Shaft Mining

haggie® Steel Wire Ropes for Mining

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haggie®
steel wire rope

Ordering and Handling of Steel Wire Ropes for Mining

To ensure that the correct rope is supplied it is important that complete information is given when ordering. If rope particulars are not known, full details of the duty and operating conditions should be supplied so that a recommendation can be made for the most suitable rope.

How to order steel wire rope

Information which should be supplied when ordering rope:

1. Dimensions

(a) Length (m)

(b) Nominal diameter (mm)

2. Construction

(a) Number of strands

(b) Number of wires per strand

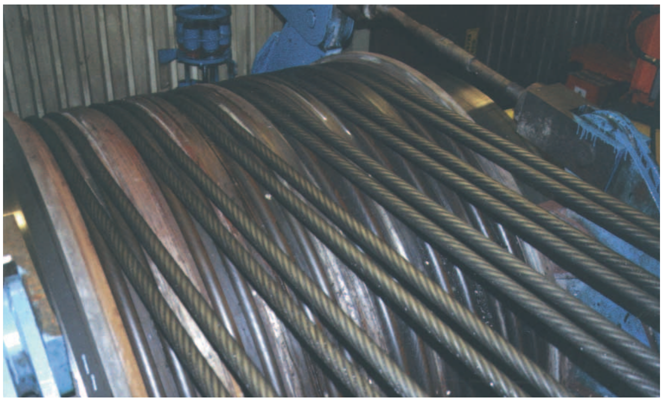
(c) Arrangement of wires in strands

(d) Type of rope core

(e) Lay: direction and type

3. Strength

Tensile strength of steel (MPa) or Breaking force required (kN)



4. Finish of Steel

Galvanised, drawn-galvanised, etc.

5. Lubrication

Any special requirements regarding lubrication should be stated.

6. Specification

If the rope is to be manufactured to a special manufacturing specification this must be clearly stated. haggie®'s specifications are specially tailored to suit South African mining conditions.

7. Tests

If special testing is required this should be stated. In terms of mining regulations winding ropes have to be tested by an approved test authority.

8. End Terminations

If end terminations are required these must be specified in detail.

9. Tolerances

If special tolerances are required this should be stated.

10. Reels

Unless otherwise specified the rope will be packed on a standard reel. For rope mass of less than 10 tons, a wooden reel will be used and for 10 or more tons a steel reel will be used.

11. Application

It is most important that the type of winder or application is stated with an order. For example the standard lubrication required for a Koepe winder is very different from that required for a rope intended for a drum winder. In the case of repeat orders it is strongly recommended that details of the winder and shaft names and numbers be provided. Previous order number and coil number information will ensure that repeat orders are efficiently processed. The use of the winder permit number is strongly recommended.

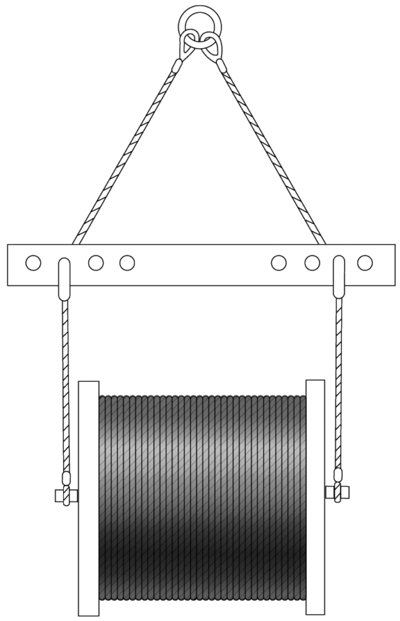
Packaging

For strength reasons the use of wooden reels is limited to rope masses of less than 18 tons. If a heavier rope is required steel reels are recommended. Customers may supply their own reels provided it has been established that these reels will fit the manufacturing machinery.

Unloading

Care should be exercised when unloading reels of steel wire rope. The reels should never be dropped from a truck or rail car. The correct method is as follows:

A steel bar should be introduced through the centre holes of the flanges and the reel lifted by means of a sling or attached to a spreader beam. Under no circumstances should the slings come into contact with the reel flanges because once the lift commences the slings will compress the flanges. The flanges can be damaged in this manner and smooth uncoiling prevented with the possibility of damage to the rope. The reel may even collapse completely and render the rope unusable. Therefore, use of a spreader beam above the reel is strongly recommended.



Correct Handling of Reels

Storage

Wire ropes should always be stored in a dry place. The reels on which ropes, made by haggie®, are packed are sufficiently large to ensure that the rope will not come in contact with the ground, provided that the floor is level and hard. It is advantageous, however, to keep the reels clear of the ground using a simple "A" frame or other arrangement. On no account should reels be stored on a cinder or ash floor or in proximity to sulphur or acid fumes, or mine tailings. If ropes have to be stored outside, adequate means should be provided to protect the rope from the elements. The rope should never be allowed to reach a temperature in excess of the ambient.

If ropes are stored for any length of time, it is advisable to apply an occasional dressing of lubricant to the top layer of rope on the drum. Turning the reel occasionally about half a turn helps to prevent migration of the rope to corrode or otherwise deteriorate in storage.

Handling of Steel Wire Ropes

Correct practices in the handling of wire ropes are essential for maximising rope life. Users are urged to familiarise themselves with the correct practices.

Uncoiling

Ropes should be laid out, without slack from the reel, in a straight line to prevent the possibility of kinking or disturbance to the lay of the rope (Figure 2). It is essential to ensure that the reel does not overrun and some form of braking should be applied. This should be to the reel and not the rope itself to avoid the possibility of the rope slackening on the reel, and damaging itself by kinking or birdcaging. A coil of rope should be laid out from a turntable or alternatively the coil should be rolled along the ground (Figure 4).

In no case should the rope be unwound by throwing off the turns with the coil or reel lying flat on the ground (Figures 1 and 3). This applies particularly to steel cored and non-spin ropes.

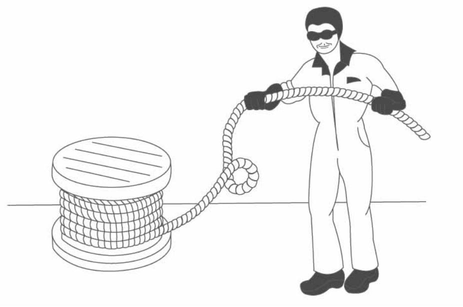


Figure 1 : Incorrect Method of Unreeling

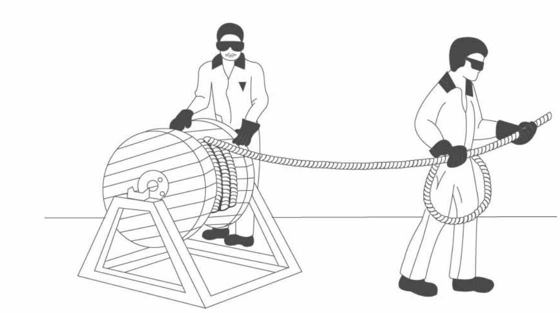


Figure 2 : Correct Method of Unreeling

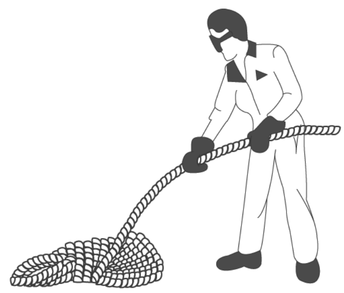


Figure 3 : Incorrect Method of Uncoiling

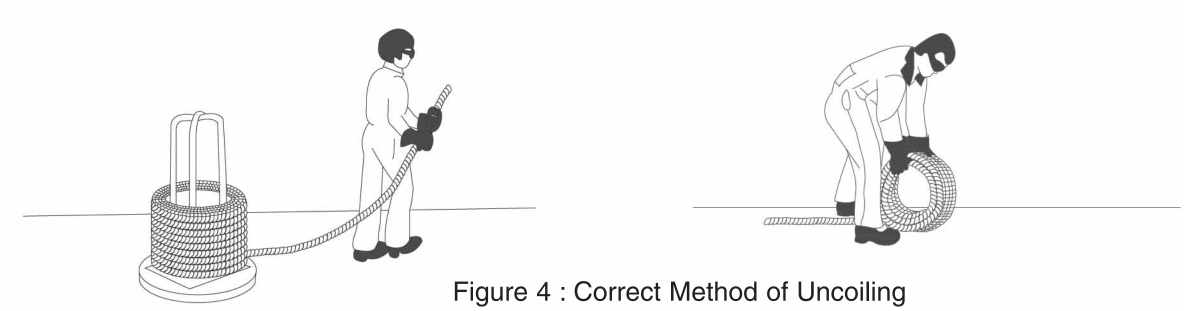


Figure 4 : Correct Method of Uncoiling

Steel Wire Ropes for Shaft Mining

Non-Spin Ropes

Special care must be exercised in the handling of non-spin ropes and the following rules should be strictly observed.

1. Where possible, non-spin ropes should be ordered on reels and not in coils.
2. Adequate seizings should be retained on the ends at all times in order to prevent any creeping movement between the inner and outer strands.
3. It is essential that no less than three seizings, each six times the diameter of the rope in length and spaced at least1 m apart, are applied when the rope is to be cut. Seizings should be applied against the lay of the rope so that any tendency of the rope to unlay, will tend to tighten the seizings.
4. When reeling non-spin ropes over deflecting or doubling down sheaves, even under lightly loaded conditions, the size of the sheave used is most important and should not be less than 35 times the diameter of the rope, for winding ropes and 18 times the diameter of the rope for crane ropes.
5. When coiling non-spin (or steel cored) ropes on the ground, this should be done in the form of a figure of eight, which ensures that turn is neither taken out, nor forced into the rope.
6. When feeding a non-spin rope off the reel for the first time, stop from time to time and allow the rope to become slack. If a tendency is noted for the rope to spiral or corkscrew, take turn out, to prevent this building up and causing a kink.

Steel Wire Ropes for Shaft Mining

haggie® was originally established to supply the growing gold mining industry with ropes for mine hoists. haggie® mine hoist ropes have been used in the world's deepest shafts for over 75 years. This section contains recommended mine winding ropes for all winder applications.

Breaking Force and Mass of Ropes

Estimated breaking force and mass figures for new ropes are given in the tables at the end of the brochure.

Tolerances

The following tolerances apply to ropes manufactured for mine winding purposes.

1. Length

For lengths up to and including 400m the tolerance is -0% to +5%. For lengths over 400m the tolerance is -0% to +2% for each 1 000m or part thereof. Ropes required with smaller tolerances, for example ropes fitted with a termination at each end, shall be the subject of special agreement.

2. Diameter

The rope is designated by a value termed the Nominal Diameter. The actual rope diameter will be within the tolerance of -0% and +5% of the nominal diameter for triangular strand ropes and -1% and +4% for non-spin and round strand ropes. Diameter is normally measured in the off-tension condition. However, in the event of dispute the diameter should be measured under a tension of 10% of the estimated breaking force.

3. Mass

The estimated mass given in the tables is approximate for normally lubricated ropes and subject to a tolerance of +0% and -7%. The estimated mass is calculated on the basis of this tolerance so that there will be no problem related to the calculation of Factors of Safety in terms of South African mining regulations.

4. Breaking Force

The estimated breaking force of new ropes is given in the tables. These are the actual loads at which the ropes are expected to break when tested to destruction. There is no specified tolerance on breaking force but the figures given can be accepted as minima.

Stretch in Wire Rope

When a new rope is subject to tensile loading it will elongate elastically and in addition will acquire a permanent stretch which will become evident after releasing the load. This permanent stretch is caused by the various components "bedding down" and depends not only upon the type of rope but also upon various features such as quality of core, preforming, etc. Single strands (7, 19, 37 and more wires) have the least permanent stretch seldom exceeding 0,1% and are therefore used as standing ropes (guys and bridge ropes).

Steel cored ropes may show a total permanent stretch of up to 0,5%, six-strand and non-spin winding ropes from 0,5% to 0,75% and eight-strand fibre cored ropes to 1% or more.

The elastic component of rope stretch is found from the following expression:

$$\Delta L = \frac{F \times L}{E \times A}$$

Where

ΔL = Stretch (metres)

F = Tension in rope (Newtons)

L = Length of rope under load (metres)

A = Metallic Area of rope (square metres)

E = Apparent Modulus of Elasticity of rope (Pascals)

The table below gives approximate metallic areas, in terms of nominal rope diameter (d), and practical values for modulus of elasticity for ropes of various constructions.

It should be noted that calculations based on the modulus values will only give elastic stretch and not total stretch.

Severe loading as in prestressing will result in very rapid "settling-down" but even under normal operating conditions most of the inelastic stretch will occur early on in the life of a running rope.

Thus in the first few hundred cycles of operation more than half the permanent stretch will have taken place although very slight elongation will continue throughout the life of the rope.

Construction	**Metallic Area**	**Modulus of Elasticity (GPa)**
6x7(6x1)/F	0,405d²	110
6x19(9/9/1)/F, 6x25(12/6F+6/1)/F	0,405d²	100
6x19(9/9/1)/IWRC	0,475d²	110
8x19(9/9/1)/F	0,355d²	86
6x36(14/7+7/7/1)/F	0,410d²	96
6x14 Triangular strand rope	0,465d²	103
6x26 to 6x29 Triangular strand rope	0,450d²	103
6x30 to 6x33 Triangular strand rope	0,457d²	110
Non-spin winding ropes	0,500d²	110
34 LR UHP	0,493d²	115
18x7 Non-spin UHP	0,500d²	115
Half Locked Coil Rope	0,640d²	138

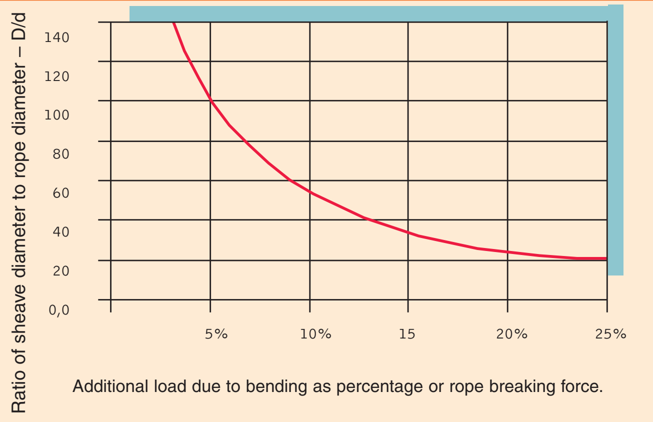


Figure 1 : Additional rope load due to bending (6x30(12/12/6Δ)/F construction).

The ratio of stress (force per unit area of steel) to strain (elastic stretch per unit length) is known as the elastic modulus. This is not a constant for any given steel wire rope particularly under loads which are less than about a quarter of the breaking force.

When loading is between approximately 25 and 60% of the breaking force most ropes behave elastically but as the load decreases below this range to zero the modulus gradually decreases also, i.e. the rope stretches relatively more proportionately. This lack of proportionality at relatively low loading occurs only to a limited extent with the more solid constructions such as single strands whereas in the case of eight-strand fibre-cored ropes it can be as much as 25% less than the high-load modulus. As "bedding-down" and permanent stretch progresses, however, the modulus values increase correspondingly particularly those at the lower load levels.

Stresses caused by bending

When a rope is bent around a sheave or pulley, its component parts attempt to re-align themselves in such a way as to equalise the stress throughout the cross-sectional area of the rope. This is, in fact, the essential characteristic of steel wire rope. Equalisation is, however, only partially achieved. In addition, the individual wires themselves are subjected to a realignment of stresses due to being bent. As a result, the effective strength of the rope is reduced by bending, and the relative mal-distribution of stress reduces the fatigue life of the wires. These two effects of bending are both inverse functions of the sheave diameter, i.e. the smaller the diameter, the greater the bending stresses.

The additional load imposed upon a rope by bending is dependent upon rope construction, internal lubrication, speed of rope travel and shape of sheave groove, and is therefore difficult to calculate with accuracy. Nevertheless, tests show that a reasonable indication of the increased load due to bending can be obtained from the following empirical formula, provided the sheave diameter is not less than the recommended minimum diameter for the particular rope construction:

$$P = \frac{ExAx\partial}{D}$$

Where

P = Increase in load due to bending (newtons)

E = Apparent Modulus of Elasticity of rope (pascals)

A = Metallic Area of rope (square metres)

∂ = Diameter of outer wire (metres)

D = Diameter of bend (metres)

When the sheave diameter is equal to the absolute minimum recommended diameter, i.e. about 350 outer wire diameters (see page 12) the increase in load obtained from the formula should be increased by 50%.

The additional load induced in a 6x30(12/12/6∆)/F rope due to bending is shown (figure 1) as a percentage of the breaking force for various ratios of sheave to rope diameter.

Percentage Reserve Strength

Unless affected by corrosion, the inner wires of a rope are usually intact after many outer wires have broken through wear or fatigue. The ratio of metallic area of inner wires only, to total metallic area of the whole rope, multiplied by 100 gives the percentage reserve strength.

Although a somewhat theoretical figure, it is of interest when choosing the best construction for an application where rope safety and economy are both of paramount importance.

The following table gives percentage reserve strengths for commonly used rope constructions:

Rope Construction	Percentage Reserve Strength
6x7(6/1)/F	14%
6x14(8/6∆)/F	19%
6x28(10/12/6∆)/F	27%
6x19(9/9/1)/F	31%
6x25(12/6F+6/1)/F	42%
18 Strand Non-spin	
12x7(6/1)/6x7(6/1)/F	43%
6x36(14/7+7/7/1)/F	48%
14 Strand Non-spin	
8x6/6x10(7/3∆)/WMC	50%
15 Strand Non-spin	
9x8/6x29(11/12/6∆)/WMC	59%

Torque In Ropes

When a rope is loaded under tension a torque is produced which will cause the rope end to tend to rotate. Six strand Lang's lay ropes must be operated with both ends restrained from rotating, otherwise the rope will unlay and become unstable.

