Properties of Extension of Steel Wire Ropes

Any assembly of steel wires spun into a helical formation either as a strand or wire rope, when subjected to a tensile load, can extend in three separate phases, depending on the magnitude of the applied load.

There are also other factors which produce rope extension which are very small and can normally be ignored.

Phase 1 - Initial or Permanent Constructional Extension

At the commencement of loading a new rope, extension is created by the bedding down of the assembled wires with a corresponding reduction in overall diameter. This reduction in diameter creates an excess length of wire which is accommodated by a lengthening of the helical lay. When sufficiently large bearing areas have been generated on adjacent wires to withstand the circumferential compressive loads, this mechanically created extension ceases and the extension in Phase 2 commences. The Initial Extension of any rope cannot be accurately determined by calculation and has no elastic properties.

The practical value of this characteristic depends upon many factors, the most important being the type and construction of rope, the range of loads and the number and frequency of the cycles of operation. It is not possible to quote exact values for the various constructions of rope in use, but the following approximate values may be employed to give reasonably accurate results.

	% of rope length	
	Fibre Core	Steel Core
Lightly loaded Factor of safety about 8:1	0.25	0.125
Normally loaded Factor of safety about 5:1	0.50	0.25
Heavily loaded Factor of safety about 3:1	0.75	0.50
Heavily loaded with many bends and/or deflections	Up to 2.00	Up to 1.00

The above figures are for guidance purposes. More precise figures are available upon request.

Phase 2 - Elastic Extension

Following Phase 1, the rope extends in a manner which complies approximately with Hookes Law (stress is proportional to strain) until the Limit of Proportionality or Elastic Limit is reached.

It is important to note that wire ropes do not possess a Young's Modulus of Elasticity, but an 'apparent' Modulus of Elasticity can be determined between two fixed loads.

The Modulus of Elasticity also varies with different rope constructions, but generally increases as the cross-sectional area of steel increases. By using the values given, it is possible to make a reasonable estimate of elastic extension, but if greater accuracy is required it is advisable to carry out a modulus test on an actual sample of the rope.

Elastic Extension $= \frac{WL}{EA}$ *(mm)*

W = load applied (kN)
L = rope length (mm)
E = elastic modulus (kN/mm²)
A = metallic cross section (mm²)

Phase 3 - Permanent Extension

The permanent, non-elastic extension of the steel caused by tensile loads exceeding the yield point of the material.

If the load exceeds the Limit of Proportionality, the rate of extension will accelerate as the load is increased, until a loading is reached at which continuous extension will commence, causing the wire rope to fracture without any further increase of load.

Thermal Expansion and Contraction

The coefficient of linear expansion ($\propto$) of steel wire rope is 0.0000125 = (12.5 x10^{-6}) per °C and therefore the change in length of 1 metre of rope produced by a temperature change of t °C would be;

Change in length $\Delta l = \propto l_o t$
where:
$\propto$ *= coefficient of linear expansion*
l_o *= original length of rope (m)*
t *= temperature change (°C)*

The change will be an increase in length if the temperature rises and a decrease in length if the temperature falls.

Extension due to Rotation

The elongation caused by a free rope end being allowed to rotate.

Extension due to Wear

The elongation due to inter-wire wear which reduces the cross-sectional area of steel and produces extra constructional extension.

Example: What will be the total elongation of a 200 metre length of 28mm diameter Blue Strand 6x36 wire rope at a tension of 55.8 kN and with an increase in temperature of 20°C.

Permanent Constructional Extension = 0.25% of rope length = 500mm

Elastic Extension $= \frac{WL}{EA} = \frac{55.8 \times 200{,}000}{105 \times 361} = 294.4mm$

Thermal Expansion $= \Delta l = \propto l_o t = 0.0000125 \times 200{,}000 \times 20 = 50mm$
Therefore total extension = 500 + 294 + 50 = 844mm

Pressures between Ropes and Sheaves or Drums

In addition to bending stresses experienced by wire ropes operating over sheaves or pulleys, ropes are also subjected to radial pressure as they make contact with the sheave. This pressure sets up shearing stresses in the wires, distorts the rope's structure and affects the rate of wear of the sheave grooves. When a rope passes over a sheave, the load on the sheave results from the tension in the rope and the angle of rope contact. It is independent of the diameter of the sheave.

$$\text{Load on bearing} = 2T \sin\frac{\theta}{2}$$

Assuming that the rope is supported in a well fitting groove, then the pressure between the rope and the groove is dependent upon the rope tension and diameter but is independent of the arc of contact.

$$\text{Pressure, } P = \frac{2T}{Dd}$$

P = *pressure (kg/cm²)*
T = *rope tension (kg)*
D = *diameter of sheave or drum (cm)*
d = *diameter of rope (cm)*

Maximum Permissible Pressures

Number of outer wires in strands	Groove material		
	Cast iron kgf/cm²	Low carbon cast steel kgf/cm²	11 to 13% Mn steel or equivalent alloy steels kgf/cm²
5 - 8 Ordinary lay	20	40	105
5 - 8 Lang's lay	25	45	120
9 - 13 Ordinary lay	35	60	175
9 - 13 Lang's lay	40	70	200
14 - 18 Ordinary lay	42	75	210
14 - 18 Lang's lay	47	85	240
Triangular strand	55	100	280

It should be emphasised that this method of estimation of pressure assumes that the area of contact of the rope in the groove is on the full rope diameter, whereas in fact only the crowns of the outer wires are actually in contact with the groove. The local pressures at these contact points may be as high as 5 times those calculated and therefore the values given above cannot be related to the compressive strength of the groove material.

