IS 3973 (1984): Code of practice for the selection, installation and maintenance of wire ropes [MED 10: Wire Ropes and Wire Products]

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Indian Standard

CODE OF PRACTICE FOR THE SELECTION, INSTALLATION AND MAINTENANCE OF WIRE ROPES

(First Revision)

UDC 677·72 005·006·76

BUREAU OF INDIAN STANDARDS
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Gr 10

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Indian Standard

CODE OF PRACTICE FOR THE SELECTION, INSTALLATION AND MAINTENANCE OF WIRE ROPES

(First Revision)

1. Scope — Relates to the selection, installation, maintenance and usage of common types of wound strand wire ropes.

Note — It is not intended that this code of practice be preferred to the statutory rules and regulations wherever they exist. It is intended only as a guide for the convenience of the rope user in proper selection, installation and maintenance of wire ropes.

2. Terminology — For the purpose of this standard, the definitions given in IS : 2363-1965 'Glossary of terms relating to wire ropes' shall apply.

3. Information Helpful in Selecting a Wire Rope

3.1 *Ordering a Wire Rope* — The five principal characteristics are required to be described while specifying a wire rope. These are:

a) dimensions,
b) rope construction,
c) grade,
d) galvanized or ungalvanized, and
e) core and lay.

Appendix A lists the information to be given with the enquiry or order.

3.1.1 *Dimensions* — The dimensions to be specified in ordering wire rope include not only the length but also the diameter of the wire rope.

3.1.1.1 *Length* — The length to be ordered is dependent on the requirements of the service to which the wire rope is put specifying a reel of rope or a coil of rope is not sufficient as there are no standard length reels or coils for a wire rope. The required length should be specifically mentioned with the enquiry or order.

3.1.1.2 *Diameter* — The diameter of the wire rope is that of the smallest circle enclosing it. The diameter shall be measured over each pair of opposite strands at each of three places at least 1 m apart with a suitable device, such as a rope caliper as shown in Fig. 1A. Care should be taken to avoid getting an incorrect measurement as shown in Fig. 1B where measurement has been obtained over two pairs of opposite strands instead of one pair.

The actual diameter of a new rope is usually slightly larger than the nominal diameter.

3.1.2 *Rope construction* — A wire rope is made up of strands and a strand is made up of one or more layers of wires (*see* Fig. 2). The rope construction refers to the number and arrangement of strands and wires and the type of core used, and it is the means of adopting the rope to the particular work that will be required of it. Appendix B gives details of rope construction designation. Typical examples to designate wire rope construction have been given in Table 4.

3.1.2.1 *Number of strands* — The number of strands denotes the number of groups of wires that are laid over the central core. Most wire ropes are composed of 6 strands although the number varies depending upon the particular application.

3.1.2.2 *Number of wires in the strand* — The number of wires in the strand is generally 7, 19 or 37.

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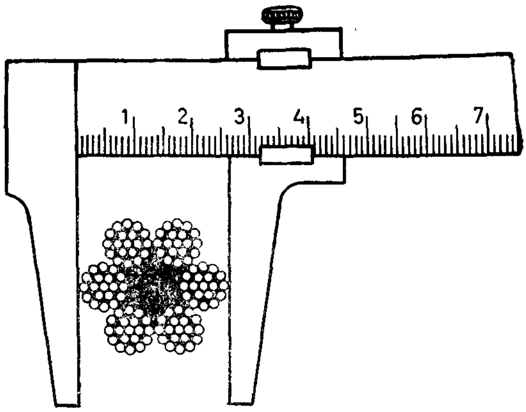
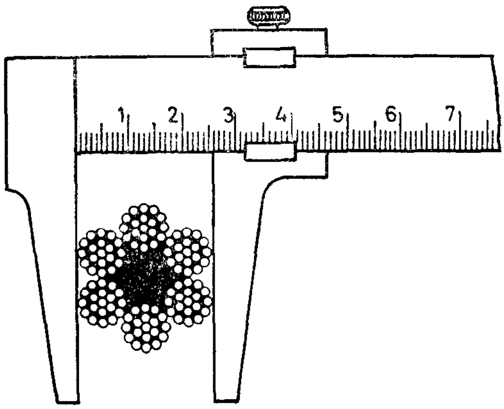


1A CORRECT



1B INCORRECT

FIG. 1 MEASURING OF DIAMETER OF WIRE ROPE

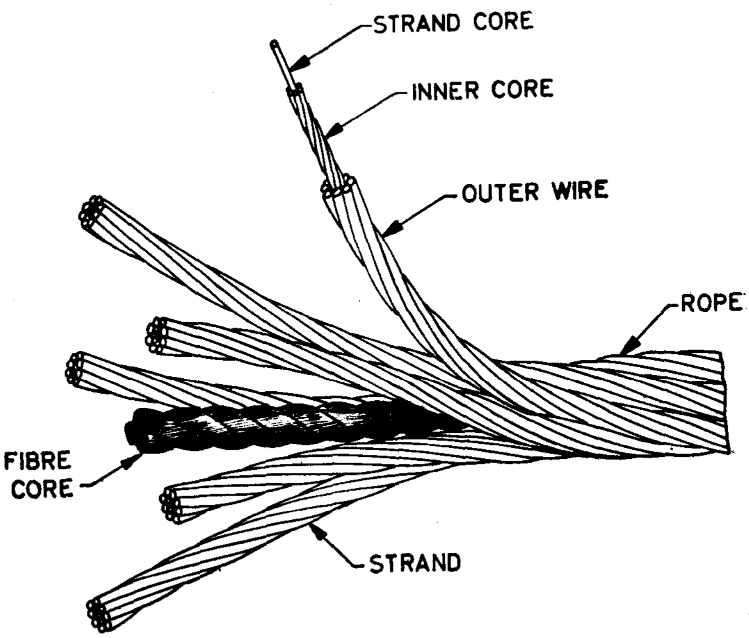


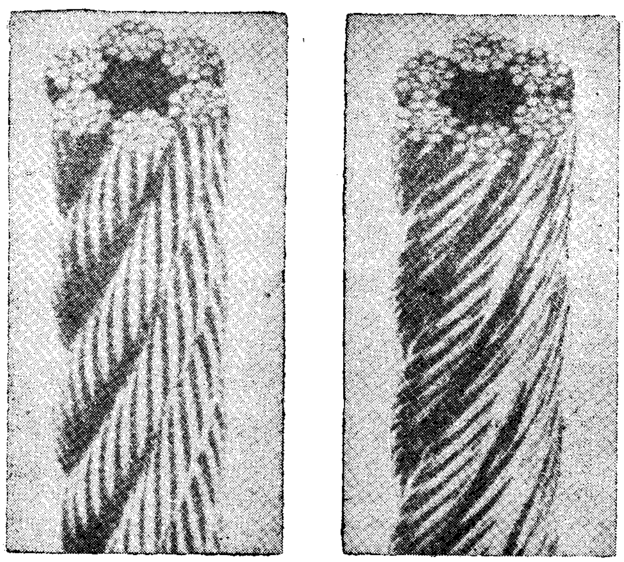
FIG. 2 CONSTRUCTION OF WIRE ROPE

3.1.2.3 *Arrangement of wires in the strand* — The arrangement of wires, also called strand construction, refers to the grouping of the various sizes of wires used in the strand. Wires may be arranged in the strand in various ways to meet certain conditions. Basically, there are two strand constructions or arrangements of wires, namely, equal laid or parallel laid construction and the cross laid construction.