Non-spin ropes are designed to adjust to this torque and reach a balance so that this type of rope can be used with ends free to rotate. The amount of readjustment necessary for a non-spin rope is dependent on its design, and Haggie Rand non-spin sinking ropes are specifically designed to minimise turn due to a change in load. This makes them particularly suitable for deep shaft sinking operations.

The torque generated when loading a rope in the "as manufactured" condition can be estimated from the following formula:

$$T = C\,d\,P$$

Where

T = Torque (newton metres)

P = Tensile load on rope (newtons)

C = Torque factor (mm per mm of rope diameter)

d = Rope diameter (metres)

Representative estimates of the torque factor for ropes in the "as manufactured" condition are given below.

Rope Construction	Torque Factor in mm per mm of rope diameter
6x19(9/9/1)/F Lang's Lay	0,157
6x19(9/9/1)/F Ordinary Lay	0,098
6x25(12/6F+6/1)/F Lang's Lay	0,143
6x25(12/6F+6/1)/F Ordinary Lay	0,089
6x30(12/12/6∆)/F Lang's Lay	0,165
15 Strand Non-spin	
9x8/6x29(11/12/6∆)/WMC	0,019
18 Strand "Fishback"	
12x10(8/2)/6x29(11/12/6∆)/WMC	0,016
15 Strand "Fishback"	
9x10(8/2)/6x14(8x6∆)/WMC	0,062

Selection of Mine Hoisting Ropes

Recommendations for the use of Mine Hoisting Ropes

Recommended rope constructions for various winder applications

Type of winder application	Rope construction
Small drum winder operating at less than 2,5 m/s in vertical shaft with fixed guides or incline shaft	6x19(9/9/1)/F Lang's Lay 6x13(7/6Δ)/F Lang's Lay
Small drum winder operating in vertical shaft with rope guides	18 Strand non-spin Lang's Lay 12x7(6/1)/6x7(6/1)/F or18 Strand Compact Strand non-spin Ordinary Lay 12x7C(6/1)/6x7C(6/1)/WMC UHP
Large drum winder operating in incline shaft	Compound triangular strand Lang's Lay rope having relatively large outer wire sizes
Large drum winder operating in vertical shaft with fixed guides	Compound triangular strand Lang's Lay rope with an outer wire size of approximately 3,20 mm
Large drum winder operating in vertical shaft with rope guides	15 Strand "Fishback" non-spin 9x10(8/2)/6x14(8/6Δ)/WMC or18 Strand "Fishback" non-spin 12x10(8/2)/6x29(11/12/6Δ)/WMC
Blair multi-rope winder	Compound triangular strand Lang's Lay rope
Koepe winder to depth of 500 m	6x25(12/6F+6/1)/F Ordinary Lay or 6x26C(10/5+5/5/1)/F UHP Ordinary Lay 6x36(14/7+7/7/1)/F Ordinary Lay or 15 Strand "Fishback" non-spin 9x10(8/2)/6x14(8/6Δ)/WMC
Koepe winder operating at depth between 500 m and 1000 m	18 Strand non-spin Ordinary Lay 12x7(6/1)/6x7(6/1)/F or 18 Strand compact strand non-spin 12x7C(6/1)/6x7C(6/1)/WMC UHP Ordinary Lay or 15 Strand "Fishback" non-spin 9x10(8/2)/6x14(8/6Δ)/WMC
Koepe winder operating at depth between 1000 m and 2000 m	18 Strand "Fishback" non-spin 12x10(8/2)/6x29(11/12/6Δ)/WMC or 34 LR 16x19C(9/9/1)/6x19C(9/9/1)+ 6x19C(9/9/1)/6x19C(9/9/1)/WMC UHP or 15 Strand "Fishback" non-spin 9x10(8/2)/6x14(8/6Δ)/WMC
Sinking stage winder	14 Strand non-spin 8x6/6x10(7/3Δ)/WMC or 15 Strand non-spin 9x6/6x10(7/3Δ)/WMC or for ropes larger than 41 mm dia. 15 Strand "Fishback" non-spin 9x10(8/2)/6x14(8/6Δ)/WMC 18 Strand "Fishback" non-spin 12x10(8/2)/6x29(11/12/6Δ)/WMC (for rope mass in excess of 100 tons). Sometimes triangular strand ropes are used but LH and RH ropes are required to balance rope torques.
Kibble winder. Short wind with rope less than 42 mm diameter	15 Strand non-spin 9x6/6x10(7/3Δ)/WMC
Kibble winder with ropes 42 mm diameter and larger for deep wind	15 Strand non-spin 9x8/6x29(11/12/6Δ)/WMC 18 Strand "Fishback" non-spin 12x10(8/2)/6x29(11/12/6Δ)/WMC
Tail (or balance) rope	18 Strand non-spin 12x7(6/1)/6x7(6/1)/WMC or 14 Strand non-spin 8x8/6x27(9/12/6Δ)/WMC

Drum Winders

1. Sheave and Drum Sizes

The ratio of rope to drum or sheave diameter is of vital importance to the life and satisfactory operation of a rope.

When wire is subject to alternating tensile stresses, it eventually fatigues and breaks with a characteristic square-ended fracture. The number of stress cycles which a particular wire will withstand before breaking is determined by the magnitude of the stress. When this exceeds about 30% of the ultimate tensile strength of the wire (i.e. the "fatigue range") breakdown becomes very rapid.

When wire is bent, the outer fibres are subjected to tensile stresses which are inversely proportional to the radius of the bend. Similarly, when a rope is bent the tensile stresses in the outer wires are increased.

Thus the life of wires, particularly outer wires, in a rope would be a function of the number and magnitude of the tensile stress cycles, as well as the number and diameter of bends to which the rope was subjected, assuming there was no abrasion.

Experience has shown that for light duty, with only one layer of rope on the drum and fairly low rope speeds, rope lives of round strand ropes will be reasonably economical with sheaves and drums having a diameter of 350 to 400 times that of the outer wire. Multi-layer coiling necessitates larger drum diameters if rope life is to remain economical. Also as the rope speed increases, so sheave and drum diameters must be increased. On the other hand, where the rope is only required to operate very occasionally it may be economical to reduce sheave and drum diameters by as much as 25% below recommended minimum values. Greater reductions than 25% should not, however, be used under any circumstances as more severe bending will not only result in very rapid rope fatigue, but will seriously affect the true safety factor because of high bending stresses.

The table over the page gives recommended minimum sheave or drum diameter (single layer coiling) in terms of rope diameter for various constructions at speeds below 1 metre per second. For every 0,5 metre per second increase in speed above 1 metre per second, 5% should be added. The correct figure can easily be calculated from the following formula:

$$D = \frac{(v + 9)}{10} Kd$$

where

D = Sheave or Drum diameter (metres)

d = Rope diameter (metres)

K = Ratio of sheave or drum diameter to rope diameter

v = Rope speed (metres per second)

It should be noted that a change in direction of a rope of 15° or more is generally accepted as constituting a complete bend to which the recommended sheave diameters given above refer. When the angle of deflection is less than 15°, sheave or roller diameters may be smaller but should never be less than one lay length (i.e. 6 to 7,5 x rope diameter, depending on the construction) for a grooved sheave or 1,5 lay lengths in the case of flat rollers. If diameters less than these are used the rope will "chatter" with detrimental effects to itself as well as the roller.

When more than one sheave is used in a system the distance between sheaves carrying the same rope is of importance. It is recommended that the length of rope from point to departure on one sheave to point of contact on the other should not be less than that given by the formula:

$$L_2 = vt = 0,5v$$

where

L_2 = Rope length between sheaves (metres)

v = Maximum rope speed (metres per second)

t = Readjustment time of 0,5 second

When sheaves are spaced closer together than this the wires in the rope are not able to change position in time and severe fatigue occurs. In the case of non-spin ropes severe distortion may result.

Rope Construction	**Recommended Minimum Drum and Sheave Diameters**
6x7(6/1)/F	39 x rope diameter
6x19(9/9/1)/F	28 x rope diameter
6x25(12/6F+6/1)/F	23 x rope diameter
6x36(14/7+7/7/1)/F	19 x rope diameter
Triangular Strand ropes	42 x rope diameter
Non-spin winding ropes	42 x rope diameter
15 Strand non-spin 9x8/6x29(11/12/6Δ)/WMC	42 x rope diameter
18 Strand "Fishback" non-spin 12x10(8/2)/6x29(11/12/6Δ)/WMC	42 x rope diameter
34 LR UHP non-spin 16x19C(9/9/1) /6x 19C(9/9/1)+6x19C(9/9/1)/6x 19C(9/9/1)/WMC	42 x rope diameter

All sheaves should be in proper alignment. If the sheaves are not perfectly aligned both the rope and sheave flanges will be subjected to severe wear and rapid deterioration will occur. A ready indication of poor alignment is rapid wear of only one of the flanges on any given sheave or an uneven build up of rope dressing on the flanges.

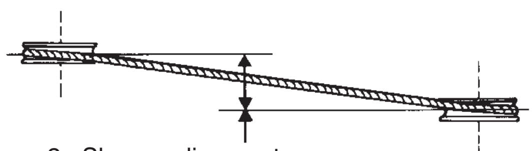


Figure 2 : Sheave alignment

2. Headgear an Deflection Sheaves

For high-speed winding the diameter of both drum and headgear sheaves should be 100 to 120 times the diameter of the rope. Figure 5 illustrates recommended sheave or drum to rope diameter ratios for triangular strand and non-spin ropes at various winding speeds.

The radius of the sheave groove should be smoothly finished to form a true arc of a circle 10 per cent greater in diameter than the nominal rope diameter for 1800 MPa and UHT ropes. Any shoulder on the flange caused by deepening of the grooves due to wear should also be machined off and an angle of flare in excess of a minimum of 45° maintained at all times. Excessive wear and fatigue will result if the groove pinches the rope through being too small. On the other hand if insufficient support is given to the rope because the groove is too large, the rope will be subjected to excessive pressure with adverse effect on the rope, particularly if it is a round strand rope.

The grooves of headgear sheaves should always be examined when installing new ropes. A groove deepened by wear may seriously reduce the life of a new rope unless it is restored to its correct size and profile by machining (figures 3 and 4).

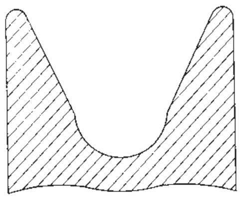


Figure 3 : Typical worn sheave groove profile

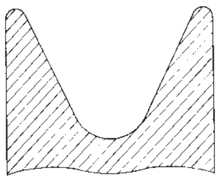


Figure 4 : Correct sheave groove profile

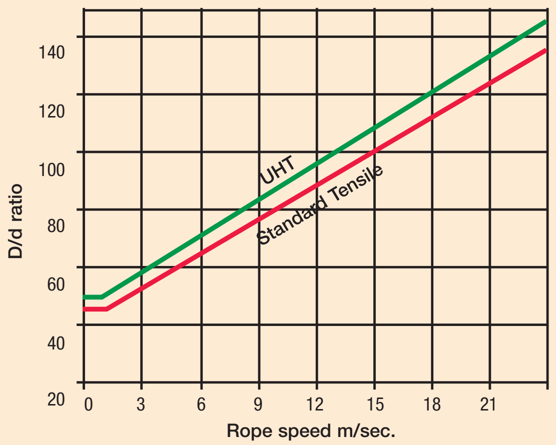


Figure 5 : Recommended D/d Ratios for Triangular Strand Winding Ropes.

The sheave profile is often overlooked but is in fact as important as the groove size. On leaving the sheave in the direction of the drum the rope tends to form an angle with the sheave equal to the fleeting angle as it rises out of the groove. If the angle of flare on the sheave is not enough or has a shoulder, the rope will be deflected unevenly and will abrade on the offending section.

Sheaves should be made of material sufficiently hard to avoid rapid wear in service. The following table gives a guide to sheave materials suitable for various tread pressures.

Tread Pressures	Sheave Material
Up to 2,75 MPa	Grey Cast Iron
Up to 5 MPa	Cast Steel
Up to 6 MPa	Chilled Cast Iron
Above 6 MPa	Manganese Steel

Note: haggie® recommends that tread pressures on all winding ropes be kept below 3,5 MPa in order to enhance rope life.

Tread pressure is calculated from the following formula:

$$p = \frac{2F}{dD}$$

where

p	=	Tread pressure (Pascals)
F	=	Rope tension (Newtons)
d	=	Rope diameter (metres)
D	=	Sheave diameter (metres)

It has been found that, where the sheave material is soft, the sheave groove size and profile become rapidly worn, but that this does not affect rope life to an appreciable extent, because the rope itself maintains a reasonable groove clearance and profile. When a new rope, however, is fitted to a sheave with an undersized groove, irrespective of how soft the sheave material is, irreparable damage is done to the rope within the first two weeks of its life, very often in the form of corkscrews and subsequent heavy plastic wear.

Due to the extreme hardness of UHT wire the sheaves on which UHT ropes operate wear very rapidly and on deep winds can wear sufficiently to damage the rope. In this case, the sheave groove should be remachined during the life of the ropes and kept 2% larger than the maximum measured diameter of the rope itself.

Success has been experienced with the use of rubber, polyurethane and other man made material sheave liners which appear to give excellent lives without having to be re-cut. Replacement is easy and quick and does not require the use of bulky tools.

The sheave should have as little inertia as possible so as to reduce rope slip and it should be carefully aligned with respect to the drum so as to minimise rubbing on its flanges at the maximum fleet angles.

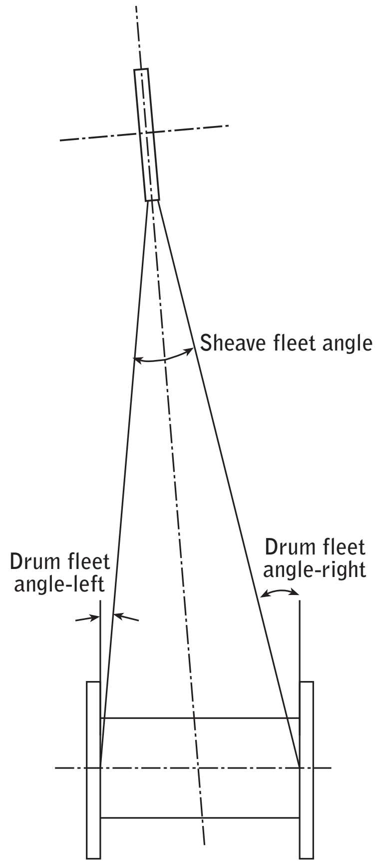
3. Fleet Angle

The angle of fleet is the angle formed between the rope in its extreme position towards the drum flange and the drum flange itself.

Excessive fleet angle results in abrasion between the rope and the sheave groove flange, and also between adjacent turns of the rope as it coils on the drum.

For triangular strand and non-spin ropes under average conditions the fleet angle should not be more than 1°30’ for plain drums and 2° for grooved drums.

The minimum fleet angle should never be less than 0°15’ for multi-layer coiling because of the danger of the rope climbing on itself at the drum flange.



4. Track Rollers in Inclined Shaft

Supporting rollers which are essential to prevent excessive rope wear in inclined shafts should have a diameter of not less than 8 times the rope diameter when they are grooved and 10 times the rope diameter when they are flat. Smaller rollers than these will result in “chattering”, which is detrimental to both roller and rope.

Rollers are frequently lined with non-metallic substances such as natural rubber or synthetics with beneficial effects on the rope and on roller life. Curve or knuckle sheaves should not be placed too close together but their recommended minimum spacing is a matter of experience rather than calculation.

It is suggested that a rope stress adjustment period of one-fifth of a second should be allowed between sheaves with a minimum distance of 20 x rope diameter. Thus a 30 mm diameter rope travelling at 7,5 m/sec would require a minimum spacing between knuckle sheaves of 1,5 m but one travelling at 2,5 m/sec or less would require 0,6 m. Maximum bending stresses will not develop within a rope until one complete lay length is in contact with the sheave. The angle of deflection at which this occurs depends upon sheave diameter and lay length but where recommended minimum sheave diameters are used it may be taken to be about 15°. That is, bending stresses will increase up to an angle of 15° beyond which they remain at their maximum value for the particular conditions.

The bending stresses, as well as the maximum safe unit pressure which the sheave material will stand, must be considered when deciding upon the diameter of knuckle sheaves.

5. Rope Oscillation

A common problem experienced on drum winders operating with multi-layers of rope is the occurrence of severe oscillation of the rope between the headgear sheave and the winding drum during some part of the wind. This problem is always difficult to overcome once a winder has been commissioned and it is sound practice to check on this feature when deciding on the placing of the winder.

The formula for the vibration of a stretched string will give sufficiently accurate results, and care should be taken to see that the impulse from turn cross-overs on the drum does not coincide with the fundamental frequency of vibration of the rope between the headgear sheave and the drum or the second or third harmonic.

The frequency of the fundamental vibrations may be found as follows:

$$\omega = \frac{1}{2L_c}\sqrt{\frac{F}{m}}$$

where

ω = Fundamental frequency (hertz)

L_c = Rope length from headgear sheave to drum (metres)

F = Tension in rope (Newtons)

m = Mass per unit length of rope (kilograms per metre)

6. Drums and Rope Coiling

a. Drum and Groove Size

Ideal coiling conditions are those in which there is not more than one layer of rope on the winding drum. For single layer drums, spiral grooving is preferable.

Drum diameters should be designed in accordance with the recommendations given in the previous section. This will ensure that bending and crushing stresses are kept within reason.