If the pressure is high, the compressive strength of the material in the groove may be insufficient to prevent excessive wear and indentation and this in turn will damage the outer wires of the rope and effect its working life. As with bending stresses, stresses due to radial pressure increase as the diameter of the sheave decreases. Although high bending stresses generally call for the use of flexible rope constructions having relatively small diameter outer wires, these have less ability to withstand heavy pressures than do the larger wires in the less flexible constructions. If the calculated pressures are too high for the particular material chosen for the sheaves or drums or indentations are being experienced, consideration should be given to an increase in sheave or drum diameter. Such a modification would not only reduce the groove pressure, but would also improve the fatigue life of the rope.

The pressure of the rope against the sheave also cause distortion and flattening of the rope structure. This can be controlled by using sheaves with the correct groove profile which, for general purposes, suggests an optimum groove radius of nominal rope radius +7.5%. The profile at the bottom of the groove should be circular over an angle of approximately 120°, and the angle of flare between the sides of the sheave should be approximately 52°.

Hardness of Rope Wire

Rope grade	Approximate Equivalent	Approximate Hardness	
Min. Tensile Strength	API 9A Grade	Brinel	Rockwell 'C'
2160N / mm²	EEIPS	480 / 500	52
1960N / mm²	EIPS	470 / 480	51
1770N / mm²	IPS	445 / 470	49
1570N / mm²	PS	405 / 425	45

Suggested pulley hardness: 250-300 Brinell for Mn steel or equivalent alloy steel.

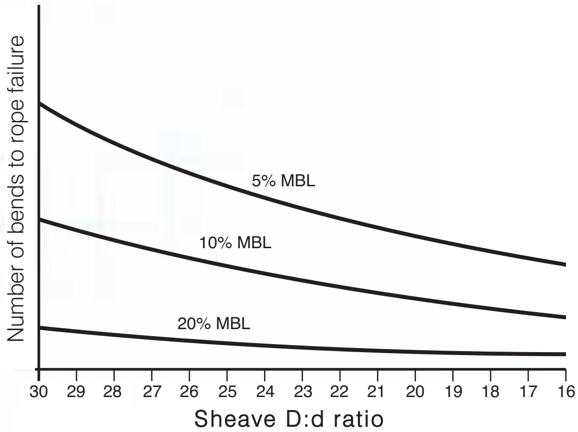
If the calculated pressure is too high for the particular material chosen for the pulley or drum, consideration should be given to increase in pulley or drum diameter. Such a modification would not only reduce the groove pressure, but would also improve the fatigue life of the rope by reducing the bending stresses imposed.

Bend Fatigue

Bend fatigue testing of ropes usually consists of cycling a length of rope over a sheave while the rope is under a constant tension and as part of its ongoing development programme Bridon has tested literally thousands of ropes in this manner over the years on its in-house own design bend testing equipment.

Through this work, Bridon has been able to compare the effects of rope construction, tensile strength, lay direction, sheave size, groove profile and tensile loading on bend fatigue performance under ideal operating conditions. At the same time it has been possible to compare rope life to discard criteria (e.g. as laid down in ISO 4309) with that to complete failure of the rope, i.e. to the point where the rope has been unable to sustain the load any longer. As part of the exercise, it has also been possible to establish the residual breaking strength of the rope at discard level of deterioration.

Effects of D:d Ratio and loading on fatigue life - Typical example Dyform 6

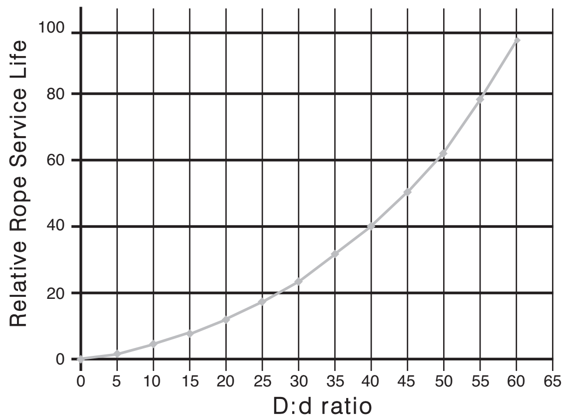


What needs to be recognised, however, is that very few ropes operate under these controlled operating conditions, making it very difficult to use this base information when attempting to predict rope life under other conditions. Other influencing factors, such as dynamic loading, differential loads in the cycle, fleet angle, reeving arrangement, type of coiling on the drum, change in rope direction, sheave alignment, sheave size and groove profile, can have an equally dramatic effect on rope performance.

However, the benefit of such testing can be particularly helpful to the rope manufacturer when developing new or improving existing products.

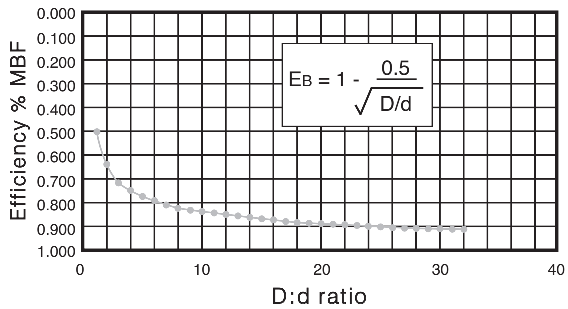
If designers or operators of equipment are seeking optimum rope performance or regard bending fatigue life as a key factor in the operation of equipment, such information can be provided by Bridon for guidance purposes.