a) *'Equal laid' or 'parallel laid' construction* — In the equal laid construction, all the wires making up the strand are laid in one operation, with the result that each covering layer of wires has the same length of lay or pitch as the underlaying layer, thereby eliminating any crossing of the wires in the strand. The various types of equal lay are sometimes called, Seale Lay, Filler Seale Lay and Warrington Lay, depending upon the relative numbers and sizes of wires in the layers. The greatest advantage of this type of construction is that the wires are continuously supported by being in continuous contact with other wires and, therefore, are not so liable to fail in fatigue due to secondary bending. Another advantage is the avoidance of nicking between crossing wires. However, this lay is less flexible than cross lay because it is more compact. Also there are less spaces left for lubricant because of its compactness with the result that under the same conditions of service, internal corrosion is rather more likely to occur.

b) *Gross laid construction* — All the wires in a strand are more or less of the same diameter. The wires of each covering layer have a longer lay than the underlaying layer of wires with the result that wires in a covering layer, although spiralling in the same direction as the wires in the underlaying layer will repeatedly cross over the inner wires.

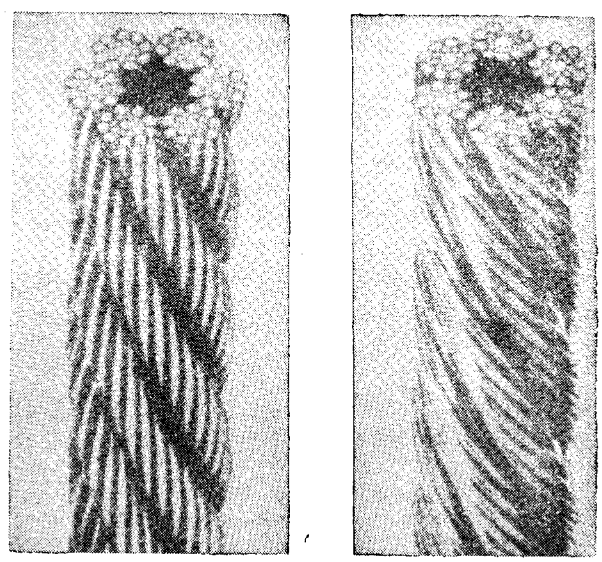
3.1.2.4 *Rope lay* — This refers to the manner in which wires are helically laid into strands and strands into rope. If in the rope, the strands coil in the same direction as a right-hand screw thread then the rope is said to be of the right-hand lay, also called the *Z* lay. If the strands coil around the rope in the same direction as a left-hand screw thread then the rope is said to be of left-hand or *S* lay. If the wires in a strand coil in the same direction as the strand, then the rope is a Lang's lay and if the coil in the opposite direction to that of the strand then the rope is in regular or ordinary lay. Thus a rope can be either "right-hand Lang's lay or left-hand Lang's lay" (right-hand regular lay or left-hand reguler lay) (*see* Fig. 3). When the kind of lay wanted is not mentionod in the order it is customary to supply regular lay and when the direction of lay is not mentioned, right-hand lay is always supplied. Thus, if information regarding lay is omitted altogether, it is customary to supply right-hand regular lay.



Ordinary Lay-Wires in Strand Spiral to Left

Lang's Lay-Wires in Strand Spiral to Right

FIG. 3A RIGHT-HAND (*Z*) LAY, STRAND IN ROPE SPIRAL UPWARDS TO THE RIGHT



Ordinary Lay-Wires in Strand Spiral to Right

Lang's Lay-Wires in Strand Spiral to Left

FIG. 3B LEFT-HAND (*S*) LAY, STRANDS IN ROPE SPIRAL UPWARDS TO THE LEFT

3.1.2.5 *Preformed or non-preformed* — The wires or strands or both in a rope may be pre-shaped to conform to the helical shape which they take in the finished rope so as to make them lie dead in the rope without any tendency to unlay themselves while the rope is in the unloaded condition. In this case the wire rope is said to be preformed. It is recognizable as a rope which remains more limp and neutral than an ordinary rope, and in which the strands or wires will not untwist or fly apart when the rope is cut without being siezed at the ends.

3.1.2.6 *Core* — The central part of a wire rope or a strand is called the core of rope or strand core respectively. This may be of fibre, wire or synthetic material. When no mention is made of the type of core in the order for wire rope, a fibre core is always used for the rope and wire core for the strand.

a) *Fibre cores* — Fibre cores are made of vegetable fibre ropes, namely, sisal, jute, hemp, phormium or cotton. The fibre core is very flexible and very suitable for all conditions except those in which the rope is subjected to severe crushing (working under high load on very small pulleys and drums, coiling on top of itself on numerous layers on a drum, etc). Jute and cotton cores are not permitted in man riding ropes and cotton fibre ropes are used as fibre cores only in small diameter wire ropes.

b) *Wire cores* — The main core of a stranded rope may also be of a single straight strand of fairly soft wires (wire main core or WMC also called wire strand core or WSC) or even a small wire rope made up of strands of very small wires (independent wire rope core or IWRC). The wires of the core are generally of lower tensile strength than those of the strand to obviate the possibility of the wire cores indenting the wire ropes. Wire cores are specified where the wire rope has to strand severe heat or crushing conditions. The rope with the independent wire rope core is more flexible than rope with a wire main core and is only slightly less flexible than a rope with a fibre core.

c) *Plastic cores* — Plastic cores are also used in the case of special purpose wire ropes. It may be a plastic impregnated fibre core, plastic covered fibre core or a solid plastic core. In a plastic impregnated fibre core, the individual fibres of the core (generally sisal fibre) are impregnated with PVC during the fabrication of the fibre core. The plastic covered fibre core is essentially a sisal fibre core over which a specified thickness of PVC has been extruded. Solid plastic cores are PVC rods of specified hardness.

3.1.3 *Grade* — Ropes are classified according to the tensile strength of the wire which is used in the manufacture of the rope and according to the finish of the wire.