The length of the drum, or the distance between flanges, is determined from the required number of rope layers and the required fleet angle.

When multi-layer coiling has to be used, drum diameters should preferably be increased above the minimum figure quoted by at least 5% per layer. The rope should be carefully coiled on the drum either in parallel turns or in one of the patterned coiling systems. The groove diameter should be nominal rope diameter plus 7,5% and the pitch should not be less than the nominal rope diameter plus 5,5% to a maximum of 7%.

The drum surface or grooves must be smooth and uniform without indentations, holes or gaps.

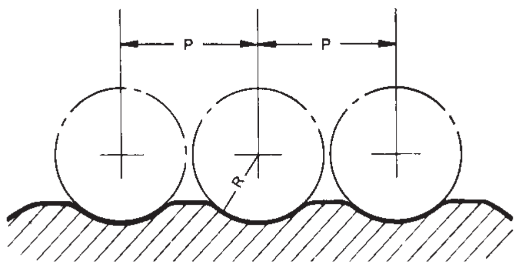


Figure 7 : Dimensions of Parallel Grooving

P = Nominal Rope Diameter + 5,5% to 7%

R = Nominal Radius of Rope + 6% to 8%

b. Hawse Hole Positions

It is preferable to have the bottom layer of rope supported and guided to its correct position by means of grooves in the drum. More precise coiling is obtained in this way, not only for the bottom layer but for all subsequent layers.

When a plain drum is to be used it is important to select the correct hawse hole for anchoring the rope end because the plain drum is unable to afford a definite guide to the rope.

Where the centre of the sheave does not fall on the centre line of the drum but to one side of it, the hawse hole on that side should be used irrespective of the hand of lay of the rope. It should further be arranged that the number of unused turns of rope on the drum is sufficient to cause the live turns of rope to always be on the side of the drum beyond the sheave centre line with respect to the hawse hole which is in use.

In general Right Hand lay rope should be used but if poor coiling or plucking of the outer wires is a problem a check should be made to assess if it would be advantageous to change the lay of the rope. Fig 8 illustrates the general rule for use with plain drums, the flange from which coiling should start being indicated by the index finger.

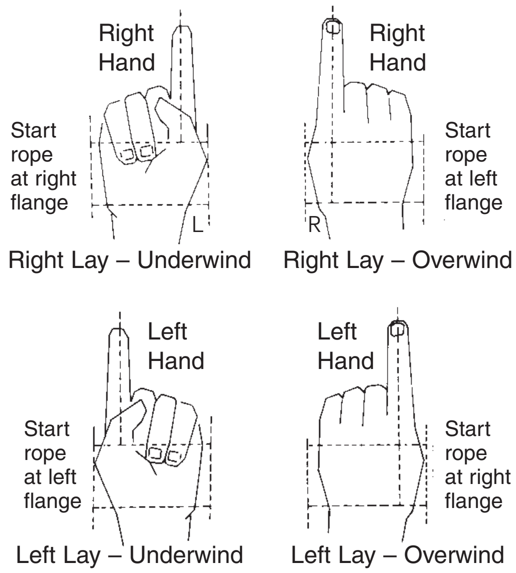


Figure 8 : Method of Determining Direction of Coiling

c. Wedges and Risers

When the rope is coiled onto a plain drum it runs from the hawse hole around the drum periphery against the flange until it reaches the hawse hole again. Here it must deflect itself to form the second turn. At the point of deflection severe abrasion occurs between the section of rope just appearing out of the hawse hole and the section of rope just beginning the second turn.

To reduce wear and make for more even and controlled coiling a steel wedge should be fixed against the flange just in front of the hawse hole. The wedge should be one rope diameter in width, tapered from nothing to one rope diameter, about 24 rope diameters long and with the parallel face curved to suit the drum diameter. This wedge will also prevent the second layer from falling into the space just before the hawse hole

If coiling of the rope onto the bottom layer is now continued until the whole drum width has been traversed the final turn of rope should just fit against the far flange. On completing the last bottom layer turn the rope will be forced to rise to the second layer at a position not quite in line with the wedge. At this point of deflection, fairly severe crushing can occur To obviate this a steel riser is fixed against the flange and onto the drum wrapper.

The riser is a wedge shaped in two planes, tapered in plan to fit the space between rope and flange at the beginning of the last turn and tapered in elevation from nothing at its widest section to one rope diameter at its narrowest section to raise the end of the last turn to a second layer. The length of the riser should again be about 24 rope diameters.

d. Bottom Layer Spacing and Support

When the rope is coiled onto a parallel drum to form the first layer, the last turn must fit snugly against the far flange. If this does not occur some arrangement must be made which ensures that it will happen every time the rope coils on the drum irrespective of speed or loading. The most definite method is through the use of a grooved drum.

Where this is not possible mild steel rods or a strand of suitable diameter can be introduced between the dead turns on the bottom layer. The rod or strand should be of such diameter that the turns of rope on the bottom layer are spaced out to make the last turn fit snugly against the flange.

The theoretical diameter required to give a particular gap can be found from the following:

$$D_S = \frac{(d + G)^2}{4d}$$

where

D_S = diameter of spacer (metres)

d = rope diameter (metres)

G = required gap between adjacent coils (metres)

This method is satisfactory where the number of rope layers will not exceed three as the bottom layer turns are not regularly spaced out.

Yet another method of overcoming a gap between the last turn on the bottom layer and the flange is by fitting a packing (or false cheek) on the inside of the flange made of suitable thickness plate. If this method is used particular attention must be paid to the fixing of the plate as, if any bolts become loose in operation, irreparable damage can be done to the rope.

7. Factors of Safety

Statutory requirements for safety factors are given under Section 16.33 to 16.40 of the Minerals Act.

When selecting the safety factor for a new installation, it should be remembered that rope life can be considerably reduced by lowering the safety factor although other considerations may outweigh the disadvantages of comparatively short rope life.

In the case of inclined shafts the dynamic loads brought about by braking and acceleration are not reduced by the inclination of the shaft whereas the gross static load is reduced in proportion to the sin of the angle of inclination when calculating safety factors. For this reason it is recommended that static safety factors of not less than 7 to 1 should be used for inclined shafts.

8. Calculation of Breaking Force

Calculations of the required breaking force of a rope for a particular application by trial and error can be a tedious matter. By using the concept of an efficiency factor the calculation is considerably simplified and a convenient formula for the initial calculations to determine the required breaking force of a winding rope is as follows:

$$B = \frac{M}{\frac{1}{sg} \quad \frac{L}{f}}$$

where

B = Required Breaking Force (kilonewtons)

M = Mass of loaded conveyance (tons)

s = Factor of Safety

L = Length of suspended rope (metres)

g = Acceleration due to gravity (approximately 9,81 m/s^2)

f = Efficiency factor for rope (Nm/kg) (ratio of breaking force to mass per unit length of rope).

It should be noted that having arrived at a breaking force and chosen a rope the actual factor of safety should be checked because the efficiency factor given for the rope is an average figure, the actual varying slightly from rope to rope.

See table on next page.

9. Ropes

By far the greatest proportion of ropes used for drum winding with fixed guides in South Africa are preformed triangular strand ropes. They are highly resistant to both crushing and wear, possess a good strength-to-diameter ratio and a strength-to-mass ratio which cannot be surpassed by any other types of rope suitable for this duty.

Triangular strand ropes are available in many constructions as listed in the tables. However, to promote standardisation a list of preferred ropes is given. As far as possible these ropes are designed with outer wire sizes between 3,00 mm and 3,25 mm diameter and the construction is varied to incorporate this feature. This range of wires has proved to be eminently satisfactory and it is possible to achieve excellent mechanical properties as well as the tensile strengths required.

Design Criteria for the use of Mine Hoisting Ropes

Where shafts are fitted with rope guides it becomes necessary to use non-spin ropes. In South Africa non-spin ropes of the multi-strand type are generally used. Under severe operating conditions such as multi-layer winding they require frequent pulling in (or spooling out) of back-ends on the drums, in order to shift cross-over points. Under multi-layer winding conditions it is highly advisable also to pull in triangular strand ropes at intervals of about 10 000 cycles or skips hoisted per drum.

Full-locked coil ropes which are non-rotating under load have not been used to any significant extent by the South African Mining Industry mainly because their strength-to-mass ratio is lower than that of triangular strand ropes, which puts them at a disadvantage for deep level mining.

Approximate efficiency factors for various types of ropes

Rope Construction	Efficiency Factor (Nm/kg)					
	1800 MPa	1900 MPa	1960 MPa	2000 MPa	2050 MPa	2100 MPa
6x19(9/9/1)/F	159 000	—	—	—	—	—
6x25(12/6F+6/1)/F	162 000	—	—	—	—	—
6x13(7/6Δ)/F	159 000	—	—	—	—	—
6x14(8/6Δ)/F	157 000	—	—	—	—	—
6x15(9/6Δ)/F	157 000	—	—	—	—	—
6x26(8/12/6Δ)/F	171 000	180 000	186 000	190 000	194 000	198 000
6x27(9/12/6Δ)/F	172 000	181 000	186 000	189 000	194 000	198 000
6X28(10/12/6Δ)/F	172 000	181 000	186 000	189 000	194 000	198 000
6x29(11/12/6Δ)/F	172 000	181 000	186 000	189 000	194 000	198 000
6x30(12/12/6Δ)/F	172 000	181 000	186 000	189 000	193 000	197 000
6x31(13/12/6Δ)/F	172 000	180 000	185 000	189 000	193 000	197 000
6x32(14/12/6Δ)/F	172 000	180 000	185 000	188 000	193 000	197 000
6x33(15/12/6Δ)/F	172 000	180 000	185 000	188 000	192 000	196 000
6x34(16/12/6Δ)/F	172 000	180 000	184 000	188 000	191 000	195 000
8x6/6x10(7/3Δ)/WMC	166 000	175 000	—	—	—	—
9x6/6x10(7/3Δ)/WMC	162 000	170 000	—	—	—	—
9x8/6x29(11/12/6Δ)/WMC	166 000	175 000	180 000	—	—	—
9x10(8/2)/6x14(8/6Δ)/WMC P61 Koepe	167 000	—	—	—	—	
P11	166 000	175 000	180 000	183 000	187 000	192 000
12x10(8/2)/6x29(11/12/6Δ)/WMC Koepe	171 000	—	—	—	—	—
12x10(8/2)/6x29(11/12/6Δ)/WMC	167 000	176 000	181 000	185 000	189 000	193 000
12x19(9/9/1)/6x19(9/9/1)/WMC	—	170 000	175 000	178 000	183 000	—
18 Strand non-spin UHP	162 000	—	—	—	—	—
34 LR UHP	162 000	—	—	—	—	—

A value of the efficiency factor for compound triangular strand ropes to within + or –5% can be obtained by multiplying the Tensile Strength Grade Number by 94.

10. Installation and Maintenance of Drum Winder Ropes

a. Installation of Winding Ropes

The reel of new rope should be mounted on an axle between two stands with a suitable braking arrangement which will ensure a positive rope tension. Where there is multi-layer coiling on the winder drum and it is not possible subsequently to tension the dead turns of rope on the drum this must be done at this stage and the back tension arrangement must be capable of producing a tension equal preferably to the working tension, but certainly not less than half the working tension in the rope. Under no circumstances should an attempt be made to use the rope reel for providing the tension on the drum. Rope reels are designed for the tension used in coiling the ropes during manufacture which is of the order of 15 kN. An attempt to brake the reel to provide greater tension may either cause the reel to collapse or the rope to pull into underlying layers.

Back tension for this purpose can be conveniently accomplished by either tensioning the rope by winding it onto another drum and coiling it back under a controlled tension, or by doubling the rope down the shaft with a loaded conveyance connected to a doubling down sheave.

It is important to ensure that the doubling down sheave is the correct size. The groove diameter should be nominal rope diameter plus 10% and the sheave diameter should not be less than 32 rope diameters for triangular strand ropes, and not less than 35 rope diameters for non-spin ropes.

The tensioning of the dead turns on the bottom layer is important, because this section of rope is not able to stretch with the operating section, due to friction between rope and drum. The result is that as overlying layers of rope cause the dead turns to bed down, the wires lose tension and become slack. Continuous movement of these wires by the overlying layers causes them to fatigue and break. In non-spin ropes this action becomes even more noticeable causing birdcaging of the rope, or even whole outer strands to fail in fatigue.

Care must be taken to ensure that torque is not induced into the rope during installation. This can happen if the rope to be removed is used to reeve the new rope through the system. The old rope may contain a degree of torque which, if the two ropes are welded, brazed or clamped together, will be invariably transmitted into the new rope.

A check should me made to ensure that no torque is induced into the new rope during the installation. A match stuck between the strands or lacquer spray applied onto the rope should remain in the same plane at all times. If such a marker moves or disappears behind the rope, torque is present, either the residual torque or torque induced by the system, e.g. misaligned sheaves. The cause of the torque as well as the torque itself must be removed.

b. Rope Length Adjustment on Double Drum Winders

When winding with more than one layer of rope the effective diameter of each drum varies in stages throughout the winding cycle. For this reason it is essential that the two ropes should be of equal length in order to ensure accurate alignment of both skips with the tips and boxes at the end of each wind.

It sometimes happens that one rope is longer than the other and adjustment in rope length is necessary. This is a simple geometrical problem which is solved as follows:

Suppose after the two winding ropes have been installed on the drums of a certain winder it is found that the north compartment rope is too short. The empty skips are run through the shaft compartments and the north skip is set accurately at the ore box underground. In this position the north drum of the winder is unclutched and the south skip is set accurately in the headgear tip. The hoist is then clutched and the north skip is moved into the tipping position in the headgear. Suppose in this position it is found that the south skip is below the position required at the ore box underground, it follows that more rope has been paid out from the south drum than has been wound on the north drum. Assume also that there are three layers of rope on the drums.

All the adjustment can then be made to the south rope without interfering with the rope in the north compartment. If one turn of rope is cut off from the outside layer of the south drum the active number of turns on this third layer of the drum is decreased by one whereas the active number of turns on the first layer is increased by one.

If Db is the pitch circle diameter in metres of the first layer of rope and Dt is the pitch circle diameter of the third layer in metres, then the decrease in active length of rope on the third layer is πDt whereas the increase in active length of rope on the first layer is πDb.

Therefore the total decrease in active length of rope is $\pi Dt - \pi Db$ for a length Dt cut off. Thus for a unit decrease in active length of rope the amount:

$$\frac{\pi D_t}{\pi D_t - \pi D_b} = \frac{D_t}{D_t - D_b}$$ must be cut off the rope.

Therefore the total amount to be cut off from the rope

$$L_c = \frac{L_u D_t}{(D_t - D_b)}$$

where

L_c = length of rope to be cut off (metres)

L_u = distance of skip below loading box (metres)

D_t = pitch circle diameter of top layer of rope (metres)

D_b = pitch circle diameter of bottom layer of rope (metres)

Similar procedures may be adopted for the pairing of ropes on bicylindroconical drums.

c. Maintenance

Good rope maintenance is a matter of common sense and consists mainly of ensuring that:

(i) The rope is kept well lubricated.

(ii) Points of heavy wear are moved regularly with respect to their position on the drum.

(iii) Machinery associated with the ropes such as sheaves, bearings, hoist drums, etc., is kept in good condition.

(iv) Coiling is always neat and even and adequate tension is maintained in the dead turns.

(v) Acceleration or deceleration should never occur at layer cross-overs.

(vi) Non-spin ropes should be disconnected from the cage or skip at the shaft bottom every 25 000 cycles, or skips hoisted per drum, and allowed to rotate freely. One or two more turns should then be added in the same direction and the rope re-attached.

d. Lubrication

Thorough lubrication of wire ropes, not only during manufacture, but throughout their working life is of great importance to prevent both corrosion and fatigue caused by excessive internal friction.

The greatest care is exercised at manufacture to ensure that the ropes are properly lubricated before despatch. Fibre cores receive special attention and the individual fibres of which they are composed are impregnated with a suitable lubricant prior to spinning. The wires of the rope are also thoroughly lubricated at stranding and both the fibre core and strands receive a further dressing at closing.

Ropes manufactured in this manner can be kept free from corrosion under reasonable conditions provided they are given attention by the user.

For extreme conditions where ropes come in contact with saline or acid water, acid fumes, etc., rapid corrosion will take place resulting in weakening and embrittlement of wires.

It is not possible by means of lubrication to overcome such conditions entirely, but it is certainly possible to prolong the life of the rope if it is treated correctly and given frequent applications of good rope dressing. The use of galvanised or semi-galvanised wire rope is strongly recommended under the majority of corrosive conditions.

The ideal wire rope dressing is one that is at all times pliable, waterproof, acid and gas proof and free from any destructive acids, or any excess of sulphur within itself. It should be such that it cannot be easily wiped off or flung off by centrifugal force, and it must not decompose.

Many engineers favour the use of relatively fluid dressings, which can easily penetrate between the outer wires of the rope and displace any water which may have entered. Dressings of this type are best applied by means of sprays, automatically operated to apply the lubricant at regular intervals. When ropes are to be stored for prolonged periods the heavier bitumastic type of dressing is preferable to low viscosity dressings, which tend to drain off the rope, thus exposing it to corrosion.

e. Sheave Wheels

When installing a new rope the sheave wheel grooves should be checked for size and remachined to the recommended diameter and profile before the rope is installed. Operating a rope for even one or two weeks on an undersize sheave groove can do irreversible damage to a winding rope.

In general sheave grooves only need be remachined when new ropes are installed. However, when UHT ropes are used on very deep winds the variation in rope diameter over the length of the rope may be such that the sheave groove can be worn to a size less than the actual rope diameter at the front end. In this case it is recommended that the groove be remachined when its diameter wears to the maximum measured rope diameter. The groove should be machined to a diameter 2% greater than the maximum measured rope diameter.