Service life curve for various D:d ratios



When considering the use of a steel wire rope around a minimum D:d ratio, it is generally accepted that at below 4:1 the effect on the strength of the rope needs to be considered. Permanent distortions within the rope will occur when using ratios of 10:1 and less and that a minimum ratio of 16:1 be used for a rope operating around sheaves.

Approximate loss in breaking strength due to bending



Swivels

Rotating loads can put at risk the safety of those persons within a lifting zone during a lifting operation.

In order to reduce the risk of rotation the machinery designer or user may find it may be necessary to incorporate a swivel in the reeving system; however, it should be recognised that excessive rotation could have an adverse effect on rope performance depending on the rope's rotational characteristics.

To assist the machinery designer or user in determining whether or not a swivel should be used in a lifting system, the following guidance, taking into account the rope type, construction and lay type and direction, is given.
For simplicity, the ropes are grouped according to their rotational characteristics.

Note 1: *A swivel should not be used when installing a rope.*

Note 2: *Further guidance on the use of swivels with six strand and rotation-resistant ropes is given in ISO 4308 'Cranes and lifting appliances - selection of wire ropes - part 1 General'.*

Note 3: *Swivels have varying degrees of efficiency and may be either an independent accessory or an integral part of a lifting accessory such as a crane hook.*

Group 1

Both sets of ropes in this group have high values of rotation when loaded and must not be used unless both ends of the rope are fixed and prevented from rotating however **they must NOT be used with a swivel, under any circumstances.**

DO NOT USE A SWIVEL

Group 1a: Single layer ropes Lang's lay	Group 1b: Parallel-closed ropes Lang's and Ordinary (Regular) lay
Blue Strand 6x19 Lang's lay Blue Strand 6x36 Lang's lay Endurance 8 Lang's lay Endurance 8PI Lang's lay Endurance Dyform 8 Lang's lay Endurance Dyform 8PI Lang's lay Endurance Dyform 6 Lang's lay Endurance Dyform 6PI Lang's lay	Endurance DSC 8 Endurance Dyform DSC 8

Group 2

With one end free to rotate, all of the ropes in this group will generate less rotation when loaded than those listed in Group 1. However, such ropes are still likely to unlay and distort under this condition.

When used in single part reeving they may require a swivel to prevent rotation in certain operating conditions but this should only apply when employee safety is an issue.

Group 2: Single layer ropes Ordinary (Regular) lay	
Blue Strand 6x19 Ordinary lay Blue Strand 6x36 Ordinary lay Endurance 8 Ordinary lay Endurance Dyform 6 Ordinary lay Endurance Dyform 6PI Ordinary lay	Endurance Dyform 8 Ordinary lay Endurance 8PI Ordinary lay Endurance Dyform 8PI Ordinary lay Endurance 6FS Ordinary lay Endurance Dyform 6FS Ordinary lay

Swivels

Group 3

The ropes in this group incorporate a centre which is laid in the opposite direction to that of the outer strands and are specifically designed to have a medium amount of resistance to rotation.

If it is necessary to use a swivel with any of these ropes in single part reeving to prevent rotation of the load, the rope should operate within the normal design factor of 5, not be subject to any shock loading and be checked daily for any evidence of distortion.

Where any of these ropes are used in multi-part reeving, the use of an anti-friction swivel at the outboard anchor point is not recommended. However, a swivel which can be locked may be useful when optimising the reeving, following rope installation or after subsequent changes to the reeving arrangement.

It should be noted that if a swivel is used in conjunction with these ropes, the bending fatigue life may be reduced due to increased internal deterioration between the outer strands and the underlying layer.

Group 3: Rotation-resistant ropes Lang's and Ordinary (Regular) lay		
Endurance 18	Endurance Dyform 18	Endurance 18PI

Group 4

The ropes in this group are designed to have extremely low levels of rotation when loaded and, if necessary, may operate with a swivel in both single and multi-part reeving systems.

Any induced rotation which might normally result from any fleet angle or loads cycle effect would be expected to be relieved when the rope is used with a swivel.

Testing has also shown that when used with a swivel at normal design factor of 5 and zero fleet angle, no reduction in either rope breaking force or bending fatigue life would be expected.

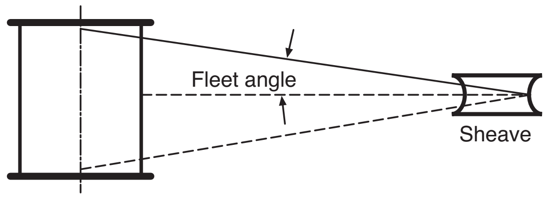
Group 4: Low rotation ropes		
Endurance 35LS	Endurance Dyform 34LR	Endurance Dyform 34LRPI

Fleet Angle

Of all the factors which have some influence on the winding of a rope on a smooth drum, the fleet angle, arguably, has the greatest effect.

Fleet angle is usually defined as the included angle between two lines, one which extends from a fixed sheave to the flange of a drum and the other which extends from the same fixed sheave to the drum in a line perpendicular to the axis of the drum. (See illustration).

Illustration of Fleet Angle



If the drum incorporates helical grooving, the helix angle of the groove needs to be added or subtracted from the fleet angle as described above to determine the actual fleet angle experienced by the rope.

At the drum

When spooling rope onto a drum it is generally recommended that the fleet angle is limited to between 0.5^{O} and 2.5^{O}. If the fleet angle is too small, i.e. less than 0.5^{O}, the rope will tend to pile up at the drum flange and fail to return across the drum. In this situation, the problem may be alleviated by introducing a 'kicker' device or by increasing the fleet angle through the introduction of a sheave or spooling mechanism.