3.1.3.1 *Tensile grade* — The following ranges of tensile strength for the wires used in the wire rope construction are specified in IS : 1835-1976 'Specification for steel wire for ropes (*third revision*)'.

Tensile Designation	*Tensile Strength Range* N/mm²
1 230	1 230 to 1620
1 420	1 420 to 1810
1 570	1 570 to 1960
1 770	1 770 to 2150
1 960	1 960 to 2340

Note — The tensile range depends on the wire diameter. The values given in the table correspond to the tensile range for wire below 0·5 mm. For coarser wire the range is narrower.

The wires used for making the wire rope should be selected from within one of these ranges taking into account the service conditions under which the rope has to operate. A wire of higher tensile strength is of course stronger than wire of the lower tensile range but it is also rather more sensitive than wire of lower tensile range to the effects of any service irregularities which may be present or which may appear in service, such as scratches on the wire surface.

3.1.3.2 *Finish* — The rope may be made from galvanized wire or bright wire. In the case of galvanized wire, it may be supplied with one of the recognized types of finish, that is, Type A, AB or B conforming to IS : 1837-1976 'Round steel wire for ropes (*third revision*)'. Type B wires have a lighter zinc coating but are required to comply with higher mechanical properties than wires of Type A.

3.2 *Choice of a Wire Rope*

3.2.1 Wire ropes have to meet the following requirements to various extent. Before deciding on the construction of a rope or before making a change in the present construction, these various conditions should be carefully weighed to determine whether one particular factor should be favoured above others:

a) strength,
b) abrasion resistance,
c) flexibility,
d) resistance to crushing,
e) fatigue or endurance strength, and
f) corrosion resistance.

3.2.2 *Tensile strength* — The tensile strength of a wire rope primarily depends on the tensile strength of the wire constituting a wire rope and the effective metal cross-sectional areas of the rope. Use of a wire core in the place of fibre rope increases the strength of the wire rope to a certain extent but decreases flexibility.

3.2.3 *Abrasion* – Where abrasion from the rope dragging through gritty material or across stationary objects is the governing factor, large outer wires in the strand are necessary, 6 × 7 construction offers the best abrasion resistance. Lang's lay ropes offer better resistance to abrasive wear than regular lay ropes.

3.2.4 *Flexibility* — Where sheaves are small or where the rope makes a great many bends in proportion to the wear present, a special flexible rope is called for. Flexibility increases with the number of outer wires for a given rope diameter. Lang's lay is slightly more flexible than regular lay and where it can be applied, it increases the life of a rope. Preforming enables the rope to stand more bending, thus giving the rope a better chance to withstand wear abuse where small sheaves are present. Wire strand cores result in ropes which are not as flexible as fibre core ropes. However, IWRC ropes are nearly as flexible as fibre-cored ones.

Note — Experiments with wire ropes coated with polyamide (nylon type) resins have shown that these coated ropes have a bending endurance strength nearly five to six times that of the uncoated rope. (*See* Addendum to the document 372/C.L.E. 8 issued by Association Des Industriels De Belgique, 29, Avenue Andre Drouart, Bruxelles 16).

3.2.5 *Resistance to crushing* — When a rope is subjected to over-winding on drums or to other abuses that tend to crush or distort the shape of the rope, a wire main core makes it more resistant to crushing than a rope with that of fibre core but unfortunately it also makes it less flexible. An independent wire rope core makes the rope resistant to crushing without greatly reducing its flexibility. A construction which employs much oversize wires also helps in meeting this condition.

3.2.6 *Corrosion* – *see* **8.1.2**.

3.2.7 *Fatigue* — *see* **8.1.3**.

3.2.8 *Lay selection* — The lay of the rope to be selected depends on the following overall considerations:

a) *Regular lay rope* — The balance resulting from the opposite direction of the lay of the strands to that of the wires together with the shorter length of exposed wires gives:
   1) more structural stability,
   2) greater resistance to crushing and distortion,
   3) less tendency to rotate under load,
   4) less likelihood of kinking, and
   5) greater ease in handling during installation.
b) *Lang's lay ropes* — In a Lang's rope, the lay of the strands and that of the wires are in the same direction. This, while unbalancing the structure, does result in the outer wires being bent on a larger arc of a circle and so exposes a longer length of the wire to wear and give Lang's lay ropes.

Note — Greater wearing surface and, therefore, increases resistance to abrasion and results in less wear on ropes, sheaves and drums; and

Greater flexibility and, therefore, increases resistance to fatigue.

However, Lang's lay ropes are:

1) very difficult to handle and install due to the inherent characteristics of their construction;
2) liable to link if allowed to become slack;
3) less resistant to crushing and distortion and so, unsuitable where there is poor winding or severe overload; and
4) liable to untwist unless both ends are permanently fastened and hence, not recommended for single part hoist, free ends, swivel terminals, etc.

The above shortcomings of Lang's lay rope can, however, to a certain extent, be reduced by performing.

4. Installation — Ropes prior to installation require careful handling to ensure that the lay lengths are not disturbed. The rope shall preferably received on reels and kept on reels as late as possible prior to installation. Care shall be exercised when making fast this rope to ensure that the entire cross-section of the rope is firmly secured in order to avoid the core drawing from the rope end and the surface length of the core protruding in the rope.

4.1 *Holding Capacity of the Reels* — The rope capacity L (m), of a reel, in any size and length may be calculated by the following formula:

$$L = \frac{(A + B) \times A \times C}{1\,000\, d^2}$$

where

L = rope capacity of reel (m),

A = depth of rope layer (mm), $= \frac{H - B}{2}$,

B = diameter of reel barrel (mm),

C = width between reel flanges (mm),

d^2 = rope diameter (mm), and

H = diameter of the drum (mm) as measured over the outermost layer filling the drum.

This forumla is based on assumption of uniform rope winding and will not give correct results if rope is not wound uniformly in a reel.

4.2 *Unreeling and Uncoiling Wire Ropes*

4.2.1 *Unreeling* — During installation, the rope should be mounted on a reel if not supplied on a reel. The reel should be mounted on a horizontal shaft so that it is free to turn. One method is to put a shaft through the centre of the reel and jack it up so that the reel will revolve freely. The rope is pulled straight ahead keeping it taut to prevent it from loosening up on the reel. A board held against one flange may be used as a brake to keep the reel from revolving too fast (*see* Fig. 4).

The other method to fix the reel on shaft and mount shaft on bearing so that reel with shafting will revolve. In this method, a brake can be fixed on the shaft by the reel to see that the rope is tight during installation.

4.2.2 *Uncoiling* — When the rope is supplied in coils, the uncoiling can be done in the following way:

The ties are removed and the the coil is rolled along the ground so that the rope lies straight. Care should be taken that there is no twist or kink in the rope while uncoiling (*see* Fig. 5).