When measuring the sheave groove with a disc of the minimum permissible diameter, it should be possible to scrape grease off the very bottom of the groove. The disc itself, after being drawn along the bottom of the groove, should have collected grease all around the arc of contact.

In cases of doubt a plaster cast can be taken and sent to Haggie Rand Technical Services Department for comments. This is easily done by cleaning a section of the sheave groove, greasing or oiling it very lightly, then immersing a plaster of paris bandage briefly in water, draining it for about ten seconds, and finally forcing it into the groove where it must be held firmly for about a minute. After the cast has been in position for five to ten minutes it can be removed by tapping it with a hammer.

11. Inspection

The factors of safety normally used for ropes take care of not only dynamic and static stresses but also a reasonable degree of deterioration in service. It is nevertheless essential that all ropes be inspected at regular intervals so that the rope is discarded before deterioration becomes dangerous. Inspection requirements are laid down in the Minerals Act and Regulations and the South African Standard Code of Practice “condition assessment of steel wire ropes on mine winders”. What follows is meant to supplement these requirements and not to detract from them in any way.

The requirements regarding frequency of examination and the persons to carry out these inspections are specified in the Regulations. In general the daily and weekly examinations are cursory whereas the monthly examination is a detailed one.

a. Cursory Examination
The object of this examination is to discover unusual appearances which may have been caused by some accident, such as cut or broken wires, a kinked rope or loose rope fittings. To this end a visual examination should be made of the rope as it is run through from one end to the other. End connections and fittings should be checked and the rope lubrication assessed. A note should be made in the rope record book of the rope condition.

b. Detailed Examination
The object of this examination is quite different to that of the cursory inspection. From information gathered at this examination, decisions will be made on whether to discard the rope, on whether the rope is of the correct construction, on whether the associated machine parts are sufficiently well maintained, on whether drum coiling is satisfactory, on whether the rope should have a length cut from its front end or from its back end and so on.

With this in mind the rope should be marked (an aerosol paint spray is a convenient method) at the following points:
i. The layer cross-over points
ii. The section subjected to the most bending

The whole rope should then be inspected at regular intervals along its length, cleaning it at these points and at the marked points, noting rope size, lay length, external corrosion, wear of outer wires and the occurrence of any broken wires and strand slackness. The point of connection of the rope to the drum, and where it passes through the hawse hole, should be carefully inspected for broken wires and slackening of bolts or clamps. The end connection to the conveyance should also be examined for any anomalies such as broken wires or splice tucks which have moved. All these points should be noted in the rope inspection book.

c. Electro Magnetic Testing
It is strongly recommended that all mine winding ropes be regularly non-destructively tested by means of one of the available types of electromagnetic test instruments.

d. Measuring Rope Diameter and Lay Length
To find the correct diameter at any point in a rope the calliper must be placed over each pair of opposite strands i.e. three separate readings for a six-strand rope. The readings are then averaged.

Refer to figures 9 and 10 for correct and incorrect method of measuring the rope diameter using a calliper.

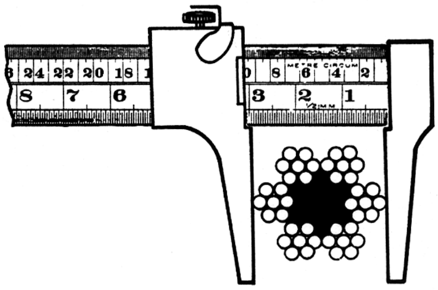


Figure 9 : Correct Method

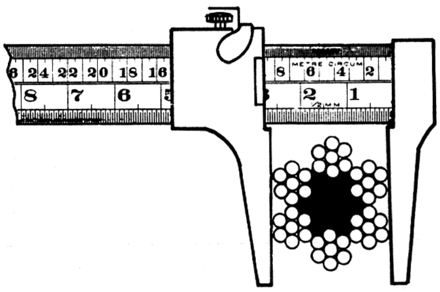


Figure 10 : Incorrect Method

Ropes tapes can be used very conveniently for measuring rope circumferences or when suitably graduated, diameters. They must be used with caution, however, as readings will be inaccurate if the tape is pulled too tightly, particularly when measuring round strand ropes.

To find the rope lay length, a strand is marked by means of chalk at a point on the rope then that strand is followed until it reappears at a point on the rope periphery exactly in line with the first chalk mark. A second mark is made at this point. The rope lay length is the distance between the two marks. (For accuracy measure two or more lay lengths and divide the measured distance by the number of lay lengths).

12. Assessment of Rope Condition

While a rope is being inspected it is necessary for an assessment of its condition to be made and the following points have been set out to assist the person responsible in this regard:

a. Plastic Flow and Wear at Cross-over Points

Where more than a single layer of rope is coiled on the drum, the rope will tend to develop points of what appear to be heavy wear where the rope is forced against the drum flange in climbing onto the succeeding layer. The rope diameter will be found to reduce rapidly at these points, but most of this reduction is not caused by wear but by a deformation or peening of the wires which does tend to hasten the onset of fatigue.

The more often these points of concentrated impact can be changed the better, but in general they should not be left for longer than 10 000 cycles.

In general, a rope will only have to be removed when broken wires appear at these points and the decision will be made as discussed under "Broken Wires".

b. Plastic Flow over Rope Length

When a rope is able to rotate freely as it works, wear will occur around the whole periphery of the section which passes over the sheaves. If the sheaves have been consistently undersize since rope installation, however, plastic flow will become evident and eventually develop into wires broken in fatigue.

Heavy plastic flow of the wires early in the rope's life on the section running over sheaves, is this an indication of undersize sheave grooves.

c. Wear

Generally speaking apparent wear on outer wires will not seriously affect the rope's breaking strength unless accompanied by broken wires. A reduction of only 10% of the cross-sectional area of a wire will expose a flat with a width of about 70% of the wire's diameter so what appears to be severe wear frequently represents an insignificant loss in steel area. As a rough guide, ropes having relatively large outer wires such as 6x7/F, 6x19(9/9/1)/F and triangular strand winding ropes, should be discarded when the rope diameter has been reduced by about 5% through wear.

d. Mechanical Damage

Irregularities caused by kinks, bends, or other distortion, falling rocks or pieces of steel and other accidental damage can reduce the rope strength considerably. Such sections are likely to cause stress raisers, hastening the onset of fatigue and broken wires. Where a kink or bend has caused the individual wires to be bent in such a way that they cannot be completely straightened, the rope should be discarded.

e. Broken Wires

Square ended fractures of outer wires indicate the onset of fatigue and may indicate serious weakening of the rope if many broken wires are concentrated in one place.

If the broken wires are well spaced, the rope should be discarded if the number of broken wires in one lay length exceeds 5% of the total number of wires in the rope. However, if 3 or 4 adjacent broken wires are found in only one strand of a triangular strand rope the rope becomes unbalanced and may have reduced in strength by more than 10%.

It is important to remove broken wires as soon as they are discovered in order to prevent damage to neighbouring wires. This is most easily done by bending the wire back and forth until it breaks off close to the rope.

f. Corrosion

Where a localised reduction in rope size and change of lay length is found together with signs of external corrosion, there is likely to be internal corrosion. The load should be removed from the rope and the inner wires inspected with the help of marline spikes.

Usually if internal corrosion has caused a noticeable reduction in diameter it has become sufficiently far advanced to warrant discard of the rope.

In the case of galvanised wire ropes operating under corrosive conditions, a careful check should be made periodically to ascertain whether zinc is still present other than on worn crowns. Once zinc has been corroded away the rope will start to deteriorate rapidly.

Shaft Sinking

When considering kibble ropes and where drum winding is used for raising and lowering the stage, reference should be made to the remarks under "Drum Winders", in this section.

1. Stage Ropes

There are several methods of suspending the sinking stage or platform. These vary from four separate hoist drums and ropes, each suspending a corner of the stage, to the Blair system in which the stage suspension ropes are driven by a fleeting wheel or double drum capstan and operate in several falls or parts of rope.

Stage suspension ropes are normally required to act also as guide ropes for the kibble so resistance to wear is a necessary feature. Also as these ropes operate in an acid environment due to blasting fumes, worn outer wires may corrode rapidly thus hastening the wear process. It is recommended that zinc buses be used on the kibble crosshead guides to reduce this phenomenon as far as possible.

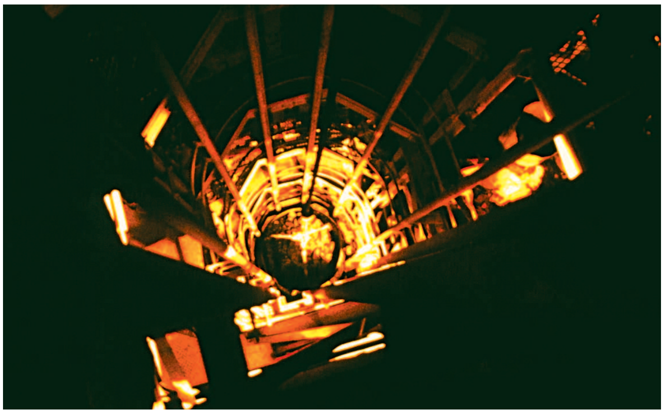
Triangular strand ropes are sometimes used in sets comprising equal numbers of left and right hand ropes to neutralise torque effects on the platform. With this type of rope, however, difficulty may be experienced in holding the turn or spin while recovering the ropes after sinking is complete. For this reason non-spin ropes are commonly used and these also possess the advantage that they will not kink as easily in the event of the platform being blasted or hanging up during lowering.

The Blair system requires unusually long ropes due to the number of rope falls employed. Continuous lengths of up to 15 000 metres are commonly required and ropes having a mass of up to 130 tons have been made for this purpose. Due to limitations on the size of six-stranded rope-making machinery (maximum mass of rope of 118 tons) such ropes have of necessity to be of multi-strand construction and are therefore made non-spin. It is now possible to manufacture ropes of this type up to a maximum mass of 160 tons depending on construction.

2. Kibble Ropes

Because the conveyance ceases to be guided as it approaches the shaft bottom, kibble ropes for vertical shafts must be non-rotating. The deeper the shaft the more important become the non-rotating properties of the kibble rope and for sinking shafts deeper than about 1 500 m, 15 stand non-spin ropes 9x8/6x29(11/12/6Δ)/WMC or 18 Strand "Fishback" non-spin ropes 12x10 (8/2)6x29(11/12/6Δ)/WMC are recommended. If tensile strengths higher than 1800 MPa are required, the 18 strand "Fishback" rope is preferred.

Due to the presence of water vapour and nitrous fumes and also the wide variations in tension inherent in kibble rope duty, galvanised rope is strongly recommended to avoid the danger of internal corrosion which is difficult to detect in non-spin ropes. However, it should be noted that galvanising is not available in tensile strengths higher than 1900 MPa. In the event that ungalvanised ropes are used it is extremely important that the rope is carefully and regularly lubricated and that extra attention be given to the evaluation of corrosion in the monthly examination.



3. Installation and Maintenance of Kibble Ropes

When sinking deep shafts it is recommended that more than one set of kibble ropes be used. It has been found that when sinking the first part of the shaft with the full length of rope on the drum, difficulty is experienced in maintaining adequate tension in the dead turns of rope with consequent problems of slackness and distortion. Due to the shallow depth it is not possible to double down satisfactorily and maintenance is therefore difficult. The use of short ropes for the initial part of the shaft is the most satisfactory solution and for very deep shafts an intermediate set of ropes is sometimes used.

When installing new ropes before sinking commences it is essential that the ropes are wound on under adequate tension. Failure to do so will result in trouble being experienced through accumulated slack on the bottom layer forcing its way through the second layer on the drum or else the occurrence of birdcaging of the outer strands of portions of rope in the dead turns. In some cases slackness which develops leads to the early occurrence of wires broken in fatigue in the dead turns.

Two methods are available for ensuring adequate tension, the one being through the use of suitable installation winders or capstans; the other method is by means of a type of doubling down procedure. The one rope splice end is fed through a doubling down sheave which is attached to a full kibble and joined to the other rope splice end. The one rope is then coiled in and the other out, always maintaining the skip at a constant level in the air. Eventually all the rope will have been wound off the one drum and at this stage the drum directions are reversed and the rope wound on under a tension of half the full skip mass plus whatever rope mass there is. This is continued until the splices are near the doubling down sheave when the ends are disconnected, passed through the sheave, and the whole process repeated.

This method will, of course, only work when the drums are able to carry the full length of both ropes. This is generally the case with the initial ropes where it is common practice to start the shaft with short ropes capable of sinking the shaft to the half-way mark.

Besides the normal maintenance usually carried out on drum winders additional attention should be given to kibble ropes, viz

a. Regular lubrication to avoid or reduce the possibility of internal corrosion.

b. The dead turns of rope on the drum should be regularly inspected for signs of slackness developing. As soon as any slackness is noted the rope should be doubled down the shaft and re-tensioned on the drum.

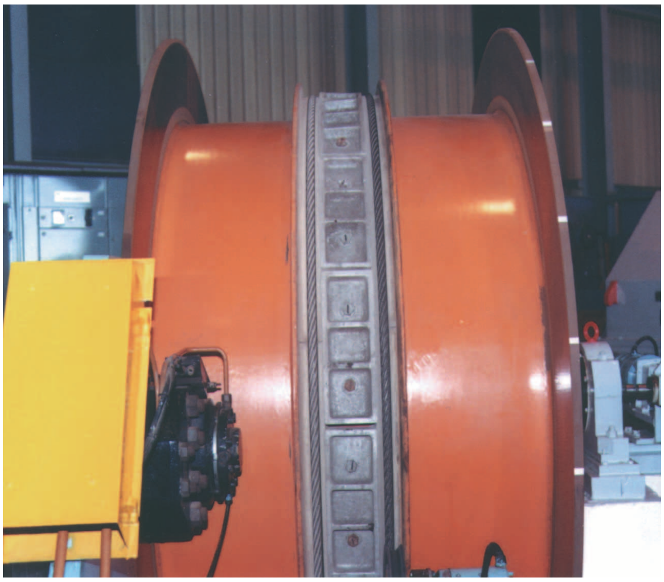
Friction Winding

1. Head Ropes

The head ropes in a Koepe winding system are inverted or "end-for-ended" with each wind, with consequent inversion also of the load distribution pattern in each rope. This upsets the torque equilibrium throughout a six stand winding rope and produces a tendency for the ropes to spin with each winding cycle. The friction tread on the drum checks the spinning and in so doing is abraded by the rope which itself may in extreme cases deteriorate rapidly due to the continual twisting and untwisting.

This spinning action of six strand ropes increases with depth of wind and in general becomes serious at depths of from 500 metres to 1 000 metres. At greater depths it is essential to use non-rotating ropes and these are generally also desirable for considerably shallower depths.

Because of restrictions on lubrication, Koepe head ropes should always be galvanised.



2. Head Rope Construction

The 15 and 18 strand "Fishback" construction ropes have been found to be the most successful head ropes for deep level Koepe winding to date. Recent developments, however, indicate that the 34LR UHP Compact Strand rope can give equal and sometimes even better performance.

3. Static Factor of Safety

On conventional drum winders it is common practice that the factor of safety is reduced somewhat with increase of depth. Although allowed in mining regulations this is not appropriate for Koepe head ropes as the load range increases with depth. It is therefore recommended that a static factor of safety of not less than 7 be used and in general it should conform with the formula:

$$s = \frac{1}{2R - \frac{L_d g}{f}}$$

where

s = Static Factor of Safety

R = Maximum static load range (fraction of head rope breaking force)

L_d = Depth of wind (metres)

f = Rope efficiency factor

g = Acceleration due to gravity (9,81 metres/sec^2)

4. Static Load Range

As mentioned above the load range increases with depth. This load range is the change in tension in any particular part of the rope during a winding cycle and is a maximum in that portion of the rope which is at the Koepe drum at the ends of the wind. There is a direct relationship between this factor and rope life in service. For economic rope performance it is recommended that the maximum static load range should not exceed 11,5% of the estimated rope breaking force.

5. Dynamic Load Range

This incorporates peak acceleration forces at the start of the wind and should not exceed 15% of the estimated rope breaking force.

6. Acceleration and Deceleration

Winder control should be smooth and even and acceleration and deceleration should be kept as low as possible. The maximum peak acceleration should not exceed 1,5 m/s^2 and changes in acceleration should not be abrupt.

7. Rope Length between Drum and Tip

This distance, which should be as large as possible, plays a part in rope life in that it is in this section of rope that inequalities in rope length and differences in drum paths, become evident.

An indication of the minimum practical distance can be gained from the following formula:

$$L_m = \mu \frac{y\, d^2\, L_d\, E\, s}{p\, D\, B_h}$$

Where

μ = Maximum practical allowable difference in tread circumference between rope grooves (m) (this would normally be about 0,00046m)

d = Rope diameter, (m)

L_d = Length of wind (m)

L_m = Rope length from highest tipping point to Koepe Drum (m)

D = Drum diameter (m)

E = Apparent Modulus of Elasticity of head-rope (Pa) (117 GPa for stranded non-spin ropes)

B_h = Breaking strength of one head-rope (N)

y = Area factor for head-rope construction

s = Factor of Safety of Head-rope

8. Drum and Deflecting Sheave Diameter

There should preferably be no deflection sheave but if this is not possible its diameter should not be less than 120 rope diameters (for rope speeds of 15 metres per second), and should be spaced at least 7,5 metres from the drum. The drum diameter should not be less than 105 rope diameters for a rope speed of 15 metres per second.