If the rope is allowed to pile up it will eventually roll away from the flange creating a shock load in both the rope and the structure of the mechanism, an undesirable and unsafe operating condition.

Excessively high fleet angles will return the rope across the drum prematurely, creating gaps between wraps of rope close to the flanges as well as increasing the pressure on the rope at the cross-over positions.

Even where helical grooving is provided, large fleet angles will inevitably result in localised areas of mechanical damage as the wires 'pluck' against each other. This is often referred to as 'interference' but the amount can be reduced by selecting a Lang's lay rope if the reeving allows. The "interference" effect can also be reduced by employing a Dyform rope which offers a much smoother exterior surface than conventional rope constructions.

Floating sheaves or specially designed fleet angle compensating devices may also be employed to reduce the fleet angle effect.

At the sheave

Where a fleet angle exists as the rope enters a sheave, it initially makes contact with the sheave flange. As the rope continues to pass through the sheave it moves down the flange until it sits in the bottom of the groove. In doing so, even when under tension, the rope will actually roll as well as slide. As a result of the rolling action the rope is twisted, i.e. turn is induced into or out of the rope, either shortening or lengthening the lay length of the outer layer of strands. As the fleet angle increases so does the amount of twist.

To reduce the amount of twist to an acceptable level the fleet angle should be limited to 2.5^{O} for grooved drums and 1.5^{O} for plain drums and when using rotation-resistant low rotation and parallel-closed ropes the fleet angle should be limited to 1.5^{O}.

However, for some applications it is recognised that for practical reasons it is not always possible to comply with these general recommendations, in which case the rope life could be affected.

Rope Torque

The problem of torsional instability in hoist ropes would not exist if the ropes could be perfectly torque balanced under load. The torque generated in a wire rope under load is usually directly related to the applied load by a constant 'torque factor'. For a given rope construction the torque factor can be expressed as a proportion of the rope diameter and this has been done below..

Variation with rope construction is relatively small and hence the scope for dramatically changing the stability of a hoisting system is limited. Nevertheless the choice of the correct rope can have a deciding influence, especially in systems which are operating close to the critical limit. It should be noted that the rope torque referred to here is purely that due to tensile loading. No account is taken of the possible residual torque due, for example, to rope manufacture or installation procedures.

Torsional Stability

The torque factors quoted on page 45 are approximate maximum values for the particular constructions.
To calculate the torque value for a particular rope size multiply by the nominal rope diameter.
Example: for 20mm dia. Dyform 34LR Lang's Lay at 20% of minimum breaking force:-

Torque value = torque factor x rope dia.
= 1.8% x 20mm
= 0.36mm

To calculate the torque generated in a particular rope when subjected to a tensile load, multiply the load by the torque value and conbine the units.
Example:- For 20mm dia. Dyform 34LR Lang's Lay at 75kN:

Torque generated = torque value x load.
= 0.36 x 75
= 27Nm

Rope Torque

The torsional characteristics of wire rope will have the effect of causing angular displacement of a sheave block when used in multi-fall reeving arrangements.
The formula below gives a good approximation under such arrangements.

$$S^2 = \frac{4000L.\ T_v}{\sin\theta}$$

Where S is the rope spacing in mm

L is the length of each part in the reeving
T_v is the torque value of the rope
θ is the angular displacement of the sheave block

When the angular displacement of the sheave block exceeds 90^o ($\sin\theta = 1$) torsional instability results and 'cabling' of the reeving will occur. Therefore the test for stability of any particular reeving can be expressed as:

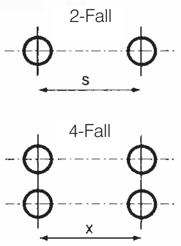
$$S > \sqrt{4\,000\ L.\ T_v}$$

Where S is the rope spacing in mm
L is length of each part in metres
T_v is torque value in mm

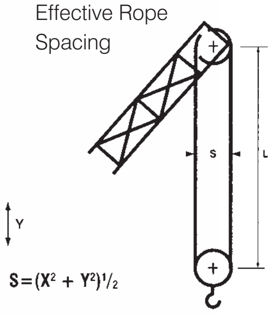
The preceding equations are all relative to a simple two part reeving. For more complex systems a similar approach may be used if account is taken of the different spacings of the ropes.

Even Number of Falls

Rope Plan



Effective Rope Spacing

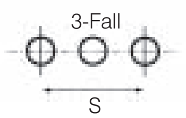


Note: For hoisting arrangements in which the rope falls are not parallel an average rope spacing should be used.

Uneven Number of Falls

(Rope Termination at Bottom Block)

Rope Plan



Effective Rope Spacing and modified formula for stable condition

Effective Rope Spacing S

Stable condition if

$$S > \sqrt{6\,000\ .\ L.\ T_v}$$

Angular displacement of block

To predict the amount of angular displacement by which a sheave block may turn under the influence of rope torque:

$$\sin\theta = \frac{(4\,000\ L.\ T_v)}{S^2}$$

(for even number of falls)

The equations assume that rope is torque-free in the no-load condition, therefore, induced torque during or immediately after installation will adversely influence the calculated effect.

The above data assumes a constant torque value which is a valid assumption for a new rope. Wear and usage can have a significant effect on the torque value but practical work shows that under such circumstances the torque value will diminish, thus improving the stability of the arrangement. Some arrangements may be of such complexity that the evaluation demands a computer study.