4.3 *Kinking*

4.3.1 Kinking of wire rope can be avoided if ropes are properly handled and installed. Kinking is caused by the rope taking a spiral shape as a result of unnatural twist in the rope. One of the most common causes for this twist is improper unreeling and uncoiling.

Kinking may also occur in a rope in use if slack rope is allowed and is pulled before carefully coiling up the slack.

4.3.2 Figure 6A shows the start of a kink. At this stage, no harm will be done if the loop is immediately thrown out to prevent further kinking.

4.3.3 Figure 6B shows the effect of kinking. The rope has been kinked and is permanently injured.

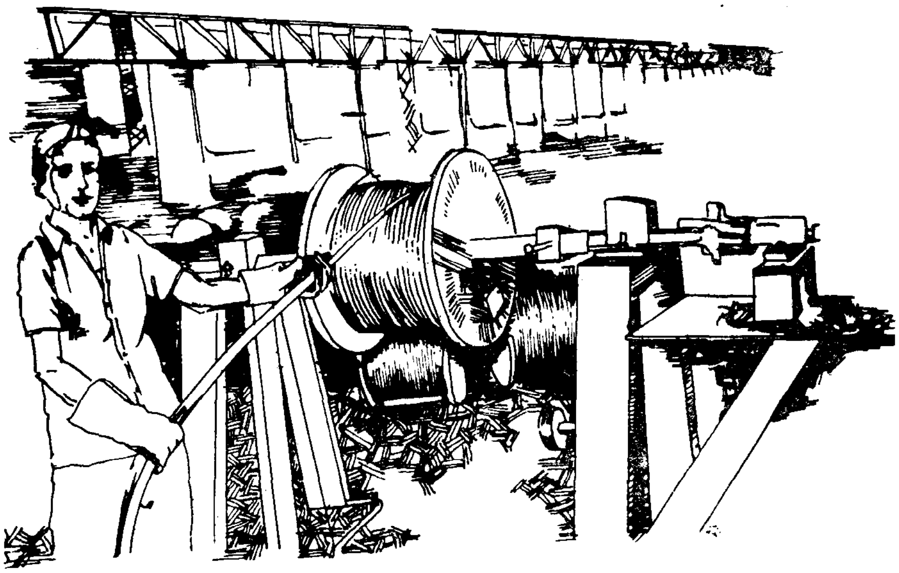


FIG. 4A CORRECT WAY OF UNREELING

FIG. 4B INCORRECT WAY OF UNREELING

4.3.4 Figure 6C shows the result of a rope that has been kinked. Strands and wires are out of position, which results in unequal tension and brings excessive wear on this part of the rope.

4.3.5 Even though the kink may be straightened so that the damage appears to be slight — the relative adjustment between the strands will have been disturbed and the rope cannot give proper service. A kinked rope is liable to fracture without warning.

4.4 *Preparing the Wire Rope for Use*

4.4.1 *Storage of the wire ropes* — Wire rope is a steel product and as such is subject to rust and corrosion. Therefore, all precautions should be taken in storing both new and used ropes to ensure that the deterioration is minimum. The rope should be stored under cover, protected from rain and moisture. Used wire rope should be kept coiled up, lubricated and kept free of twists and kinks.

FIG. 5A CORRECT WAY OF UNCOILING

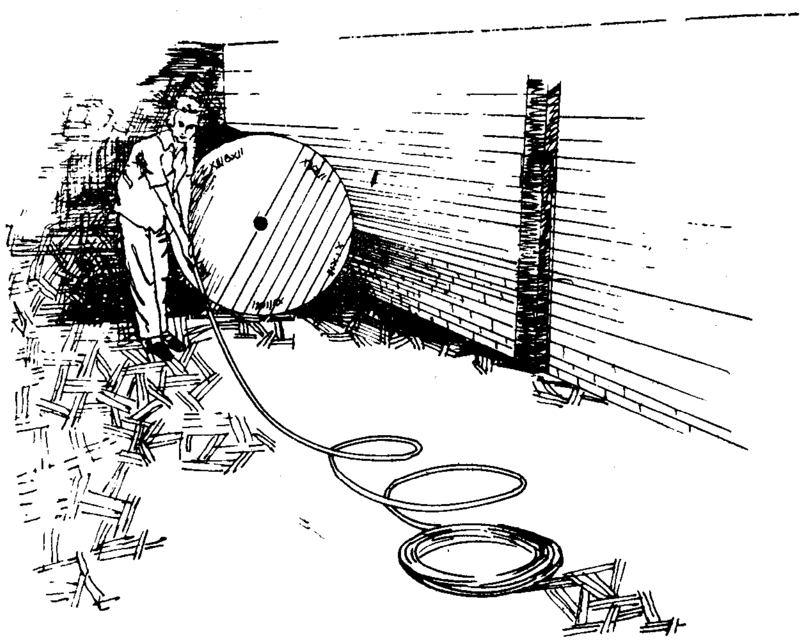
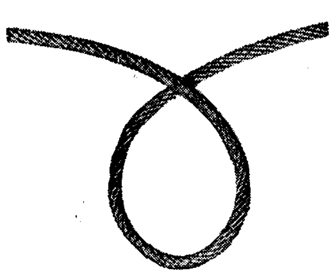
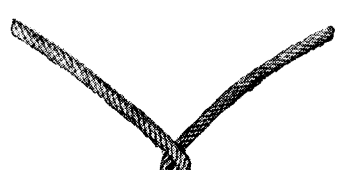


FIG. 5B INCORRECT WAY OF UNCOILING



6A



6B

6C

FIG. 6 KINKING OF WIRE ROPE

4.4.2 *Economical lengths of ropes* — Highly important is the economical length of the wire rope to be cut off the reel or coil. It should neither be very short as nothing will be left for cutoffs at the drum end to permit shifting the rope, nor should it be too long as the excess length will pile up in the multiple layers on the drum which cuts down service materially.

4.4.3 *Cutting a wire rope* — A wire rope can be cut at a desired point by any suitable method which does not disturb the wires. Special care has to be taken in the case of percussive or shearing methods to ensure that the seizing or the rope lay is not disturbed. Oxy-acetylene cutting should not be employed as it is likely to affect the wire and lubrication.