9. Drum Tread Pressure

It is recommended that this be kept to below 1,72 MPa. Tread pressure is given by the following formula:

$$p = \frac{2F}{dD}$$

where

p = Tread pressure (Pascals)

F = Maximum Static Tension (Newtons)

d = Rope diameter (metres)

D = Drum diameter (metres)

10. Drum Tread Material

Both hard rubber and polyurethane have proved themselves to be dependable tread materials on deep level Koepe hoists. The hardness considered most effective is between 80 and 85 Shore. Proprietary brands of plastic tread materials have been gaining increased acceptance.

11. Maintenance of Head Ropes

It is generally accepted that the easiest and quickest method of changing head ropes is from the mid-shaft position, using the Koepe drum to move the ropes. It is recommended that where ropes have to be fed down a shaft, a cross-head be used to prevent the ropes from losing any turn which can change the operating performance of the ropes.

As with all non-spin ropes it is essential that good seizings be maintained on rope ends at all times.
Drum tread lengths should be checked at frequent intervals during the rope life to ensure that rope tensions do not vary to an abnormal extent during an individual cycle. Where the distance between drum and tip is short, drum tread lengths are extremely critical and should be carefully watched.

Where equalising links are used, differences in rope length can be seen and adjustments made accordingly. Where such links are not used a skip has to be supported at the shaft bottom position and the head ropes slackened off on that side. It is then possible to see from the angle of the attachments, how rope lengths compare. It will be necessary to adjust the rope lengths daily for the first two weeks of operation of a new rope but thereafter once a week should be sufficient.

When non-spin ropes have been operating for a few months the outer layers of strands become bedded into the inner layer of strands with the result that the outer strands tend to become slack and additional load is transferred to the inner rope. It is therefore recommended that all non-spin ropes be checked for direction of spin every 10 000 to 20 000 cycles. This should be done at a position on the down-going side. If the rope tends to spin in a direction causing the outer strands to tighten it should be loosened and allowed to spin free. When it has ceased spinning one or two extra turns can be added in the same direction and the rope reconnected. Ropes should be shortened alternately from both ends to ensure that one end never remains at the cappel for the duration of rope life.

It is good practice to keep a record, usually in chart form, of the rope stretch. This can be of great assistance when the rope is nearing the end of its life as secondary extension gives a useful indication that the rope should be discarded. The use of electromagnetic testing is also useful in assessing when a rope should be discarded.

Tail Ropes

Tail Ropes

The use of tail ropes in South Africa is generally restricted to Koepe winder installations. Experience of the operation of these ropes has resulted in the following recommendations set out in table form for convenience.

1. Recommendations for the satisfactory operation of Tail Ropes:

Item	With tail sheaves	Without tail sheaves
Rope construction	Spinning characteristics are only important in so far as rope fatigue is concerned, where the inner rope takes too much of the load. Suitable construction 12x19(9/9/1)/6x19(9/9/1)/IWRC Ordinary Lay	Good non-spinning characteristics are advantageous for shallow winds but for deep winds a certain amount of spin is advantageous to keep swivels operating satisfactorily. Suitable Construction 8x8/6x27(9/12/6Δ)/WMC
Loop to rope diameter:ratio	Not less than 35:1	Not less than 45:1 (other constructions are available which allow for greater or lesser ratios).
Swivels	Swivels need not be used	Freely operating swivels are required on both ends of rope. Behaviour and stability of ropes are dependent on swivels being completely free at all times. Maximum swivel starting torque should not be more than 0,281 x load in kN +2,11 Nm at any point in the wind.
Lubrication	Good quality rope dressing should be used	Non-tacky rope dressing should be used otherwise no outer lubrication.
Maintenance	Effects of internal wear in rope should be counteracted at regular intervals by allowing the rope end to turn in direction to tighten outer strands. Swivels can be used to achieve this. Tail sheave grooves should be maintained in good condition and be machined to 10% larger than the nominal rope dia. when new rope is installed.	When more than one tail rope is used, ropes should not be divided from each other but should have a baulk through the centre of the loops. Height of loops should be maintained within 150 mm of each other.
Rope installation	Care must be taken to ensure that turn is not put into the rope during installation. The use of swivels is advantageous with certain rope constructions.	Rope connected to swivel for installation.

2. Tail Rope Installation and Maintenance

Installation of tail ropes should be done from shaft bottom and consists simply of unreeling the new rope up the shaft by means of the hoist, at the same time reeling the descending old rope onto an empty reel.

Tail rope extension is not as critical as for head ropes because tail sheaves, where used, are individually mounted. In the case of free looping ropes it is good practice to maintain the loops at approximately the same levels.

Free looping tail ropes should not be separated from one another. However, trip wires are usually strung through the loops to stop the hoist should they rise too high.

Guide Ropes

The use of guide ropes in mine shafts in South Africa has not been popular for various reasons, the most important being the fact that more than one winder is used for hoisting in most shafts. The effect of 4 or 6 conveyances in a shaft on the behaviour of guide ropes is not known. A further disadvantage has been the difficulty of controlling conveyances when hoisting from intermediate levels.

In spite of this the used of guide ropes offers several advantages. Ventilation is not as restricted as in conventional shafts. Furthermore the use of guide ropes can lead to high winding speeds due to smoother running of conveyances.

The recommended rope for guides is the Half-Locked Coil. This rope is more rigid than other ropes, has a smooth exterior and due to large outer wires, is less affected by external wear.

Preferred Triangular Strand Winding Ropes

Nominal Rope Diameter (mm)	Construction	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
			1800MPa	1900MPa	
26,0	6x26Δ/F	2,80	480	504	2,50
27,0	6x26Δ/F	3,12	534	561	2,60
28,0	6x26Δ/F	3,26	558	586	2,70
29,0	6x26Δ/F	3,50	600	630	2,80
30,0	6x26Δ/F	3,76	645	677	2,90
31,0	6x26Δ/F	4,02	691	726	3,00
32,0	6x26Δ/F	4,29	738	776	3,10
33,0	6x26Δ/F	4,55	785	824	3,20
34,0	6x26Δ/F	4,85	836	878	3,30
35,0	6x27Δ/F	5,18	893	938	3,15
36,0	6x27Δ/F	5,51	951	999	3,25
37,0	6x27Δ/F	5,73	988	1038	3,30
38,0	6x28Δ/F	6,07	1045	1097	3,15
38,5	6x28Δ/F	6,26	1080	1134	3,20
39,0	6x28Δ/F	6,44	1111	1165	3,25
40,0	6x29Δ/F	6,78	1170	1227	3,10
41,0	6x29Δ/F	7,19	1242	1302	3,20
42,0	6x29Δ/F	7,47	1288	1351	3,25
43,0	6x30Δ/F	7,95	1371	1437	3,15
43,5	6x30Δ/F	8,02	1384	1451	3,15
44,0	6x30Δ/F	8,24	1421	1490	3,20
45,0	6x30Δ/F	8,71	1502	1575	3,30
46,0	6x31Δ/F	9,04	1557	1631	3,15
47,0	6x31Δ/F	9,31	1604	1680	3,20
48,0	6x31Δ/F	9,94	1715	1797	3,30
49,0	6x32Δ/F	10,14	1746	1829	3,15
50,0	6x32Δ/F	10,49	1804	1889	3,20
51,0	6x32Δ/F	11,13	1917	2008	3,30
52,0	6x33Δ/F	11,32	1945	2036	3,15
53,0	6x33Δ/F	12,04	2068	2165	3,25
54,0	6x33Δ/F	12,47	2140	2240	3,30
55,0	6x33Δ/F	12,88	2213	2316	3,35
56,0	6x33Δ/F	13,32	2284	2391	3,40
57,0	6x33Δ/F	13,74	2359	2469	3,45
58,0	6x33Δ/F	14,39	2475	2591	3,55
59,0	6x33Δ/F	14,84	2550	2670	3,60
60,0	6x33Δ/F	15,29	2630	2753	3,65

Ultra High Tensile Triangular Strand Winding Ropes

Nominal Rope Diameter (mm)	Construction	Estimated Mass (kg/m)	Estimated Breaking Force (kN)				Outer Wire Diameter (mm)
			1960 MPa	2000 MPa	2050 MPa	2100 MPa	
31,0	6x26Δ/F	4,02	747	761	778	796	3,00
32,0	6x26Δ/F	4,29	798	813	831	850	3,10
33,0	6x26Δ/F	4,55	848	864	884	904	3,20
34,0	6x27Δ/F	4,90	908	925	946	967	3,05
35,0	6x27Δ/F	5,18	964	982	1005	1027	3,15
36,0	6x28Δ/F	5,48	1017	1036	1059	1083	3,00
37,0	6x28Δ/F	5,83	1084	1104	1129	1154	3,10
38,0	6x28Δ/F	6,07	1128	1148	1174	1200	3,15
38,5	6x28Δ/F	6,26	1166	1187	1214	1240	3,20
39,0	6x29Δ/F	6,57	1220	1242	1270	1298	3,05
40,0	6x29Δ/F	6,78	1261	1284	1313	1341	3,10
41,0	6x29Δ/F	7,19	1339	1363	1393	1424	3,20
41,0	6x30Δ/F	7,24	1343	1367	1397	1427	3,00
42,0	6x30Δ/F	7,49	1393	1418	1449	1480	3,05
43,0	6x30Δ/F	7,95	1476	1503	1536	1569	3,15
43,5	6x30Δ/F	8,02	1491	1518	1552	1585	3,15
44,0	6x30Δ/F	8,24	1531	1558	1592	1627	3,20
44,0	6x31Δ/F	8,42	1560	1588	1622	1657	3,05
45,0	6x31Δ/F	8,73	1617	1646	1682	1718	3,10
46,0	6x31Δ/F	9,04	1676	1705	1743	1780	3,15
47,0	6x31Δ/F	9,31	1726	1757	1795	1834	3,20
47,0	6x32Δ/F	9,47	1752	1783	1822	1861	3,05
48,0	6x32Δ/F	9,81	1815	1847	1887	1926	3,10
49,0	6x32Δ/F	10,14	1878	1911	1952	1994	3,15
50,0	6x32Δ/F	10,49	1940	1974	2017	2059	3,20
50,0	6x33Δ/F	10,67	1966	2000	2043	2085	3,05
51,0	6x33Δ/F	11,03	2033	2068	2113	2157	3,10
52,0	6x33Δ/F	11,32	2091	2128	2173	2219	3,15
53,0	6x33Δ/F	12,04	2223	2262	2311	2359	3,25
54,0	6x34Δ/F	12,26	2258	2297	2346	2395	3,10
55,0	6x34Δ/F	13,10	2414	2456	2508	2560	3,20
56,0	6x34Δ/F	13,39	2468	2511	2564	2617	3,25
57,0	6x34Δ/F	13,79	2539	2583	2638	2693	3,30
58,0	6x34Δ/F	14,21	2620	2665	2722	2779	3,35

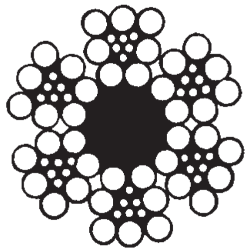
Large Diameter Ultra High Tensile Triangular Strand Winding Ropes

Nominal Rope Diameter (mm)	Con-struction	Estimated Mass (kg/m)	Estimated Breaking Force (kN)			Outer Wire Diameter (mm)
			1900 MPa	1960 MPa	2000 MPa	
54,0	6x32Δ/F	12,53	2259	2321	2361	3,50
55,0	6x32Δ/F	12,80	2309	2372	2414	3,55
56,0	6x32Δ/F	13,24	2385	2449	2492	3,60
57,0	6x32Δ/F	14,04	2528	2597	2643	3,70
58,0	6x32Δ/F	14,62	2630	2701	2749	3,78
59,0	6x32Δ/F	15,18	2736	2811	2860	3,86
60,0	6x32Δ/F	15,76	2845	2922	2974	3,94
54,0	6x33Δ/F	12,47	2240	2300	2340	3,30
55,0	6x33Δ/F	12,88	2316	2378	2420	3,35
56,0	6x33Δ/F	13,32	2391	2455	2498	3,40
57,0	6x33Δ/F	13,74	2469	2535	2580	3,45
58,0	6x33Δ/F	14,39	2591	2661	2707	3,55
59,0	6x33Δ/F	14,84	2670	2742	2790	3,60
60,0	6x33Δ/F	15,29	2753	2827	2876	3,65
61,0	6x33Δ/F	15,71	2833	2909	2960	3,70
62,0	6x33Δ/F	16,42	2948	3027	3080	3,78
63,0	6x33Δ/F	17,02	3062	3144	3199	3,86
64,0	6x33Δ/F	17,70	3181	3267	3324	3,94
65,0	6x33Δ/F	17,95	3226	3313	3371	3,94
66,0	6x33Δ/F	18,50	3333	—	—	4,02
67,0	6x33Δ/F	19,20	3458	—	—	4,10
68,0	6x33Δ/F	19,88	3585	—	—	4,18
54,0	6x34Δ/F	12,26	2200	2258	2297	3,10
55,0	6x34Δ/F	13,10	2352	2414	2456	3,20
56,0	6x34Δ/F	13,39	2404	2468	2511	3,25
57,0	6x34Δ/F	13,79	2473	2539	2583	3,30
58,0	6x34Δ/F	14,21	2551	2620	2665	3,35
59,0	6x34Δ/F	14,65	2634	2704	2751	3,40
60,0	6x34Δ/F	15,20	2728	2801	2849	3,45
61,0	6x34Δ/F	15,65	2813	2888	2937	3,50
62,0	6x34Δ/F	16,42	2948	3026	3079	3,60
63,0	6x34Δ/F	16,91	3039	3120	3174	3,65
64,0	6x34Δ/F	17,36	3116	3199	3255	3,70
65,0	6x34Δ/F	18,05	3239	3325	3383	3,78
66,0	6x34Δ/F	18,32	3286	3373	3431	3,78
67,0	6x34Δ/F	19,02	3411	3502	3563	3,86
68,0	6x34Δ/F	19,70	3540	3634	3697	3,94

Note: 6x32Δ/F or 6x33Δ/F constructions should be used in preference to the 6x34Δ/F construction.

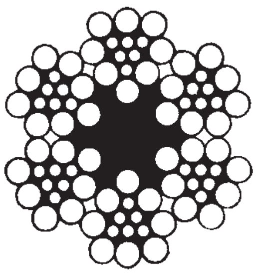
Simple Triangular Strand Winding Ropes

6x13(7/6/Δ)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
13,0	0,76	119	1,40
14,0	0,89	141	1,52
15,0	1,02	162	1,64
16,0	1,13	180	1,72
17,0	1,29	206	1,84
18,0	1,47	233	1,96
19,0	1,64	262	2,08
20,0	1,83	293	2,20
21,0	1,99	316	2,28
22,0	2,19	349	2,40
23,0	2,37	378	2,50
24,0	2,59	411	2,60
25,0	2,86	457	2,75
26,0	3,06	490	2,85
27,0	3,30	528	2,95
28,0	3,52	564	3,05
29,0	3,74	601	3,15
30,0	4,02	643	3,25
31,0	4,36	700	3,40
32,0	4,61	741	3,50

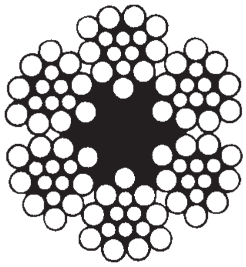
6x14(8/6/ΔΔ)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
24,0	2,62	411	2,40
25,0	2,86	448	2,50
26,0	3,08	483	2,60
27,0	3,33	523	2,70
28,0	3,57	560	2,80
29,0	3,85	603	2,90
30,0	4,09	643	3,00
31,0	4,39	690	3,10
32,0	4,66	732	3,20

Simple Triangular Strand Winding Ropes

6x15(9/6ΔΔ)/F

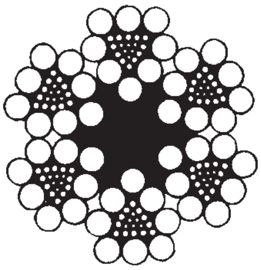


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
26,0	3,14	482	2,40
27,0	3,37	519	2,50
28,0	3,66	563	2,60
29,0	3,95	608	2,70
30,0	4,20	650	2,80
31,0	4,52	699	2,90
32,0	4,85	749	3,00
33,0	4,81	780	3,10
34,0	5,15	834	3,20
35,0	5,46	884	3,30
36,0	5,77	936	3,40

Plaited Triangular Strand Cores supplied in ropes above 32 mm diameter.

Compound Triangular Strand Winding Ropes

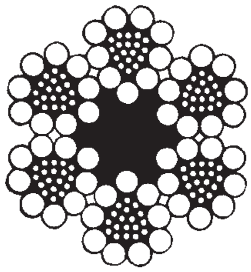
6x26(8/12/6ΔΔ)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
22,0	2,07	343	361	2,12
23,0	2,24	371	390	2,20
24,0	2,47	410	431	2,32
25,0	2,72	451	474	2,44
26,0	2,80	480	504	2,50
27,0	3,12	534	561	2,60
28,0	3,26	558	586	2,70
29,0	3,50	600	630	2,80
30,0	3,84	638	671	2,90
31,0	4,11	684	719	3,00
32,0	4,39	732	769	3,10
33,0	4,70	781	821	3,20
34,0	4,96	829	871	3,30
35,0	5,22	873	918	3,40
36,0	5,54	927	974	3,50
37,0	5,88	982	1032	3,60
38,0	6,24	1039	1092	3,70

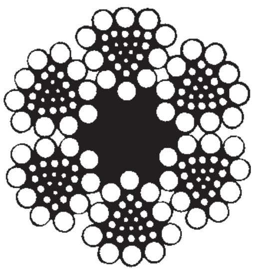
Compound Triangular Strand Winding Ropes

6x27(9/12/6△△)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
30,0	3,93	650	682	2,70
31,0	4,09	676	710	2,75
32,0	4,39	726	763	2,85
33,0	4,69	778	817	2,95
34,0	5,01	831	873	3,05
35,0	5,18	893	938	3,15
36,0	5,51	951	999	3,25
37,0	5,73	988	1038	3,30
38,0	6,24	1038	1090	3,40

6x28(10/12/6△△)/F

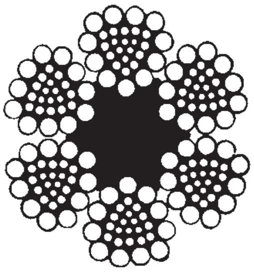


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
32,0	4,41	728	765	2,65
33,0	4,76	786	825	2,75
34,0	4,94	816	857	2,80
35,0	5,13	883	926	2,90
36,0	5,48	943	990	3,00
37,0	5,83	1005	1055	3,10
38,0	6,07	1045	1097	3,15
38,5	6,26	1080	1134	3,20
39,0	6,44	1111	1165	3,25
40,0	6,82	1177	1235	3,35
41,0	7,03	1214	1274	3,40
42,0	7,43	1285	1349	3,50

Plaited Triangular Strand Cores supplied in ropes above 34 mm diameter.