Examples:

Assuming a pedestal crane working on two falls is roped with 20mm diameter DYFORM 34LR and the bottom block carries a sheave of 360mm diameter with the falls parallel:

Torque value $= 1.8\% \times 20$
$= 0.36mm$

If the rope is new (worst condition) and no account is taken of block weight and friction then angular displacement for a height of lift of 30 metres is given by

$$\sin\theta = \frac{(4\,000\ .\ 30\ .\ 0.36)}{360^2}$$

$$= 0.333 \text{ i.e. } 19^o\ 47'$$

The reeving would be expected to 'cable' at a height of lift calculated as:

$$L = \frac{S^2}{4\,000\ .\ T_v}$$

$$= \frac{360^2}{4\,000\ .\ 0.36}$$

$$= 90 \text{ metres}$$

From the crane designer's viewpoint a safety factor against 'cabling' should be recognised (angular displacement limited at 30^o) hence the practical height of lift is approximately 45 metres.

Summary Technical Information and Conversion Factors

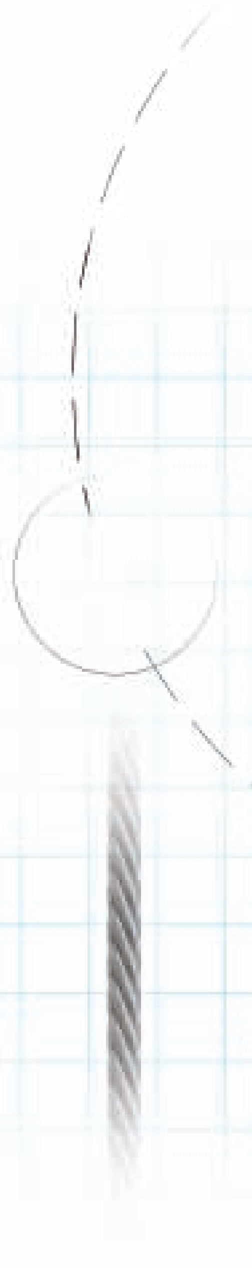
(For guidance purposes only)

Bridon supply a range of 'Endurance' High Performance steel wire ropes specifically designed and manufactured to meet the needs of today's cranes and the demanding applications to which they are exposed. High performance ropes are normally selected by customers when they require the specific characteristics of improved performance, high strength, low extension or low rotation.

Rope Construction	Fill Factor f ′ %	Nominal Metallic Area Factor C ′	Extension characteristics		Rotational characteristics			Nominal Rope Lay length mm
			Rope modulus at 20% of breaking force kN/mm²	Initial permanent extension %	Torque factor at 20% of breaking force %		Turn value at 20% of breaking force degrees/ rope lay	
					Ordinary	Lang's		
6 & 8 Strand High Performance								
Dyform 6 & 6-PI	67.0	0.526	103	0.1	6.9	10.9	60	6.5 x Nom. rope dia.
Dyform Bristar 6	66.0	0.518	103	0.1	6.9	10.9	60	6.5 x Nom. rope dia.
Endurance 8 & 8-PI	63.0	0.495	96	0.2	7.0	9.0	90	6.5 x Nom. rope dia.
Dyform 8 & 8-PI	68.0	0.534	100	0.15	7.0	9.0	90	6.5 x Nom. rope dia.
Dyform DSC 8	75.0	0.589	107	0.09	8.1	11.0	70	6.5 x Nom. rope dia.
Constructex	72.1	0.566	108	0.05	7	n/a	60	6.0 x Nom. rope dia.
Dyform Zebra	59.1	0.464	103	0.1	7	11	60	6.5 x Nom. rope dia.
Brifil 6x36 iwrc class	58.6	0.460	102	0.15	7	11	60	6.5 x Nom. rope dia.
Rotation Resistant								
Dyform 18 & 18-PI	71.0	0.558	95	0.1	3	4.5	4	6.25 x Nom. rope dia.
Endurance 50DB	63.0	0.495	97	0.24	n/a	3.6	3	6.5 x Nom. rope dia.
Low Rotation								
Dyform 34LR & 34LR-PI	74.0	0.581	99	0.05	0.8	1.8	0.7	6.0 x Nom. rope dia.
Endurance 35LS	63.9	0.502	102	0.1	0.8	1.8	0.7	6.0 x Nom. rope dia.
Conventional Constructions								
Blue Strand 6 x 19 iwrc class	57.2	0.449	103	0.15	7	9	50	6.5 x Nom. rope dia.
Blue Strand 6 x 36 iwrc class	58.6	0.460	104	0.17	7	9	60	6.5 x Nom. rope dia.

The figures shown in the above table are nominal values given for the product range and are for guidance purposes only, for specific values please contact Bridon.

The above modulus vales are based on the nominal rope metallic area



Guide to Examination

The continued safe operation of lifting equipment, lifting accessories (e.g. slings) and other systems employing wire rope depends to a large extent on the operation of well programmed periodic rope examinations and the assessment by the competent person of the fitness of the rope for further service.

Examination and discard of ropes by the competent person should be in accordance with the instructions given in the original equipment manufacturer's handbook. In addition, account should be taken of any local or application specific Regulations.

The competent person should also be familiar, as appropriate, with the latest versions of related International, European or National standards such as ISO 4309 "Cranes - Wire ropes - code of practice for examination.

Particular attention must be paid to those sections of rope which experience has shown to be liable to deterioration. Excessive wear, broken wires, distortions and corrosion are the more common visible signs of deterioration.