4.4.4 *Seizing* — A seizing is a wrapping of wire laid around a rope to prevent its wires from 'kinking' or moving to slacken themselves when the rope is cut between two adjacent seizings. Before cutting a wire rope, seizing should be placed on each side of the place where the rope is to be cut to prevent unlaying of the strands. The length of the seizing and the diameters of the wires used for seizing depend on the rope diameter. One of the methods of seizing is as follows:

a) The seizing wire is wound on the rope by hand, keeping the coils together with a considerable tension on the wire. The application of not less than 8 or more than 10 wraps of seizing wire for each seizing made, is recommended.

b) The ends of the wire are twisted together counter-clockwise by hand, so that the twisted portion of the wire is near the middle of the seizing.

c) Using rippers, the ends of the wire are gripped just above the first twist. The twist is continued just enough to take up the slack. No attempt should be made to tighten the seizing by twisting.

d) The seizing is tightened by prying the twist away from the axis of the rope with the cutters.

e) The twist is again tightened as in operation (c). Operations (d) and (e) are repeated as often as is necessary to make the seizing tight. Ends of the seizing wires are cut off and the twist is pounded flat against the rope. The appearance of the finished seizing should be as in Fig. 7.

4.4.5 *Attachments* — Since wire rope is no safer than its attachments, fitting should be selected with care and attached properly to obtain the desired strength. The fittings could be attached to the wire rope by splicing, swaging, wedge socketing by means of molten metal or by the use of grips and socketing clamps. The efficiency of the attachments depend on the type of attachment and the care with which it is attached. Zinc and white metal filled sockets develop 100 percent of the rope's breaking strength when properly attached, but the socket attachment efficiency can drop as low as 25 percent if babbit metal or lead is used in place of zinc or white metal. In the case of the swaged fittings 100 percent efficiency could be expected. In the case of wedge type sockets with a rope looped around the wedge 70 to 80 percent efficiency could be expected. In the case of wire rope clips, the efficiency is dependent upon the arrangement, care in tightening and the number of clips used. With properly attached U-bolts 70 to 80 percent efficiency could be expected and 50 percent efficiency with knot and clip attachment. When wires break from fatigue near the attachment, clips or wedge sockets are preferable to metal filled sockets inspite of their lower efficiency in strength tests. Clips shall be placed with the U-bolt over the dead end of the rope and the base against the live end.

4.5 *Correct Spooling of Rope on Drums*

4.5.1 *Single layer winding*

4.5.1.1 *Flat or smoothface drums* — If a rope is fitted incorrectly to a smooth surface drum, it may coil badly forming open or widely spaced coils instead of closely packed coils. When a rope is wound into a drum, any tendency of the rope to twist when the tension is released will be in a direction which would untwist the rope at the free end. The advantage of applying rope of proper direction of lay is that when the load is slacked off, the several coils on the drum will be together and maintain on even layer. The proper direction of rope lay to give best results is shown in Fig. 8. This applies to either regular or Lang's lay rope.

On new equipment and also on existing equipment, where possible, the drum anchorages shall be so positioned so as to favour right-hand lay rope since left-hand lay rope is not always available from stock.