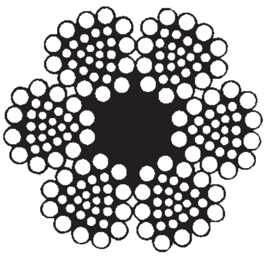
High Tensile Triangular Strand Winding Ropes

6x29(11/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
34,0	4,91	846	888	2,65
35,0	5,14	885	928	2,70
36,0	5,49	947	993	2,80
37,0	5,86	1011	1060	2,90
38,0	6,17	1064	1115	2,95
39,0	6,57	1132	1187	3,05
40,0	6,78	1170	1227	3,10
41,0	7,19	1242	1302	3,20
42,0	7,47	1288	1351	3,25
43,0	7,90	1364	1430	3,35
44,0	8,16	1411	1479	3,40

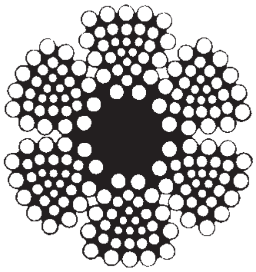
6x30(12/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
24,0	2,51	408	427	1,72
25,0	2,73	444	466	1,80
26,0	2,96	482	505	1,88
27,0	3,23	525	550	1,96
28,0	3,47	566	593	2,04
29,0	3,73	608	638	2,12
30,0	3,91	637	668	2,16
31,0	4,18	682	715	2,24
32,0	4,50	739	775	2,32
33,0	4,81	788	826	2,40
34,0	5,11	838	878	2,48
35,0	5,40	885	928	2,55
36,0	5,61	965	1012	2,65
37,0	5,83	1001	1049	2,70
38,0	6,07	1044	1095	2,75
39,0	6,47	1114	1168	2,85
40,0	6,73	1160	1216	2,90
40,5	6,96	1199	1257	2,95
41,0	7,24	1246	1307	3,00
42,0	7,49	1293	1355	3,05
43,0	7,95	1371	1437	3,15
43,5	8,02	1384	1451	3,15
44,0	8,24	1421	1490	3,20
45,0	8,71	1502	1575	3,30
46,0	8,95	1547	1622	3,35
47,0	9,25	1599	1676	3,40
48,0	9,74	1685	1767	3,50
Plaited Triangular Strand Cores supplied in ropes above 35 mm diameter.				

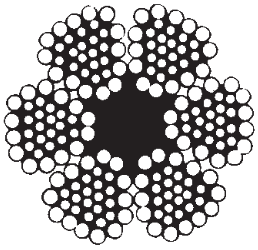
Compound Triangular Strand Winding Ropes

6x31(13/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
40,0	6,86	1179	1235	2,75
41,0	7,14	1227	1285	2,80
42,0	7,66	1318	1381	2,90
43,0	7,96	1369	1435	2,95
44,0	8,42	1449	1518	3,05
45,0	8,73	1503	1574	3,10
46,0	9,04	1557	1631	3,15
47,0	9,31	1604	1680	3,20
48,0	9,94	1715	1797	3,30
49,0	10,15	1748	1831	3,35
50,0	10,81	1866	1955	3,45
51,0	11,10	1917	2009	3,50
52,0	11,45	1976	2071	3,55
53,0	11,81	2038	2136	3,60
54,0	12,43	2138	2240	3,70

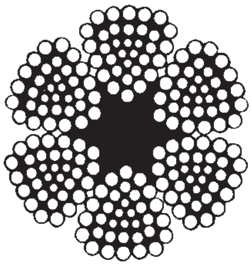
6x32(14/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
42,0	7,50	1285	1346	2,70
43,0	7,78	1335	1398	2,75
44,0	8,09	1388	1453	2,80
45,0	8,66	1487	1557	2,90
46,0	8,97	1540	1613	2,95
47,0	9,47	1629	1706	3,05
48,0	9,81	1687	1767	3,10
49,0	10,14	1746	1829	3,15
50,0	10,49	1804	1889	3,20
51,0	11,13	1917	2008	3,30
52,0	11,50	1980	2073	3,35
53,0	11,87	2044	2140	3,40
54,0	12,53	2157	2259	3,50
55,0	12,80	2205	2309	3,55
56,0	13,24	2277	2385	3,60
57,0	14,04	2414	2528	3,70
58,0	14,62	2510	2630	3,78

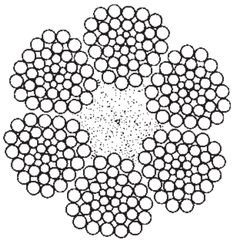
High Tensile Triangular Strand Winding Ropes

6x33(15/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
50,0	10,67	1829	1914	3,05
51,0	11,03	1892	1980	3,10
52,0	11,32	1945	2036	3,15
53,0	12,04	2068	2165	3,25
54,0	12,47	2140	2240	3,30
55,0	12,88	2213	2316	3,35
56,0	13,32	2284	2391	3,40
57,0	13,74	2359	2469	3,45
58,0	14,39	2475	2591	3,55
59,0	14,84	2550	2670	3,60
60,0	15,29	2630	2753	3,65
61,0	15,76	2706	2833	3,70
62,0	16,42	2815	2948	3,78

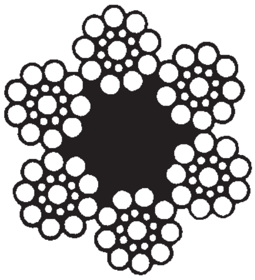
6x34(16/12/6∆∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
52,0	11,43	1959	2050	3,00
53,0	11,84	2030	2124	3,05
54,0	12,26	2102	2200	3,10
55,0	13,10	2247	2352	3,20
56,0	13,39	2298	2404	3,25
57,0	13,79	2363	2473	3,30
58,0	14,21	2438	2551	3,35
59,0	14,65	2517	2634	3,40
60,0	15,20	2607	2728	3,45
61,0	15,65	2688	2813	3,50
62,0	16,42	2817	2948	3,60
63,0	16,91	2904	3039	3,65
64,0	17,36	2977	3116	3,70
65,0	18,05	3095	3239	3,78
66,0	18,32	3140	3286	3,78
67,0	19,02	3260	3411	3,86
68,0	19,70	3383	3540	3,94

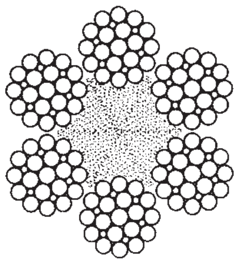
Round Strand Winding Ropes

6x19(9/9/1Δ)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
13,0	0,66	103,6	1,04
14,0	0,75	118,7	1,12
15,0	0,87	138,0	1,20
16,0	0,98	155,2	1,28
17,0	1,08	170,1	1,32
18,0	1,23	196,1	1,44
19,0	1,34	212,7	1,48
20,0	1,49	237,6	1,56
21,0	1,64	260,0	1,64
22,0	1,80	285,7	1,72
23,0	1,97	311,6	1,80
24,0	2,18	348,8	1,92
25,0	2,36	377,5	2,00
26,0	2,59	414,6	2,08
27,0	2,69	427,8	2,12
28,0	2,98	477,8	2,24
29,0	3,13	499,5	2,28
30,0	3,34	534,2	2,36

6x25(12/6F+6/1Δ)/F



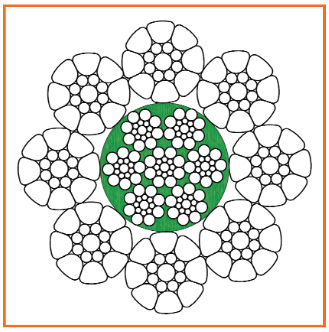
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
26,0	2,60	420	1,64
27,0	2,85	460	1,72
28,0	2,99	482	1,76
29,0	3,24	525	1,84
30,0	3,51	570	1,92
31,0	3,68	595	1,96
32,0	3,97	643	2,04
33,0	4,12	669	2,08
34,0	4,49	729	2,16
35,0	4,65	755	2,20
36,0	4,95	802	2,28
38,0	5,53	895	2,40
40,0	6,19	1004	2,55
42,0	6,66	1082	2,65
44,0	7,42	1206	2,80
46,0	8,00	1305	2,90
48,0	8,82	1432	3,05
50,0	9,42	1537 *	3,15
52,0	10,33	1687 *	3,30

Note: * Not available in galvanised finish.

Round Strand Winding Ropes

Compact 8 Strand Cushion Core Rope

8x17C(8/8/1)PIWRC(7x17)G09



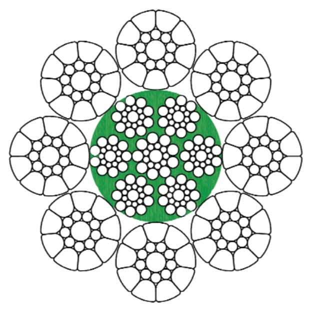
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1960 MPa	
24,0	2,654	422,5	459,1	1,80
25,0	2,890	460,5	500,5	1,88
26,0	3,060	487,5	529,7	1,92
27,0	3,358	535,5	581,8	2,00
28,0	3,546	566,1	615,1	2,08
29,0	3,906	622,8	676,6	2,16
30,0	4,143	661,1	718,3	2,24
31,0	4,423	706,3	767,4	2,32
32,0	4,704	749,1	813,9	2,36

- Larger outer wire to compensate for abrasive wear
- Flexible eight strand construction
- Plastic encapsulated core seals in rope lubrication
- Reduced stretch
- Crush resistant compact outer strands
- Higher breaking force due to IWRC
- Reduced internal stresses
- Reduced tread pressures due to the 8 outer strands

Round Strand Winding Ropes

Compact 8 Strand Cushion Core Rope

8x19C(9/9/1)PIWRC(7x19)G10



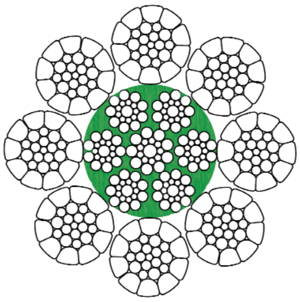
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1960 MPa	
30,0	4,173	665,2	722,8	2,04
31,0	4,493	716,9	778,9	2,12
32,0	4,826	766,9	833,3	2,20
33,0	5,048	802,9	872,3	2,24
34,0	5,392	858,2	932,4	2,32
35,0	5,731	912,9	991,8	2,40
36,0	6,074	968,8	1053	2,48
37,0	6,403	1022	1110	2,55
38,0	6,715	1072	1165	2,60
39,0	7,052	1125	1223	2,65
40,0	7,577	1210	1315	2,75
41,0	7,812	1246	1354	2,80
42,0	8,156	1301	1414	2,85
43,0	8,647	1381	1500	2,95
44,0	8,968	1433	1557	3,00
45,0	9,519	1519	1646	3,10
46,0	9,948	1588	1725	3,15
47,0	10,257	1637	1778	3,20

- Increased bending fatigue resistance
- Cushion core seals rope lubrication in the rope
- Flexible 8 strand construction
- Reduced stretch
- Crush resistant compact outer strands
- Higher breaking force due to IWRC
- Reduced internal stresses
- Reduced tread pressures due to the 8 outer strands

Round Strand Winding Ropes

Compact 8 Strand Cushion Core Rope

8x26C(10/5+5/5/1)PIWRC(7x19)G11



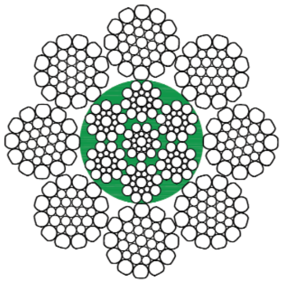
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1960 MPa	
45,0	9,555	1521	1653	2,85
46,0	9,944	1588	1720	2,90
47,0	10,33	1644	1787	2,95
48,0	10,89	1735	1885	3,05
49,0	11,28	1797	1953	3,10
50,0	11,88	1892	2056	3,15
51,0	12,06	1923	2089	3,20
52,0	12,49	1992	2165	3,25
53,0	13,11	2091	2272	3,35
54,0	13,65	2178	2366	3,40

- Recommended for multi-layer coiling
- Cushion core seals rope keeping corrosives and water out
- Flexible eight strand construction
- Reduced stretch
- Crush resistant compact outer strands
- Higher breaking force due to IWRC
- Reduced internal stresses
- Load spreading characteristic due to the 8 outer strands

Round Strand Winding Ropes

Compact 8 Strand Cushion Core Rope

8x31C(12/6+6/6/1)PIWRC(7x19)G12

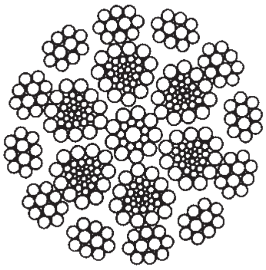


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1960 MPa	
52,0	12,93	2056	2234	2,85
53,0	13,35	2124	2308	2,90
54,0	13,89	2209	2400	2,95
55,0	14,48	2303	2502	3,00
56,0	14,86	2364	2568	3,05
57,0	15,49	2464	2677	3,10
58,0	15,88	2525	2744	3,15
59,0	16,61	2646	2875	3,25
60,0	17,21	2741	2978	3,30
61,0	17,55	2794	3036	3,30
62,0	17,97	2861	3108	3,35
63,0	18,53	2953	3208	3,40
64,0	19,35	3085	3352	3,50

- Plasticated cushion core absorbs shock loads, reduces fatigue
- Increased structural stability
- Cushion core seals lubrication in the rope
- Flexible eight strand construction
- Reduced stretch
- Crush resistant compact outer strands
- Higher breaking force due to IWRC
- Reduced internal stresses
- Load spreading characteristic due to the 8 outer strands

Koepe Head Ropes

15 Strand "Fishback" non-spin
9x10(8/2)/6x14(8/6Δ)/WMC

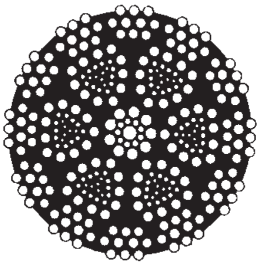


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
28,0	3,50	583	1,76
29,0	3,73	620	1,80
30,0	3,99	665	1,88
31,0	4,25	708	1,92
32,0	4,45	743	2,00
33,0	4,81	802	2,04
34,0	5,15	860	2,12
35,0	5,47	914	2,20
36,0	5,71	956	2,24
37,0	6,11	1023	2,32
38,0	6,36	1063	2,36
39,0	6,77	1131	2,44
40,0	7,10	1187	2,48
41,0	7,45	1246	2,55
42,0	7,78	1301	2,60
43,0	8,31	1391	2,70
44,0	8,63	1445	2,75
45,0	8,98	1497	2,80
46,0	9,43	1578	2,90
47,0	9,89	1658	2,95
48,0	10,13	1710	3,00

Koepe Head Ropes

18 Strand "Fishback" non-spin

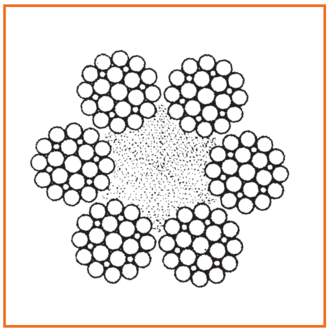
12x10(8/2)/6x29(11/12/6∆)/WMC



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
36,0	5,76	983	1,76
37,0	5,98	1021	1,80
38,0	6,36	1086	1,84
39,0	6,78	1159	1,92
40,0	7,06	1207	1,96
41,0	7,40	1266	2,00
42,0	7,75	1326	2,04
43,0	8,26	1413	2,12
44,0	8,57	1468	2,16
45,0	8,92	1528	2,20
46,0	9,30	1593	2,24
47,0	9,81	1680	2,32
48,0	10,19	1747	2,36
49,0	10,68	1829	2,40
50,0	10,93	1873	2,44
51,0	11,57	1982	2,50
52,0	12,02	2062	2,55
53,0	12,39	2124	2,60
54,0	12,88	2210	2,65
55,0	13,33	2289	2,70
56,0	13,76	2363	2,75
57,0	14,28	2451	2,80
58,0	14,95	2568	2,85
59,0	15,43	2652	2,90
60,0	15,92	2736	2,95
61,0	16,52	2839	3,00
62,0	17,02	2928	3,05
63,0	17,59	3025	3,10
64,0	18,12	3118	3,15