Note: This publication has been prepared as an aid for rope examination and should not be regarded as a substitute for the competent person.

Wear is a normal feature of rope service and the use of the correct rope construction ensures that it remains a secondary aspect of deterioration. Lubrication may help to reduce wear.

Broken wires are a normal feature of rope service towards the end of the rope's life, resulting from bending fatigue and wear. The local break up of wires may indicate some mechanical fault in the equipment. Correct lubrication in service will increase fatigue performance.

Distortions are usually as a result of mechanical damage, and if severe, can considerably affect rope strength.

Visible rusting indicates a lack of suitable lubrication, resulting in **corrosion**. Pitting of external wire surfaces becomes evident in some circumstances. Broken wires ultimately result.

Internal corrosion occurs in some environments when lubrication is inadequate or of an unsuitable type. Reduction in rope diameter will frequently guide the observer to this condition. Confirmation can only be made by opening the rope with clamps or the correct use of spike and needle to facilitate internal inspection.

Note: Non-destructive testing (NDT) using electromagnetic means may also be used to detect broken wires and/or loss in metallic area. This method complements the visual examination but does not replace it.

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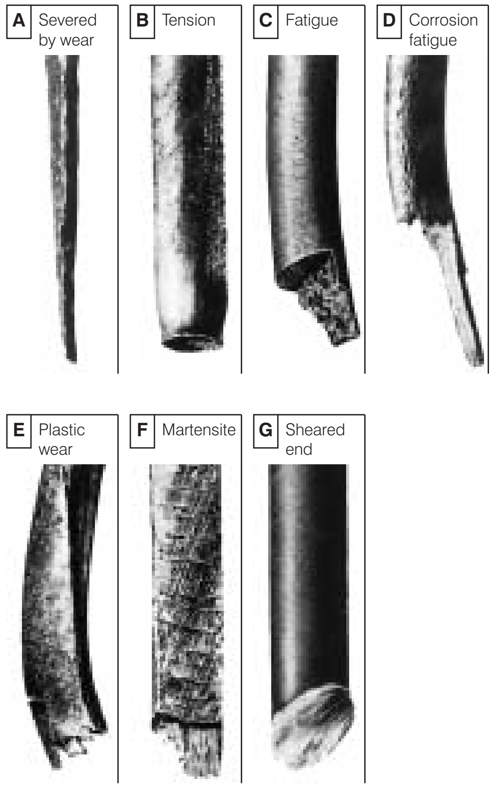
Some of the More Common Types of Wire Fractures Can Include:



Factors Affecting Rope Performance

Multi-coiling of the rope on the drum can result in severe distortion in the underlying layers.

Bad coiling (due to excessive fleet angles or slack winding) can result in mechanical damage, shown as severe crushing, and may cause shock loading during operation.

Small diameter sheaves can result in permanent set of the rope, and will certainly lead to early wire breaks due to fatigue.

Oversize grooves offer insufficient support to the rope leading to increased localised pressure, flattening of the rope and premature wire fractures. Grooves are deemed to be oversize when the groove diameter exceeds the nominal rope diameter by more than 15% steel, 20% polyurethane liners.

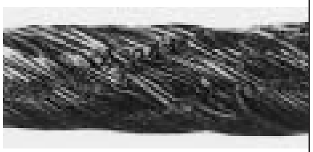
Undersize grooves in sheaves will crush and deform the rope, often leading to two clear patterns of wear and associated wire breaks.

Excessive angle of fleet can result in severe wear of the rope due to scrubbing against adjacent laps on the drum. Rope deterioration at the Termination may be exhibited in the form of broken wires. An excessive angle of fleet can also induce rotation causing torsional imbalance.

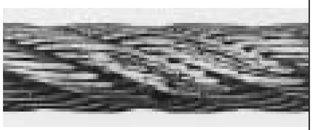
Troubleshooting Guide

Typical examples of Wire Rope deterioration

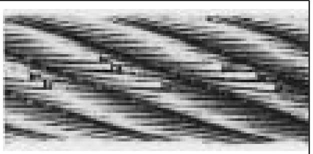
1 Mechanical damage due to rope movement over sharp edge projection whilst under load.



2 Localised wear due to abrasion on supporting structure.

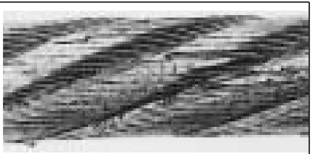


3 Narrow path of wear resulting in fatigue fractures, caused by working in a grossly oversize groove, or over small support rollers.

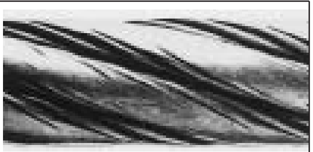


4 Two parallel paths of broken wires indicative of bending through an undersize groove in the sheave.

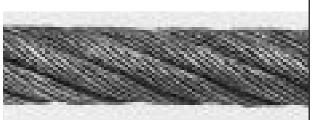
5 Severe wear, associated with high tread pressure.



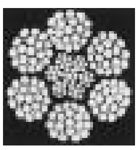
6 Severe wear in Lang's Lay, caused by abrasion.



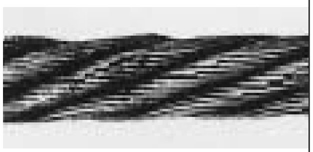
7 Severe corrosion.