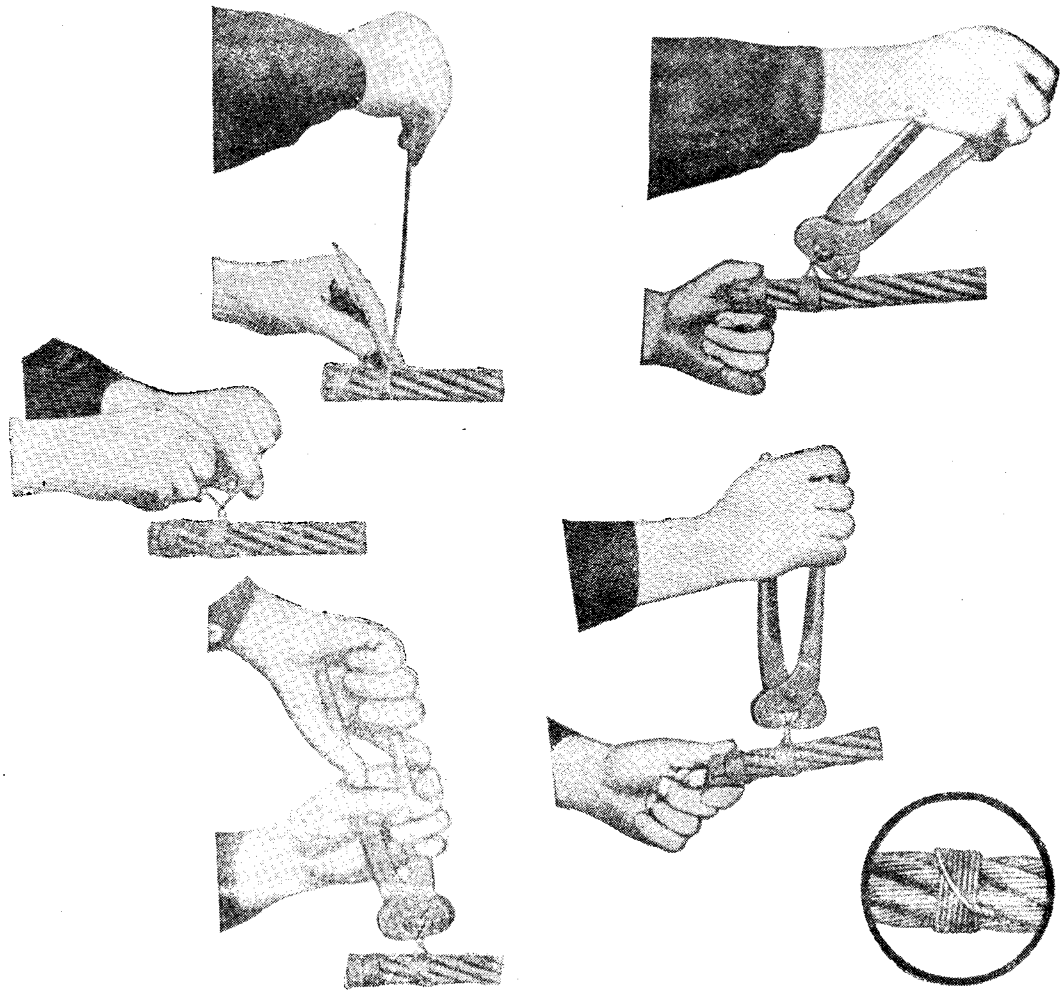


FIG. 7 SEIZING A WIRE ROPE

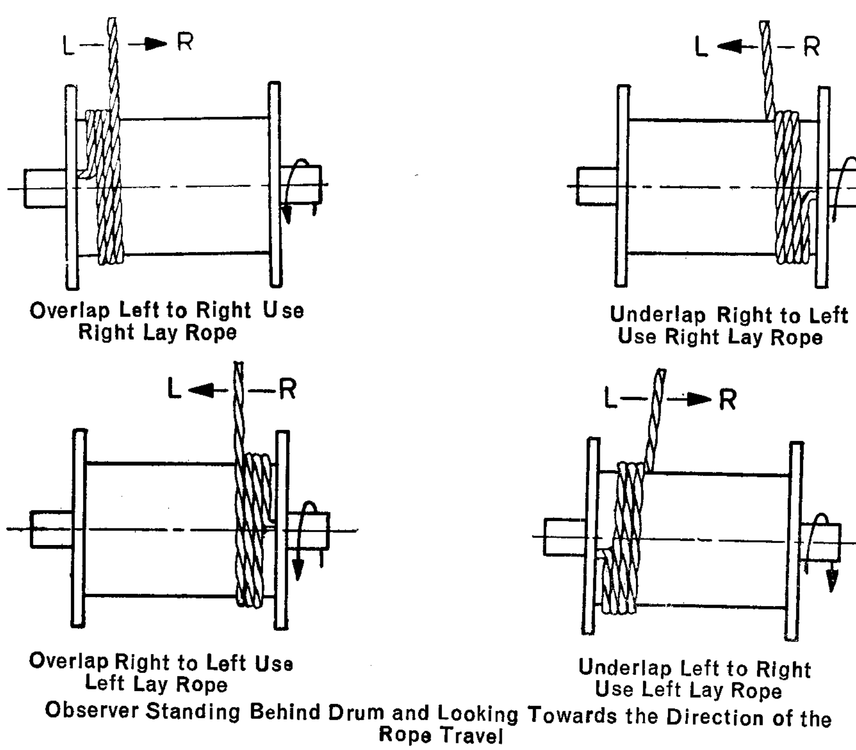


FIG. 8 SELECTION OF PROPER DIRECTION OF ROPE LAY

4.5.1.2 *Drums with spiral grooving* — For drums with spiral grooving direction of coiling is fixed and the ropes should be used to suit the grooving as follows:

A right-hand rope for a groove corresponding to a left-hand groove screw thread and *vice versa.*

4.5.2 *Multilayer winding* — Although it is advisable to resort to singlelayer winding as far as possible, there are cases where multilayer winding cannot be avoided and in such cases, great care shall be taken to ensure that cross-winding between layers does not occur.

4.6 *Fleet Angle*

4.6.1 Where a wire rope leads over a sheave and on to a drum, the rope will not remain in alignment with the sheaves but will deviate to either side depending on the width of the drum and its distance from the first fixed sheave.

4.6.2 The angle between the vertical plane of rotation of the sheaves and the rope leading to the drum is called the fleet angle (*see* Fig. 9).

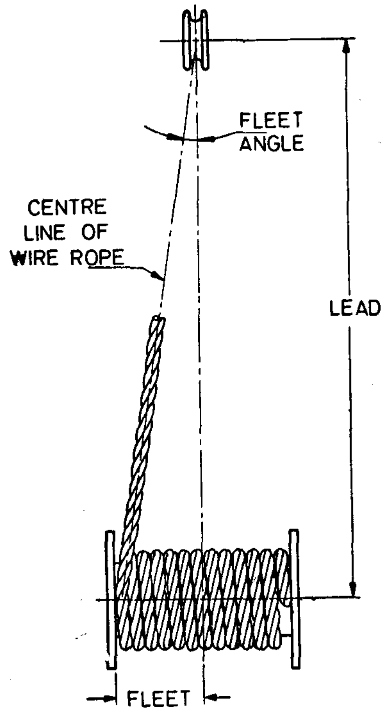


FIG. 9 FLEET ANGLE

4.6.3 To avoid excessive wear to the sheave and to prevent excessive chafing of the oncoming rope against previous wraps on the drum, it is desirable to keep the fleet angle as small as possible.

4.6.4 Where space is unrestricted, fleet angle is sometime as small as half a degree. This is equivalent to a distance of aporoximately 155 mm between the drum and the first fixed sheave for each millimetre of the drum width. It represents the minimum below which the rope will not properly wind back from the drum flange after completing only a layer. Most installations do not permit this much distance between the drum and the sheave and for average conditions, it is considered good practice to keep the fleet angle within the following limits:

Mining installations	1° 30'
Cranes and other hoisting equipment	5°

4.7 *Drums, Pulleys and Sheaves* — Sheaves and drums should be of proper size, free running and properly grooved for most economical wire rope service.

4.7.1 *Diameters of the drum and pulleys* — The purposes for which the rope may be used vary considerably and it is, therefore, not possible to recommend minimum sizes of drums and pulleys suitable for all purposes. Reference should, therefore, be made to relevant standards or statutory regulations which specify requirements of drum, pulley or sheave diameter. In the absence of such requirements, the diameter of a drum or sheave shall not be less than that given in Table 1.

TABLE 1 RATIO OF DRUM AND SHEAVE DIAMETER TO ROPE DIAMETER

(*Clause* 4.7.1)

Purpose	Construction	Minimum Ratio*		
Mining installation	Winder	100		
	Haulage			
	up to but excluding 50 kW	50		
	100 kW and above	60		
		Class 1†	*Class 2 & 3*†	*Class 4*†
Cranes and allied hoisting equipment	6 × 37 8 × 19	15	17	22
	8 × 19 8 × 19 Seale 34 × 7 Non-rotating	17	18	24
	6 × 19 Filler wire	18	20	23
	6 × 19 17 × 7 Non-rotating 18 × 7 Non-rotating	19	23	27
	6 × 19 Seale	24	28	35

*The ratio of the diameters specified are valid for rope speeds up to 50 m/min. For higher speeds, the drum or sheave diameter should be increased *pro rata* by 8 percent for each additional 50 m/min of rope speed where practicable. Larger ratio shall be used particularly for non-rotating ropes.

†*See* IS : 807-1976 'Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists (*first revision*)'.

4.7.1.1 It should be appreciated that the diameters recommended are minimum ratios and it is never advisable to allow the sheave and drum diameters to come below these values. Diameters larger than those recommended will give increased rope life and consequently more economical service.

4.7.2 *Pulley or sheave grooves* — Where requirements for pulley and sheave grooves are not specified in the standard for a particular equipment, grooves shall comply with the following requirements given in **4.7.2.1** and **4.7.2.2.**

4.7.2.1 *Groove depth and flare* — The depth and flare of the groove shall be so chosen as to ensure that the rope is not rubbing against the flange of the sheave when entering or leaving a groove. The bottom of the groove shall be a circular are over an angle of not less than 120°C and it is recommended that the sides of the groove shall be flared with an included angle of 30 to 45°C.

The pulley or sheave shall be grooved to a depth at least equal to 1·5 times the diameter of the rope and the groove shall be smoothly finished and free from surface defects liable to injure the rope. The edges shall be rounded.

4.7.2.2 *Groove diameter* — The groove diameter of the pulley or sheaves should always be larger than the actual diameter of the rope but if the groove is too large, the rope will tend to flatten. On the other hand, too small a groove will cause rope distortion in the opposite direction, namely, pinching of the rope.