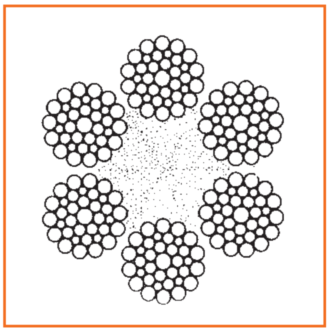
Round Strand Koepe Head Ropes

6x25(12/6F+6/1∆)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
26,0	2,59	443	1,68
27,0	2,75	471	1,72
28,0	2,93	502	1,76
29,0	3,12	535	1,84
30,0	3,40	585	1,92
31,0	3,59	618	1,96
32,0	3,87	666	2,04
33,0	4,09	705	2,12
34,0	4,31	743	2,16
35,0	4,65	799	2,24
36,0	4,79	823	2,28
37,0	5,16	888	2,36
38,0	5,47	942	2,44
39,0	5,69	979	2,48
40,0	6,04	1041	2,55
41,0	6,25	1076	2,60
42,0	6,65	1147	2,70
43,0	6,99	1203	2,75
44,0	7,22	1244	2,80
49,0	9,06	1564	3,15

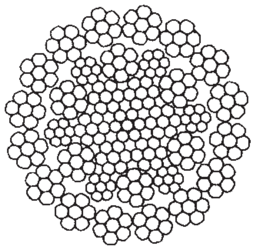
6x36(14/7+7/7/1)/F



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
30,0	3,36	557	1,68
32,0	3,90	647	1,80
34,0	4,40	730	1,92
36,0	4,93	820	2,04
38,0	5,38	894	2,12
40,0	6,11	1019	2,28
42,0	6,67	1109	2,36
44,0	7,42	1238	2,50
46,0	8,07	1345	2,60
48,0	8,71	1451	2,70
50,0	9,61	1602	2,85

Koepe Head Ropes

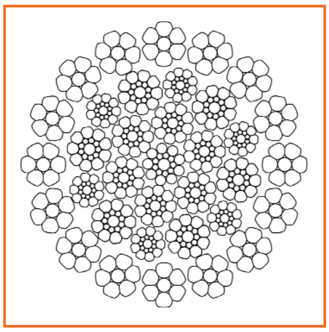
34LR UHP
16x7C(6/1)/6x7C(6/1)+6x7C(6/1)/6x7C(6/1)/WMC



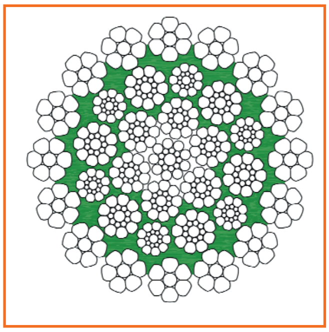
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Outer Wire Diameter (mm)
		1800MPa	
16,0	1,21	195	0,84
17,0	1,36	220	0,90
18,0	1,55	250	0,96
19,0	1,71	275	1,00
20,0	1,89	305	1,04
21,0	2,10	339	1,12
22,0	2,31	374	1,16
23,0	2,49	403	1,20
24,0	2,70	439	1,28
25,0	2,95	478	1,32
26,0	3,22	522	1,40
27,0	3,49	567	1,44
28,0	3,68	598	1,48
29,0	4,05	659	1,56
30,0	4,26	691	1,60
31,0	4,55	739	1,64
32,0	4,86	790	1,72
33,0	5,09	828	1,76
34,0	5,50	895	1,80
35,0	5,72	931	1,84
36,0	6,09	992	1,92
37,0	6,34	1033	1,96
38,0	6,81	1111	2,04
39,0	7,07	1154	2,08
40,0	7,50	1224	2,12

Koepe Head Ropes

34LR Koepe Hoist Rope, Design Code V96
16x7C(6/1)/6x19C(9/9/1)+6x19C(9/9/1)/6x19C(9/9/1)/WMC



CONVENTIONAL



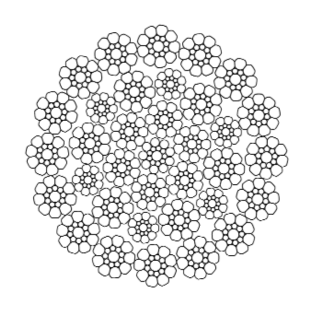
CUSHION CORE

Nominal Rope Diameter: (mm)	Estimated Mass (Koepe) Conventional (kg/m)	Estimated Mass (Koepe) Cushion Core (kg/m)	Minimum Breaking Force kN Tensile Grade (MPa)			Outer Wire Diameter (mm)
			1800	1900	1960	
38.0	6.981	7.110	1133	1194	1231	2.04
39.0	7.312	7.450	1187	1252	1290	2.08
40.0	7.502	7.645	1219	1284	1324	2.12
41.0	7.893	8.048	1283	1352	1394	2.16
42.0	8.241	8.400	1340	1412	1455	2.24
43.0	8.690	8.857	1410	1486	1532	2.28
44.0	9.004	9.179	1461	1540	1588	2.32
45.0	9.693	9.878	1574	1660	1711	2.40
46.0	10.02	10.21	1629	1717	1770	2.44
47.0	10.35	10.55	1682	1773	1827	2.50
48.0	10.98	11.19	1785	1882	1940	2.55
49.0	11.34	11.56	1854	1945	1960	2.60
50.0	11.64	11.86	1894	1997	2058	2.65
51.0	12.23	12.47	1990	2098	2162	2.70
52.0	12.62	12.87	2055	2166	2233	2.75
53.0	13.18	13.44	2140	2256	2325	2.80
54.0	13.81	14.07	2244	2365	2438	2.85
55.0	14.48	14.76	2355	2482	2559	2.95
56.0	15.05	15.33	2448	2580	2660	3.00
57.0	15.44	15.74	2512	2647	2729	3.05
58.0	16.10	16.41	2620	2761	2846	3.10
59.0	16.61	16.93	2704	2850	2937	3.15
60.0	*16.93*	17.25	2757	2906	2996	3.20

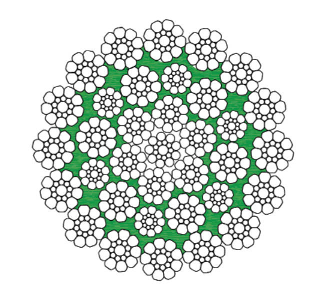
Other Tensile Grades and Rope Diameters are available upon customers request.

Koepe Head Ropes

34LR Koepe Hoist Rope, Design Code V98
16x19C(9/9/1)/6x19C(9/9/1)+6x19C(9/9/1)/6x19C(9/9/1)/WMC



CONVENTIONAL



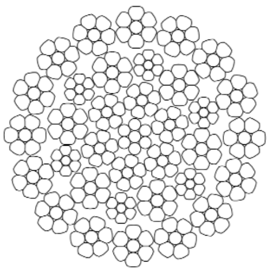
CUSHION CORE

Nominal Rope Diameter: (mm)	Estimated Mass (Fully Lubricated (kg/m)	Estimated Mass (Koepe) (kg/m)	Minimum Breaking Force kN Tensile Grade (MPa)			Outer Wire Diameter (mm)
			1800	1900	1960	
36.0	6.321	6.228	998.1	1052	1084	1.40
37.0	6.742	6.643	1065	1122	1157	1.44
38.0	7.064	6.958	1117	1177	1213	1.4
39.0	7.543	7.430	1193	1257	1297	1.52
40.0	7.862	7.744	1244	1311	1351	1.58
41.0	8.246	8.121	1306	1377	1418	1.60
42.0	8.715	8.584	1378	1452	1498	1.64
43.0	8.976	8.843	1420	1497	1542	1.68
44.0	9.645	9.449	1526	1608	1659	1.76
45.0	10.01	9.865	1585	1671	1722	1.76
46.0	10.35	10.2	1637	1725	1779	1.80
47.0	10.73	10.54	1696	1788	1843	1.84
48.0	11.43	11.26	1809	1907	1966	1.88
49.0	11.76	11.58	1861	1962	2022	1.92
50.0	12.35	12.16	1956	2062	2125	1.96
51.0	12.70	12.51	2012	2121	2186	2.00
52.0	13.05	12.85	2068	2180	2247	2.04
53.0	13.68	13.48	2167	2284	2354	2.08
54.0	14.35	14.12	2271	2394	2468	2.12
55.0	14.82	14.59	2348	2475	2551	2.16
56.0	15.49	15.26	2452	2585	2664	2.20
57.0	15.96	15.72	2527	2664	2746	2.24
58.0	16.61	16.36	2630	2772	2858	2.28
59.0	17.21	16.95	2726	2873	2962	2.32
60.0	17.95	17.68	2844	2998	3090	2.36
61.0	18.41	18.14	2918	3076	3171	2.40
62.0	19.10	18.81	3029	3193	3290	2.48
63.0	19.64	19.34	3115	3283	3384	2.48
64.0	20.07	19.77	3184	3356	3459	2.50
65.0	20.65	20.34	3277	3454	3560	2.55
66.0	21.56	21.23	3420	3605	3715	2.60
67.0	22.33	21.99	3543	3735	3850	2.65
68.0	22.96	22.62	3645	3842	3960	2.70
69.0	23.7	23.34	3763	3966	4088	2.75
70.0	24.18	23.82	3840	4048	4173	2.75

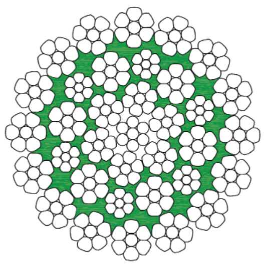
Other Tensile Grades and Rope Diameters are available upon customers request.

Koepe Head Ropes

34LR Koepe Hoist Rope, Design Code V99
16x7C(6/1)/6x7C(6/1)+6x7C(6/1)/6x7C(6/1)/WMC



CONVENTIONAL



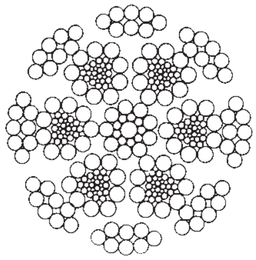
CUSHION CORE

Nominal Rope Diameter: (mm)	Estimated Mass (Fully Lubricated (kg/m)	Estimated Mass (Koepe) (kg/m)	Minimum Breaking Force kN Tensile Grade (MPa)			Outer Wire Diameter (mm)
			1800	1900	1960	
16.0	1.218	1.201	197.2	207.9	214.3	0.87
17.0	1.346	1.327	218.2	230.0	237.3	0.90
18.0	1.496	1.475	242.7	255.8	263.7	0.96
19.0	1.686	1.662	273.8	288.6	297.5	1.00
20.0	1.873	1.847	304.6	321.0	330.9	1.08
21.0	2.062	2.032	335.3	353.4	364.3	1.12
22.0	2.235	2.204	363.2	382.9	394.6	1.16
23.0	2.518	2.483	407.6	429.6	442.8	1.24
24.0	2.719	2.681	437.5	461.1	475.3	1.28
25.0	2.925	2.884	471.3	496.7	512.0	1.32
26.0	3.146	3.102	507.3	534.7	551.2	1.36
27.0	3.413	3.365	550.8	580.7	598.4	1.44
28.0	3.671	3.620	592.9	625.0	644.2	1.48
29.0	3.957	3.901	639.8	674.4	695.1	1.56
30.0	4.193	4.135	678.1	714.8	736.8	1.60
31.0	4.570	4.506	739.5	779.5	803.5	1.68
32.0	4.861	4.793	784.6	827.0	852.5	1.72
33.0	5.143	5.070	830.6	875.5	902.5	1.76
34.0	5.554	5.476	896.1	944.5	973.6	1.4
35.0	5.749	5.668	927.7	977.9	1008	1.88
36.0	6.065	5.981	979.2	1032	1064	1.92
37.0	6.350	6.260	1026	1082	1115	1.96
38.0	6.768	6.673	1095	1154	1190	2.04
39.0	7.091	6.990	1148	1210	1247	2.08
40.0	7.455	7.349	1207	1272	1312	2.12
41.0		8,008			1410	2.2
42.0	8.184				1443	

Other Tensile Grades and Rope Diameters are available upon customers request.

Tail Ropes

14 Strand non-spin
8x8/6x27(9/12/6∆)/WMC (P06 - On Advisement)

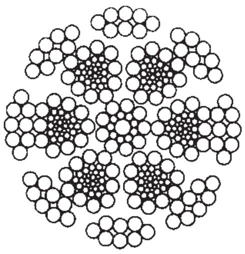


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1600MPa	1800 MPa	
20,0	1,84	268	299	1,28
21,0	2,05	299	333	1,36
22,0	2,22	324	361	1,40
23,0	2,44	356	397	1,48
24,0	2,70	394	440	1,56
25,0	2,90	423	471	1,60
26,0	3,14	458	511	1,68
27,0	3,41	498	556	1,76
28,0	3,64	532	594	1,80
29,0	3,90	570	636	1,88
30,0	4,13	604	674	1,92
31,0	4,48	656	732	2,00
32,0	4,76	698	778	2,08
33,0	5,01	736	821	2,12
34,0	5,37	791	883	2,20
35,0	5,58	823	918	2,24
36,0	5,99	882	984	2,32
37,0	6,34	934	1043	2,40
38,0	6,69	983	1097	2,44
39,0	7,02	1031	1151	2,50
40,0	7,30	1089	1215	2,55
41,0	7,68	1147	1279	2,65
42,0	8,02	1198	1336	2,70
43,0	8,44	1261	1407	2,75
44,0	8,70	1301	1452	2,80
45,0	9,30	1391	1552	2,90
46,0	9,68	1448	1615	2,95
47,0	10,04	1502	1676	3,00
48,0	10,59	1586	1769	3,10
49,0	10,97	1643	1833	3,15
50,0	11,12	1666	1858	3,15

Plaited Triangular Strand Cores supplied in ropes above 39mm diameter.

Tail Ropes

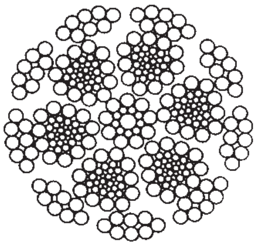
14 Strand non-spin
8x8/6x28(10/12/6∆)/WMC (P07 - On Advisement)



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1600MPa	1800 MPa	
40,0	7,44	1107	1234	2,60
41,0	7,72	1149	1281	2,65
42,0	8,05	1200	1337	2,70
43,0	8,49	1266	1412	2,75
44,0	8,98	1339	1493	2,85
45,0	9,23	1377	1535	2,90
46,0	9,61	1434	1599	2,95
47,0	10,26	1532	1708	3,05
48,0	10,54	1575	1756	3,10
49,0	10,93	1634	1821	3,15
50,0	11,29	1689	1883	3,20
51,0	12,00	1796	2002	3,30
52,0	12,36	1849	2061	3,35
53,0	12,74	1908	2127	3,40
54,0	13,49	2020	2252	3,50
55,0	13,94	2087	2327	3,55
56,0	14,35	2149	2397	3,60
57,0	15,10	2258	2518	3,70
58,0	15,18	2270	2531	3,70
59,0	15,97	2384	2658	3,78
60,0	16,58	2477	2761	3,86
61,0	17,01	2540	2832	3,94
62,0	17,68	2642	2946	4,02
63,0	18,42	2753	3069	4,10
64,0	18,82	2814	3138	4,10
65,0	19,45	2909	3243	4,18
66,0	19,94	2982	3324	4,26
67,0	20,67	3093	3448	4,34
68,0	21,45	3210	3579	4,42
69,0	21,75	3257	3632	4,42

Tail Ropes

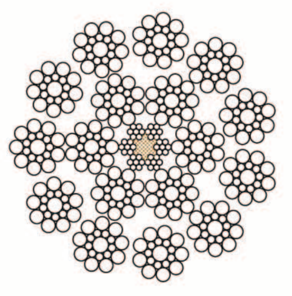
15 Strand non-spin
9x8/6x29(11/12/6∆)/WMC (P10 - On Advisement)



Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1600MPa	1800 MPa	
42,0	7,99	1190	1325	2,48
43,0	8,45	1259	1403	2,55
44,0	8,82	1314	1464	2,60
45,0	9,16	1365	1521	2,65
46,0	9,81	1464	1631	2,75
47,0	10,14	1512	1685	2,80
48,0	10,41	1553	1730	2,85
49,0	10,93	1632	1818	2,90
50,0	11,35	1694	1887	2,95
51,0	11,93	1781	1984	3,05
52,0	12,48	1866	2079	3,10
53,0	12,84	1919	2137	3,15
54,0	13,31	1990	2217	3,20
55,0	13,94	2085	2322	3,30
56,0	14,52	2173	2421	3,35
57,0	14,97	2242	2499	3,40
58,0	15,34	2298	2560	3,45
59,0	15,87	2376	2647	3,50
60,0	16,32	2445	2725	3,55
61,0	17,19	2576	2870	3,65
62,0	17,78	2655	2958	3,70
63,0	18,56	2772	3088	3,78
64,0	18,59	2777	3094	3,78
65,0	19,36	2893	3223	3,86

Tail Ropes

Koepe Tail Ropes
11x19(9/9/1)6x19(9/9/1)IWRC/F - (S25)

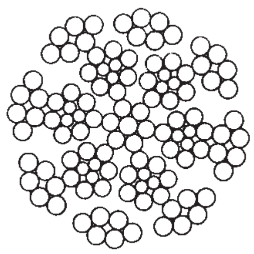


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (k/N)	Outer Wire Diameter (mm)
		1600MPa	
32	4,390	572,6	1,6
33	4.674	609,6	1,64
34	5.102	666,5	1,72
35	5,289	691	1,76
36	5,582	727,9	1,8
37	5,846	762,4	1,84
38	6,292	820,6	1,92
39	6,569	858,2	1,96
40	7,027	918	2,04
41	7,322	956,9	2,08
42	7,565	989	2,12
43	7,993	1046	2,2
44	8,471	1106	2,24
45	8,806	1150	2,28
46	9,149	1194	2,32
47	9,572	1251	2,36
48	9,968	1302	2,4
49	10,200	1333	2,44
50	10,730	1404	2,55
51	11,160	1461	2,55
52	11,820	1546	2,65
53	12,120	1586	2,65
54	12,700	1662	2,75
55	12,870	1685	2,75
56	13,240	1732	2,8
57	13,750	1798	2,85
58	14,430	1887	2,9
59	14,980	1959	2,95
60	15,390	2015	3

