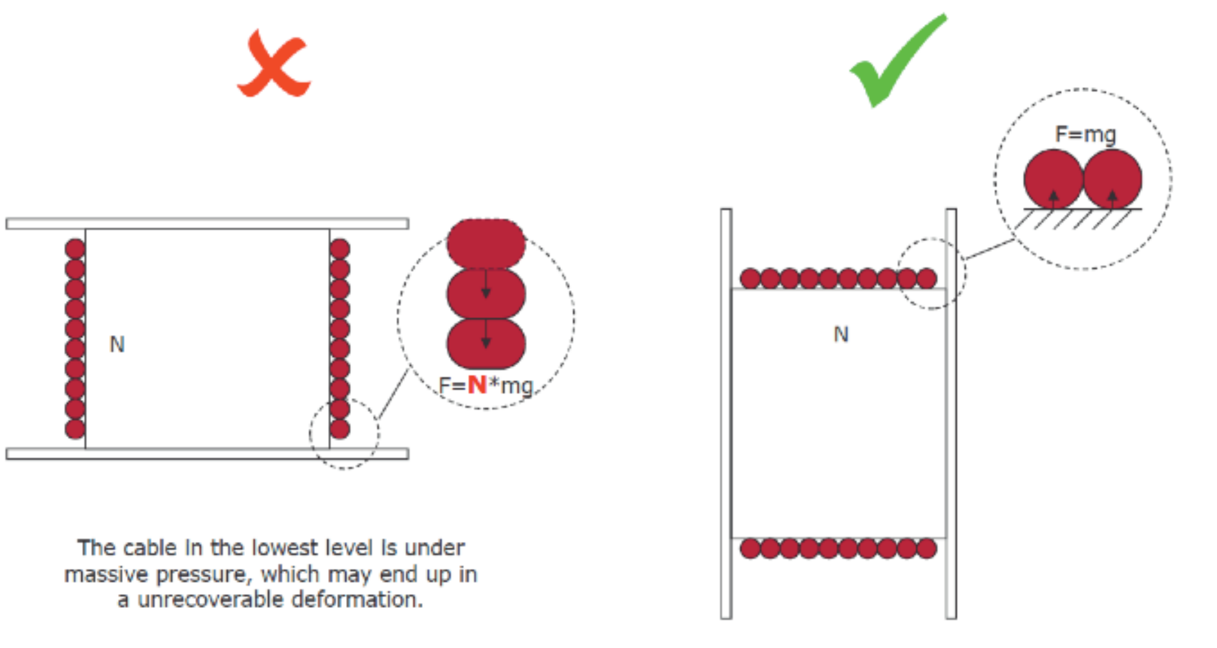
Periodic lubrication applied to the outside of the cable can be beneficial to aid smooth coiling into the basket. Because of the variation in baskets and spreader basket operation it is impossible to give general installation instructions. Therefore, it is strongly recommended that the installation advice provided by the cable manufacturer is followed. The cable manufacturer can also provide recommendations on basket design, as certain features must suit cable dimensions.

5 STORAGE, HANDLING AND TRANSPORTATION

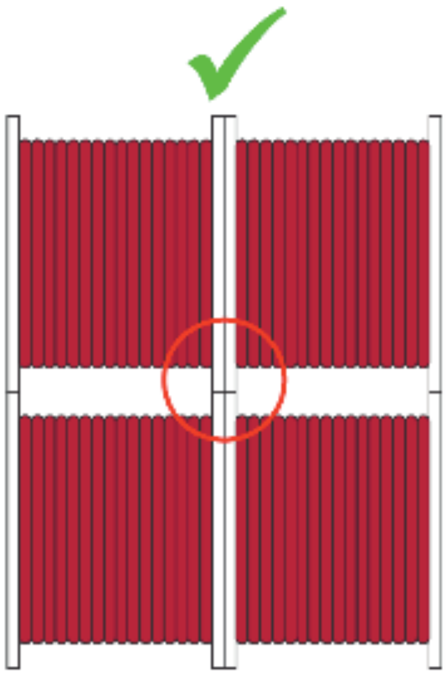
Special care should be taken in the handling of cable drums. In particular, cable drums should be stored with drum flanges vertical in an area reserved for this purpose, on a hard and dry surface, protected from damage by falling objects or any type of chemical spill, open flame, or excessive heat. If possible, the storage area should be indoors. Under no circumstances should a cable be stored outside and exposed to direct sunlight for prolonged periods.

Drums, larger than 1 m in diameter, should not be stored on their sides or stacked and care should be taken that drums cannot roll into one another. Drum flanges have to be chocked to prevent the flange of one drum from hitting the surface of the cable on another drum.

If a length of cable is cut from the drum, the open end of the cable remaining on the drum must be immediately re-sealed in a manner equivalent to the factory seal to prevent the ingress of moisture.



Picture Y: Cable reel storage position for reel diameters larger than 1 m



Picture Z: cable reel fixing

Always check each delivery for evidence of damage during shipment. Any signs of such damage must be reported immediately to the carrier.

Only trained and authorized personnel should be permitted to unload, handle and transport drums of cable.

Cable drums should not be dropped from the vehicle. If fork lift trucks are used, the forks must be placed perpendicular to the flanges and be long enough to lift both flanges. Care must be taken to prevent the forks from making direct contact with the cable or the protective covering.

Drums should always be stored and moved with the flanges vertical. Drums should only be rolled in the direction indicated by arrows painted on the drum, which will tighten it on the drum. Rolling the drum in the opposite direction will loosen the cable which can lead to it kinking and other associated problems. The protective covering must not be removed until the cable is to be installed.

Care must be be taken with the selection, storage, handling, and installation of cables for container handling port cranes. Some guidance is provided regarding each of these areas which provides a useful guideline for crane suppliers, infrastructure design engineers and end user project managers.

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Founded in 2004, PEMA provides a forum and public voice for the global port equipment and technology sectors. The Association has seen strong growth in recent years, and now has more than 100 member companies representing all facets of the industry, including crane, equipment and component manufacturers; automation, software and technology providers; consultants and other experts.

Chief among the aims of the Association is to provide a forum for the exchange of views on trends in the design, manufacture and operation of port equipment and technology worldwide.

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