As the rope is bent around a sheave, the strands and wires lie upon each other slightly in an effort to adjust themselves to this curvature. When the rope is pinched in an undersize groove the strands and wire bind against each other which not only increase the abrasion and internal and external wear but also hinder the readjustment of the rope under the load and forces some of the wires and strands to carry more than their share. In order to prevent the deteriorating effects of oversized or undersized grooves, it is recommended that the groove diameter be maintained within the limits shown in Table 2.

TABLE 2 TOLERANCES ON PULLEY OR SHEAVE GROOVE DIAMETERS

(*Clause* 4.7.2.2)

Nominal Diameter of the Rope	Minimum Clearance Before Sheave Replacement or Remachining of Groove	Minimum Clearance or New or Remachined Groove
mm	mm	mm
6 to 8	0·40	0·80
10 to 20	0·80	1·60
22 to 29	1·20	2·40
32 to 38	1·60	3·20
41 to 57	2·40	4·00
Above 57	3·20	4·80

4.7.3 *Drum grooves*

4.7.3.1 The grooved drums are recommended in preference to smooth drums as the grooves furnish better support for the rope than the flat surfaces of the smooth drums and the more uniform winding results in less abrasive wear on the rope. Annularer concentric grooves should not be greater in depth than 10 percent of the rope diameter. Deeper grooves will cause undue distortion of the rope at the points of cross-over from one groove to the next.

4.7.3.2 *Clearance between adjacent turns of rope* — The grooves on the drum shall be pitched so that there is clearance between neighbouring turns of rope on that drum and also there is clearance between the part of the rope leading on to, or leaving the drum and the adjacent coil.

The following clearances are recommended for annular or concentric grooves:

Rope Diameter		*Clearance*
From	Up to and including	
mm	mm	mm
	12	1·5
12	28	2·5
28	38	3·0

Allowance should be made for the permissible 5 percent oversized tolerance and the permissible misalignment up to 1 in 12.

The following clearances are recommended for helical type grooves:

Rope Diameter		*Clearance*
From	Up to and Including	
mm	mm	mm
	32	1·5
32	44	2·5
44	51	3·0

5. Wire Rope in Use

5.1 *Proper Working Load for Wire Ropes*

5.1.1 *Safety Factors* — The factor of safety for steel wire rope is defined as the ratio of breaking strength to safeworking load which is the maximum static load met in service. Laboratory findings and practical investigations have shown that in addition to the provision of satisfactory static safety factor, it is necessary to take into account not only kinetic stresses but the effect of bending in considering rope service. In general terms, it has been found that where the combined effect of static, kinetic, and bending stress exceed 25 percent of the nominal breaking load of rope then the satisfactory rope life cannot be expected. The safety factors recommended in Table 3 are for normal conditions. When conditions are more rigorous, for example, when the wire ropes undergo more than two windings or undergo reverse bends, it is recommended that these factors be suitably increased.

TABLE 3 FACTORS OF SAFETY FOR WIRE ROPES

Rope Application	Factor of Safety Not Less Than		
1. *Mining Ropes*			
a) For shafts of varying depths			
Up to 300 m	10		
300 to 500 m	9		
500 to 700 m	8		
700 to 1 000 m	7		
1 000 to 1 500 m	6		
Over 1 500	5		
b) Haulages	7		
2. *Wire ropes used on the cranes and other hoisting equipment*	Statutory Authority		
	*Class 1**	*Class 2 & 3**	*Class 4**
Fixed guys Unreeved rope bridles of jib cranes or ancillary appliances, such as lifting beams Ropes which are straight between terminal fittings	3·5	4·0	4·5
Hoisting, luffing and reeved bridle systems of inherently flexible cranes (for example, mobile, crawler tower, guy derrick, stiff leg derrick) where jibs are supported by ropes or where equivalent shock absorbing devices are incorporated in jib supports	4·0	4·5	5·5
Cranes and hoists in general hoist blocks	4·5	5·0	6·0
Aerial ropeways	In accordance with the values specified in relevant standards		
Slings	In accordance with the values specified in IS : 2762-1964 'Specification for wire rope slings and sling legs'.		

**See* IS : 807-1976 'Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists (*first revision*)'.

5.2 *Breaking in Period*

5.2.1 The many moving parts in the wire rope shall work together. Experience has proved that a short breaking-in period and gradual loading and slow speed adjust the moving parts amongst each other. This breaking-in period results in better spooling, more efficient performance and longer rope life.

5.2.2 The following breaking-in routine may be followed:

a) The equipment should be in a good condition;

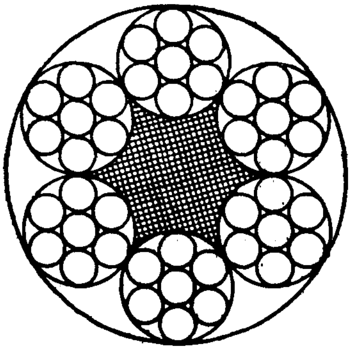
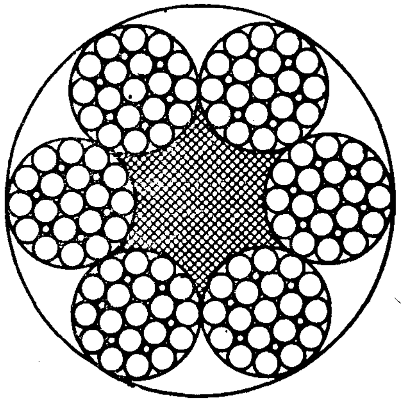
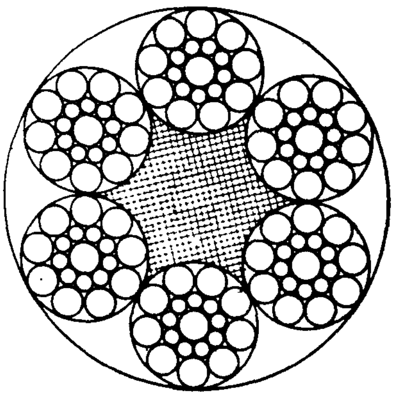
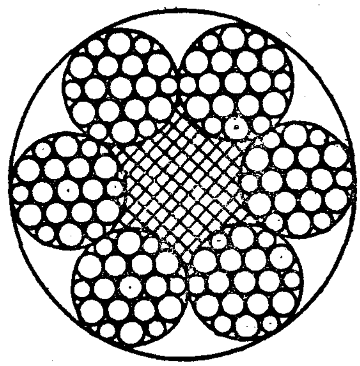
b) The rope should be unwound from the reel or coil such that twisting and kinking does not occur;

c) The rope should be firmly anchored to the equipment, taking care to seize it first with wire to prevent it from untwisting;

d) After the rope is attached and reeved around sheaves and drums, it is operated with a light load a few times, until it is flexing easily over sheaves and winding correctly on the drum; and