8 Internal corrosion whilst external surface shows little evidence of deterioration.

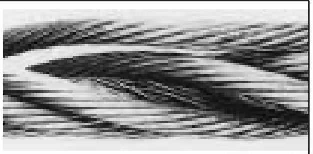


9 Typical wire fractures as a result of bend fatigue.



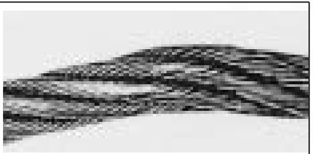
10 Wire fractures at the strand, or core interface, as distinct from 'crown' fractures.

11 Break up of IWRC resulting from high stress application.

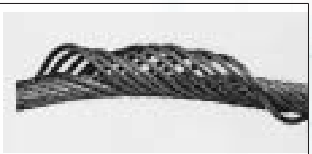


12 Looped wires as a result of torsional imbalance and/or shock loading.

13 Typical example of localised wear and deformation.

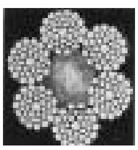


14 Multi strand rope 'bird caged' due to torsional imbalance.



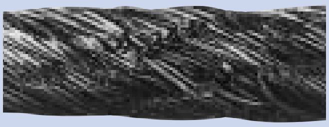
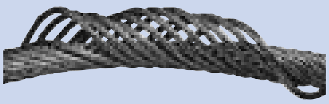
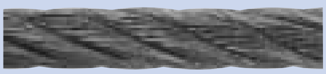
15 Protrusion of rope centre resulting from build up of turn.

16 Substantial wear and severe internal corrosion.

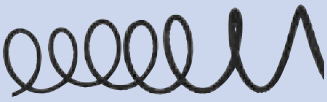
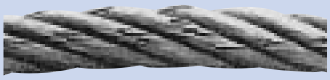
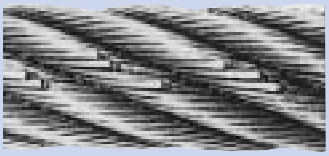
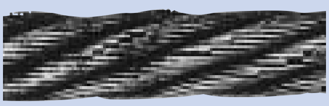
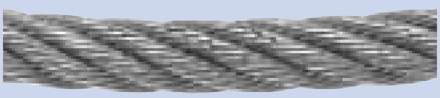


Troubleshooting Guide

The following is a simplified guide to common wire rope problems. More detailed advice can be obtained from any Bridon distributor. In the event of no other standard being applicable, Bridon recommends that ropes are inspected/examined in accordance with ISO 4309.

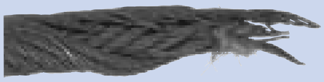
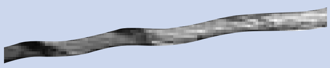
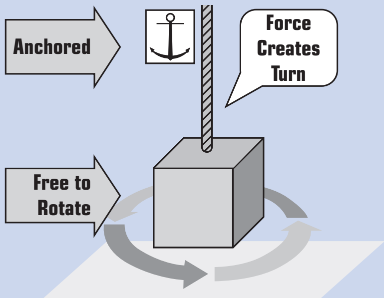
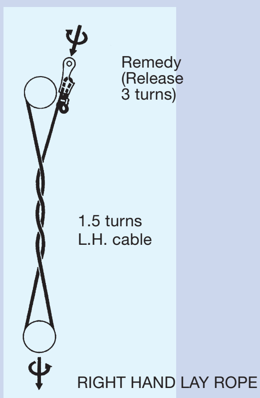
Problem	Cause/Action
Mechanical damage caused by the rope contacting the structure of the installation on which it is operating or an external structure - usually of a localised nature. 	• Generally results from operational conditions. • Check sheave guards and support/guide sheaves to ensure that the rope has not "jumped out" of the intended reeving system. • Review operating conditions.
Opening of strands in rotation resistant, low rotation and parallel closed ropes - in extreme circumstances the rope may develop a "birdcage distortion" or protrusion of inner strands. ***Note - rotation resistant and low rotation ropes are designed with a specific strand gap which may be apparent on delivery in an off tension condition. These gaps will close under load and will have no effect on the operational performance of the rope.*** 	• Check sheave and drum groove radii using sheave gauge to ensure that they are no smaller than nominal rope radius +5% - Bridon recommends that the sheave and drum groove radii are checked prior to any rope installation. • Repair or replace drum/sheaves if necessary. • Check fleet angles in the reeving system - a fleet angle in excess of 1.5 degrees may cause distortion (see page 43). • Check installation method - turn induced during installation can cause excessive rope rotation resulting in distortion (See pages 53 - 60). • Check if the rope has been cut "on site " prior to installation or cut to remove a damaged portion from the end of the rope. If so, was the correct cutting procedure used? Incorrect cutting of rotation resistant, low rotation and parallel closed ropes can cause distortion in operation (See page 57). • Rope may have experienced a shock load.
Broken wires or crushed or flattened rope on lower layers at crossover points in multi - layer coiling situations. Wire breaks usually resulting from crushing or abrasion. 	• Check tension on underlying layers. Bridon recommends an installation tension of between 2% and 10% of the minimum breaking force of the wire rope. Care should be taken to ensure that tension is retained in service. Insufficient tension will result in these lower layers being more prone to crushing damage. • Review wire rope construction. Dyform wire ropes are more resistant to crushing on underlying layers than conventional rope constructions. • Do not use more rope than necessary. • Check drum diameter. Insufficient bending ratio increases tread pressure.
Wires looping from strands. 	• Insufficient service dressing. • Consider alternative rope construction. • If wires are looping out of the rope underneath a crossover point, there may be insufficient tension on the lower wraps on the drum. • Check for areas of rope crushing or distortion.