Flattened Over Triangular Strand

Non-Spin Sinking Ropes

14 Strand non-spin 8x6/6x10(7/3Δ)/WMC

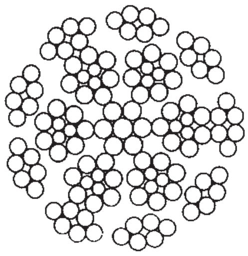


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
16,0	1,14	188	198	1,28
17,0	1,29	213	224	1,36
18,0	1,45	240	252	1,44
19,0	1,62	269	282	1,52
20,0	1,80	298	313	1,60
21,0	1,96	325	341	1,68
22,0	2,15	357	375	1,76
23,0	2,35	391	410	1,84
24,0	2,56	426	447	1,92
25,0	2,80	465	488	2,00
26,0	3,02	503	528	2,08
27,0	3,21	535	561	2,16
28,0	3,51	587	616	2,24
29,0	3,72	621	652	2,32
30,0	4,01	668	701	2,40
31,0	4,28	714	750	2,48
32,0	4,54	759	796	2,55
33,0	4,83	805	845	2,65
34,0	5,11	853	895	2,70
35,0	5,40	902	947	2,80
36,0	5,80	969	1017	2,90

Flattened Over Triangular Strand

Non-Spin Sinking Ropes

15 Strand non-spin 9x6/6x10(7/3∆)/WMC

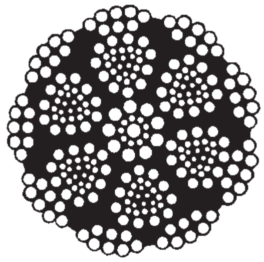


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
25,0	2,76	444	466	1,80
26,0	2,99	483	506	1,88
27,0	3,24	523	549	1,96
28,0	3,50	566	593	2,04
29,0	3,70	599	628	2,08
30,0	3,99	645	677	2,16
31,0	4,27	691	725	2,24
32,0	4,52	731	767	2,32
33,0	4,85	784	823	2,40
34,0	5,04	815	855	2,44
35,0	5,47	885	929	2,55
36,0	5,68	920	965	2,60
37,0	6,12	990	1039	2,70
38,0	6,34	1027	1078	2,75
39,0	6,67	1080	1134	2,80
40,0	7,04	1142	1198	2,90
41,0	7,38	1197	1256	2,95
42,0	7,75	1258	1320	3,05

Flattened Over Triangular Strand

Non-Spin Sinking Ropes

15 Strand non-spin 9x8/6x29(11/12/6Δ)/WMC

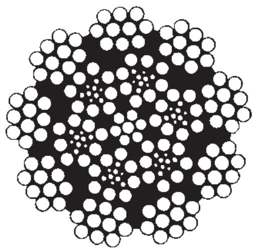


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)			Outer Wire Diameter (mm)
		1800 MPa	1900 MPa	1960 MPa	
42,0	7,99	1325	1393	1434	2,48
43,0	8,45	1403	1475	1518	2,55
44,0	8,82	1464	1539	1584	2,60
45,0	9,16	1521	1598	1645	2,65
46,0	9,81	1631	1714	1765	2,75
47,0	10,14	1685	1771	1823	2,80
48,0	10,41	1730	1818	1871	2,85
49,0	10,93	1818	1912	1967	2,90
50,0	11,35	1887	1983	2041	2,95
51,0	11,93	1984	2086	2147	3,05
52,0	12,48	2079	2186	2250	3,10
53,0	12,84	2137	2247	2312	3,15
54,0	13,31	2217	2330	2398	3,20
55,0	13,94	2322	2441	2512	3,30
56,0	14,52	2421	2545	2620	3,35
57,0	14,97	2499	2627	2704	3,40
58,0	15,34	2560	2692	2770	3,45
59,0	15,87	2647	2783	2864	3,50
60,0	16,32	2725	2864	2948	3,55
61,0	17,19	2870	3017	3106	3,65
62,0	17,78	2958	3110	3200	3,70
63,0	18,56	3088	3247	3342	3,78
64,0	18,59	3094	3252	3347	3,78
65,0	19,36	3223	3388	3487	3,86

Note: 1800 MPa and 1900 MPa tensile grades are the only grades suitable for Kibble Ropes. Galvanised Rope only available in 1800 MPa up to 60 mm diameter and 1900 MPa up to 48 mm diameter.

"Fishback" Non-Spin Stage Ropes

15 Strand non-spin
9x10(8/2)/6x14(8/6∆)/WMC

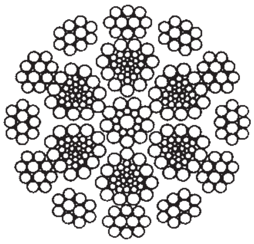


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
28,0	3,58	593	623	1,76
29,0	3,78	627	658	1,80
30,0	4,11	682	716	1,88
31,0	4,36	723	759	1,92
32,0	4,62	768	806	2,00
33,0	4,90	815	856	2,04
34,0	5,25	875	918	2,12
35,0	5,57	928	975	2,20
36,0	5,82	970	1019	2,24
37,0	6,17	1028	1080	2,32
38,0	6,50	1082	1136	2,36
39,0	6,88	1144	1202	2,44
40,0	7,23	1203	1264	2,50
41,0	7,59	1265	1328	2,55
42,0	7,90	1316	1382	2,60
43,0	8,37	1396	1466	2,70
44,0	8,80	1469	1542	2,75
45,0	9,08	1516	1592	2,80
46,0	9,57	1599	1679	2,90
47,0	10,07	1683	1767	2,95
48,0	10,43	1742	1829	3,00

Note: Galvanised rope not available in 1900 MPa in sizes above 48 mm diameter.

Ultra High Tensile "Fishback" Non-Spin Stage Ropes

15 Strand "Fishback" non-spin
9x10(8/2)/6x14(8/6Δ)/WMC

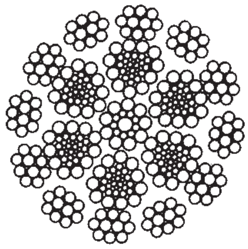


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)				Outer Wire Diameter (mm)
		1960 MPa	2000 MPa	2050 MPa	2100 MPa	
28,0	3,58	641	653	668	683	1,76
29,0	3,78	677	689	705	721	1,80
30,0	4,11	736	750	767	784	1,88
31,0	4,36	781	795	813	831	1,92
32,0	4,62	829	845	864	883	2,00
33,0	4,90	880	897	917	938	2,04
34,0	5,25	945	962	984	1006	2,12
35,0	5,57	1003	1021	1045	1068	2,20
36,0	5,82	1048	1068	1092	1117	2,24
37,0	6,17	1111	1132	1158	1183	2,32
38,0	6,50	1169	1191	1218	1245	2,36
39,0	6,88	1236	1259	1288	1317	2,44
40,0	7,23	1300	1324	1354	1384	2,50
41,0	7,59	1367	1392	1424	1456	2,55
42,0	7,90	1422	1448	1481	1514	2,60
43,0	8,37	1508	1537	1572	1607	2,70
44,0	8,80	1587	1616	1653	1690	2,75
45,0	9,08	1638	1668	1706	1745	2,80
46,0	9,57	1727	1760	1800	1840	2,90
47,0	10,07	1818	1852	1894	1937	2,95
48,0	10,43	1882	1917	1960	—	3,00

Note: Not available in galvanised finish.

"Fishback" Non-Spin Sinking Ropes

18 Strand "Fishback" non-spin
12x10(8/2)/6x29(11/12/6Δ)/WMC

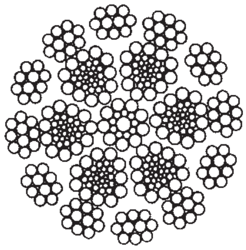


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)		Outer Wire Diameter (mm)
		1800MPa	1900 MPa	
36,0	5,90	982,5	1033	1,76
37,0	6,13	1021	1074	1,80
38,0	6,51	1086	1142	1,84
39,0	6,95	1159	1219	1,92
40,0	7,23	1207	1269	1,96
41,0	7,59	1266	1332	2,00
42,0	7,94	1326	1394	2,04
43,0	8,46	1413	1486	2,12
44,0	8,78	1468	1543	2,16
45,0	9,14	1528	1607	2,20
46,0	9,53	1593	1675	2,24
47,0	10,05	1680	1767	2,32
48,0	10,44	1747	1837	2,36
49,0	10,94	1829	1923	2,40
50,0	11,20	1873	1969	2,44
51,0	11,85	1982	2085	2,50
52,0	12,32	2062	2168	2,55
53,0	12,69	2124	2234	2,60
54,0	13,20	2210	2324	2,65
55,0	13,66	2289	2407	2,70
56,0	14,10	2363	2485	2,75
57,0	14,63	2451	2577	2,80
58,0	15,32	2568	2700	2,85
59,0	15,81	2652	2789	2,90
60,0	16,31	2736	2877	2,95
61,0	16,92	2839	2985	3,00
62,0	17,44	2928	3080	3,05
63,0	18,02	3025	3181	3,10
64,0	18,56	3118	3279	3,15

Note: Not recommended for use as kibble rope in sizes smaller than 46 mm diameter.

Ultra High Tensile "Fishback" Non-Spin Stage Ropes

18 Strand "Fishback" non-spin
12x10(8/2)/6x29(11/12/6Δ)/WMC

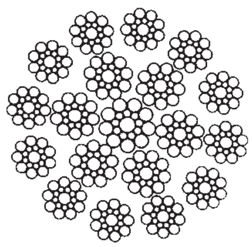


Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)				Outer Wire Diameter (mm)
		1960 MPa	2000 MPa	2050 MPa	2100 MPa	
36,0	5,90	1064	1084	1109	1135	1,76
37,0	6,13	1105	1126	1153	1179	1,80
38,0	6,51	1176	1198	1226	1254	1,84
39,0	6,95	1254	1278	1308	1337	1,92
40,0	7,23	1306	1331	1362	1393	1,96
41,0	7,59	1371	1397	1430	1462	2,00
42,0	7,94	1435	1462	1496	1531	2,04
43,0	8,46	1530	1559	1596	1632	2,12
44,0	8,78	1589	1619	1657	1695	2,16
45,0	9,14	1654	1685	1725	1764	2,20
46,0	9,53	1724	1757	1798	1839	2,24
47,0	10,05	1819	1853	1897	1940	2,32
48,0	10,44	1891	1927	1972	2017	2,36
49,0	10,94	1979	2017	2064	2111	2,40
50,0	11,20	2027	2066	2114	2163	2,44
51,0	11,85	2146	2187	2238	2289	2,50
52,0	12,32	2232	2274	2327	2380	2,55
53,0	12,69	2300	2344	2398	2453	2,60
54,0	13,20	2392	2438	2495	2552	2,65
55,0	13,66	2478	2525	2585	2644	2,70
56,0	14,10	2558	2607	2668	2729	2,75
57,0	14,63	2653	2704	2767	—	2,80
58,0	15,32	2780	2833	2899	—	2,85
59,0	15,81	2871	2926	2994	—	2,90
60,0	16,31	2962	3018	—	—	2,95
61,0	16,92	3073	3132	—	—	3,00
62,0	17,44	3170	3231	—	—	3,05
63,0	18,02	3274	3337	—	—	3,10
64,0	18,56	3375	3439	—	—	3,15

Note: Not available in galvanised finish.

Round Strand Non-Spin Stage Ropes

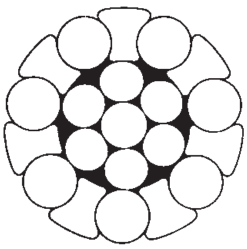
18 Strand non-spin
12x19(9/9/1)/6x19(9/9/1)/WMC



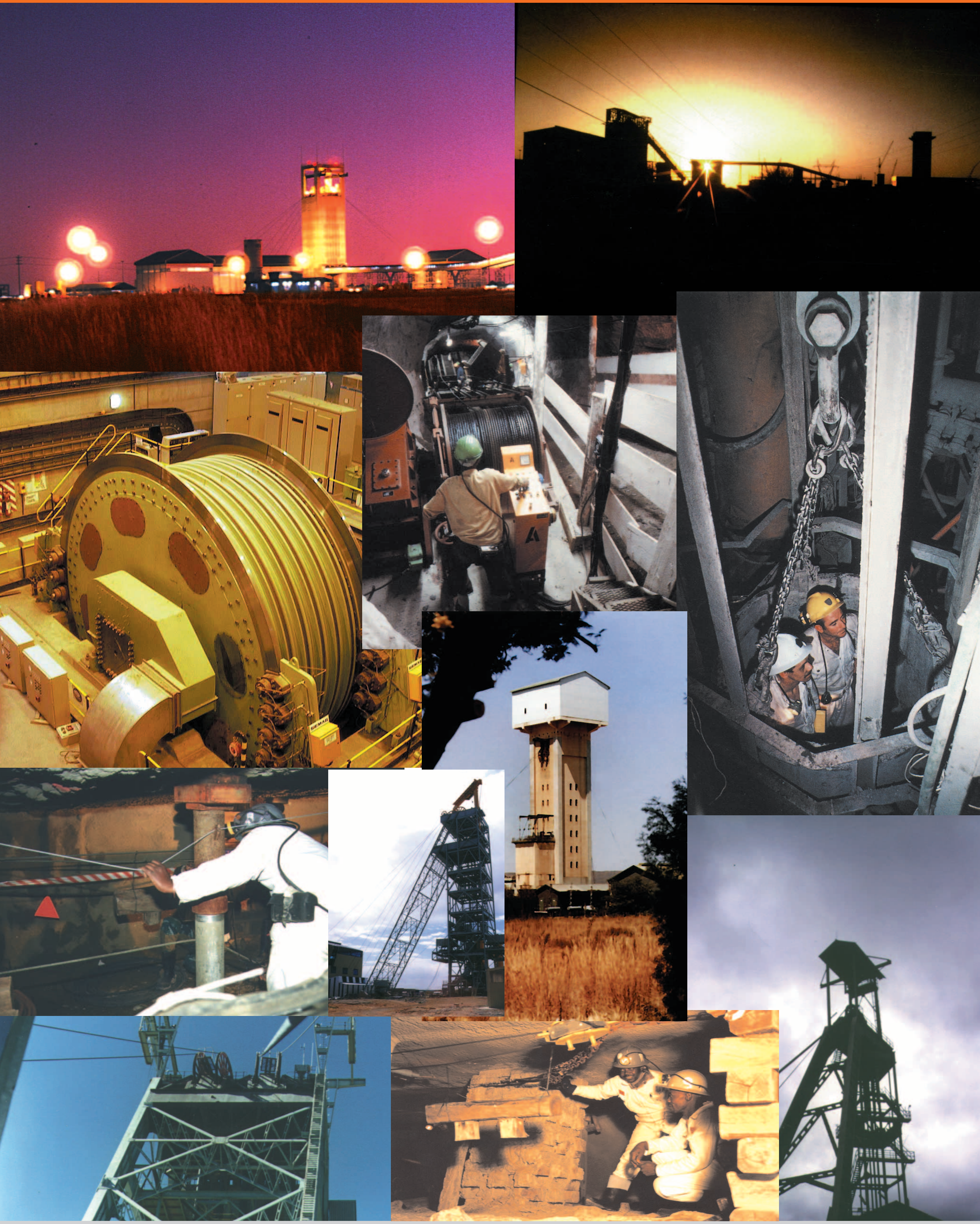
Nominal Rope Diameter (mm)	Estimated Mass (kg/m)	Estimated Breaking Force (kN)				Outer Wire Diameter (mm)
		1900 MPa	1960 MPa	2000 MPa	2050 MPa	
30,0	4,02	681	702	716	734	1,44
31,0	4,30	729	751	766	785	1,48
32,0	4,68	793	818	834	854	1,56
33,0	4,87	825	850	867	888	1,60
34,0	5,16	873	900	918	940	1,64
35,0	5,48	930	958	977	1001	1,68
36,0	5,77	978	1008	1028	1053	1,72
37,0	6,12	1038	1070	1091	1118	1,80
38,0	6,44	1093	1127	1149	1177	1,84
39,0	6,80	1154	1189	1213	1242	1,88
40,0	7,13	1212	1249	1273	1304	1,92
41,0	7,47	1270	1309	1335	1367	1,96
42,0	7,95	1352	1394	1421	1456	2,04
43,0	8,27	1408	1451	1479	1515	2,08
44,0	8,68	1477	1522	1553	1590	2,12
45,0	8,95	1525	1571	1602	1641	2,16
46,0	9,40	1602	1651	1684	1725	2,20

Guide Ropes

Half locked coil guide ropes



Nominal Rope Diameter (mm)	Con-struction	Estimated Mass (kg/m)	Estimated Breaking Force (kN)	Altitude of Rail Wire (mm)
			1400MPa	
32,0	1 x 23	5,86	873	6,35
35,0	1 x 23	7,08	974	7,11
38,0	1 x 25	7,87	1081	7,11
40,0	1 x 37	9,18	1274	7,11
45,0	1 x 41	10,89	1511	7,11
48,0	1 x 43	12,58	1751	7,11
52,0	1 x 43	14,74	2079	7,11



Scaw Metals Group

Lower Germiston Road, Heriotdale, Johannesburg, Gauteng, South Africa

Tel: +27 11 620 0251 • Fax: +27 11 620 0260 • E-mail: info@scaw.co.za • www.scaw.co.za

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