Troubleshooting Guide

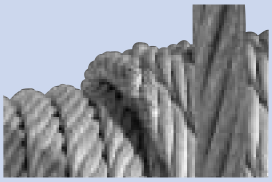
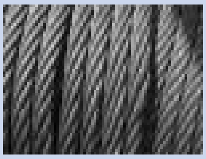
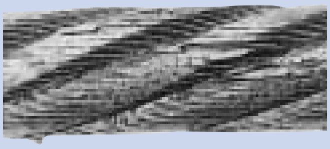
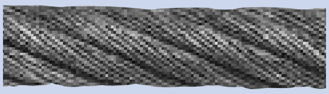
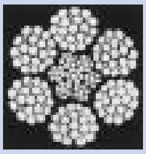
Problem	Cause/Action
"Pigtail" or severe spiralling in rope. 	• Check that the sheave and drum diameter is large enough - Bridon recommends a minimum ratio of the drum/sheave to nominal rope diameter of 18:1. • Indicates that the rope has run over a small radius or sharp edge. • Check to see if the rope has "jumped off" a sheave and has run over a shaft.
Two single axial lines of broken wires running along the length of the rope approximately 120 degrees apart indicating that the rope is being "nipped" in a tight sheave. 	• Check sheave and drum groove radii using sheave gauge to ensure that they are no smaller than nominal rope radius + 5% - Bridon would recommend that the sheave/drum groove radii are checked prior to any rope installation. • Repair or replace drum/sheaves if necessary.
One line of broken wires running along the length of the rope indicating insufficient support for the rope, generally caused by oversize sheave or drum grooving. 	• Check to see if the groove diameter is no greater than 15% greater than the nominal rope diameter. • Repair or replace drum/sheaves if necessary. • Check for contact damage.
Short rope life resulting from evenly/randomly distributed bend fatigue wire breaks caused by bending through the reeving system. Fatique induced wire breaks are characterised by flat ends on the broken wires. 	• Bending fatigue is accelerated as the load increases and as the bending radius decreases (see page 40). Consider whether either factor can be improved. • Check wire rope construction - Dyform ropes are capable of doubling the bending fatigue life of a conventional steel wire rope.
Short rope life resulting from localised bend fatigue wire breaks. Fatique induced wire breaks are characterised by flat ends on the broken wires. 	• Bending fatigue is accelerated as the load increases and as the bending radius decreases (see page 40). Consider whether either factor can be improved. • Check wire rope construction - Dyform ropes are capable of doubling the bending fatigue life of a conventional steel wire rope. • Localised fatigue breaks indicate continuous repetitive bends over a short length. Consider whether it is economic to periodically shorten the rope in order to move the rope through the system and progressively expose fresh rope to the severe bending zone. In order to facilitate this procedure it may be necessary to begin operating with a slightly longer length of rope.

Continued on next page

Troubleshooting Guide

Problem	Cause/Action
Broken rope - ropes are likely to break when subjected to substantial overload or misuse particularly when a rope has already been subjected to mechanical damage. Corrosion of the rope both internally and/or externally can also result in a significant loss in metallic area. The rope strength is reduced to a level where it is unable to sustain the normal working load. 	• Review operating conditions.
Wave or corkscrew deformations normally associated with multistrand ropes. 	• Check sheave and drum groove radii using sheave gauge to ensure that they are no smaller than nominal rope radius +5% - Bridon recommends that the sheave/drum groove radii are checked prior to any rope installation. • Repair or replace drum/sheaves if necessary. • Check fleet angles in the reeving system - a fleet angle in excess of 1.5 degrees may cause distortion (see page 43). • Check that rope end has been secured in accordance with manufacturers instructions (see page 57). • Check operating conditions for induced turn.
Rotation of the load in a single fall system. 	• Review rope selection. • Consider use of rotation resistant or low rotation rope.
Rotation of the load in a multi - fall system resulting in "cabling" of the rope falls. Possibly due to induced turn during installation or operation. 	• Review rope selection. • Consider use of rotation resistant or low rotation rope. • Review installation procedure (See pages 53 - 60) or operating procedures.

Troubleshooting Guide

Problem	Cause/Action
Core protrusion or broken core in single layer six or eight strand rope. 	• Caused by repetitive shock loading - review operating conditions.
Rope accumulating or "stacking" at drum flange - due to insufficient fleet angle. 	• Review drum design with original equipment manufacturer - consider adding rope kicker, fleeting sheave etc.
Sunken wraps of rope on the drum normally associated with insufficient support from lower layers of rope or grooving. 	• Check correct rope diameter. • If grooved drum check groove pitch. • Check tension on underlying layers - Bridon recommend an installation tension of between 2% and 10% of the minimum breaking force of the wire rope - Care should be taken to ensure that tension is retained in service. Insufficient tension will result in these lower layers being more prone to crushing damage. • Make sure that the correct rope length is being used. Too much rope (which may not be necessary) may aggravate the problem.
Short rope life induced by excessive wear and abrasion. 	• Check fleet angle to drum. • Check general alignment of sheaves in the reeving system. • Check that all sheaves are free to rotate. • Review rope selection. The smooth surface of Dyform wire ropes gives better contact with drum and sheaves and offers improved resistance to "interference" betweeen adjacent laps of rope.
External corrosion. 	• Consider selection of galvanised rope. • Review level and type of service dressing.
Internal corrosion. 	• Consider selection of galvanised rope. • Review frequency amount and type of service dressing. • Consider selection of plastic impregnated (PI) wire rope.