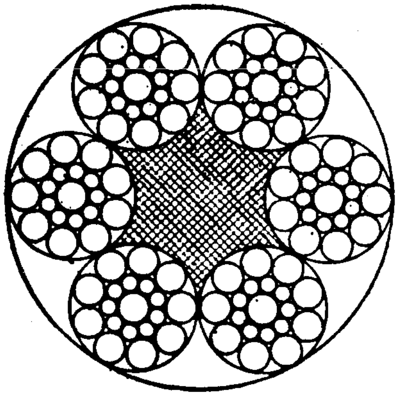
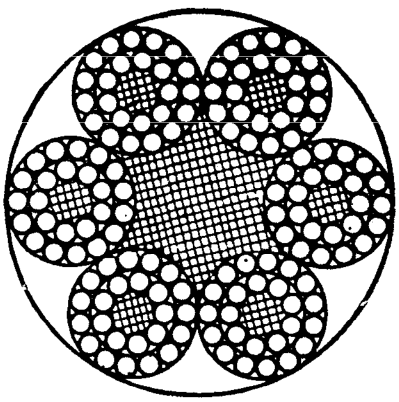
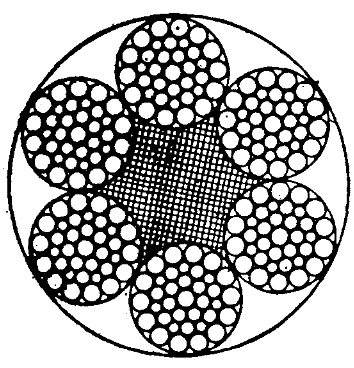
e) Gradually the speed and load are increased until the rope is operating up to its normal loading and speed.

TABLE 4 EXAMPLE OF ROPE CONSTRUCTION, DESIGNATION

General Rope Construction	Figure	Details of Construction and Designation
6×7		All the wires in the strands are of the same size except the king or centre wire. The length of lay of the outer wires is longer than that of the inners, that is, 'cross laid'. Each strand is constructed of 6 wires over 1, or the construction is 6 × 6/1.
6×19		All the wires in the strands are of the same size except the king or the centre wire. The length of the lay of the outer wires is longer than that of the inners that is, it is a 'cross laid' construction. Each strand is constructed of 12 wires over 6 wires over 1, or the rope construction is 6 × 12/6/1.
6×19 Seale		Smaller wires are used for the inner layer of strands. The length of the lay is the same for both layers, that is, 'equal lay'. Each strand is constructed of 9 wires over 9 wires over 1, or the construction is 6 × 9/9/1. If the same rope had been supplied with the independent wire rope core, the construction would have been designated as 6 × 9/9/1 IWRC.
6×19 Filler		The length of lay is the same for both the layers, that is, the construction is 'equal laid'. Filler wires are laid in the valleys formed to the wires by the inner layer. Each strand is constructed by 12 wires over 6 wires over 1 plus 6 filler wires between the outer and inner layers. The construction is designated as 6 × 12/6 + 6F/1. It is to be noted that though the number of wires in the strand is 25, it is designated as 19, as the filler wires are not taken into account in counting the number of wires.

(Continued)

TABLE 4 EXAMPLE OF ROPE CONSTRUCTION, DESIGNATION — *Contd*

General Rope Construction	Figure	Details of Construction and Designation
6×19 Warrington		Alternatively large and small wires are used for the outer layer of strands. The length of lay is the same for both layers, that is, the construction is 'equal laid' construction. Each strand is constructed of 6 large and 6 small wires over 6 wires over 1. The rope is designated as 6 × 6 and 6/6/1.
6×24		All the wires in the strands are of the same size. Each strand is constructed of 15 wires over 9 wires over fibre centre. The 15 outer wires have a longer length of lay than the 9 inners, that is, the rope is of 'cross laid' construction. This rope is designated as 6 × 15/9/Fibre.
6×36		The wires in the strands are arranged in a combination of Seale and Warrington formation. Each strand is constructed of 14 wires of one size over 7 layers of large and small wires over 7 wires of one size over 1. All the layers of wires have the same length of lay, that is, it is of 'equal laid' construction. This rope is designated as 6 × 14/7 and 7/7/1.
Multi-Strand Ropes		They are designated by the number of strands and by the number of wires. For example, 34 × 7 indicates a multi-strand rope of 34 strands of 7 wires each.

5.3 *Operation*

5.3.1 A good operation consists in the avoidance of shock loads and reverse bends and the use of proper drums and sheaves.

5.3.2 *Shock loads* — Wire ropes will continue to meet with unexpected and unforeseen stresses, but shock loads that obviously overstress the rope should be avoided. Any sudden load can develop into a shock of load. Shock loads may be avoided by:

a) making sure that there is no slack and no jerking of the rope at the start of the loading,

b) careful hoisting of load to see that there is no load beyond the rope's proper working load,

c) preventing the rope from becoming foulded or jammed either on the drum or jumping a sheave,
d) sudden breaking while hoisting rope, and
e) keeping the track in good condition to avoid obstructions and bumps.

5.3.3 *Reverse bends* — Experience and many tests have proved that reverse bending increases the risk of failure of rope. Where reverse bending cannot be eliminated, the largest sheaves possible should be used and placed as far apart as possible. By getting the maximum distance between the reverse bends, fatigue is reduced, thus ensuring longer service.

5.3.4 *Drums and sheaves*

5.3.4.1 *Drums* — Careless operation of equipment can be the greatest abuse of wire rope. This often starts with improper spooling on the drum and will cut or crush the wires leading to further trouble. If the rope repeatedly jumps out of the drum groove, the trouble may lie in letting the drum run too free or perhaps, the rope is too soft for the job. Both the situations can be easily corrected.

5.3.4.2 *Sheaves* — To get most out of the wires, the sheaves and wire ropes work together in harmony. The sheaves should run true and should not wobble on their bearing. Sheaves shall be free from roughness or burrs of any kind. Grooves shall be smooth and shall be larger than the diameter of the rope to prevent pinching and excessive wear.

5.3.4.3 *Reeving* — When reeving up, the rope should wind evenly on the drum and run freely through all sheaves.

6. Maintenance — Maintenance of wire rope means two thing-shifting the points of wire by cutting off drum ends or by changing the rope end, and ensuring adequate lubrication. Lack of lubrication is a common neglect of rope.

6.1 *Lubrication*

6.1.1 In manufacture, wire ropes are fully lubricated (including fibre core and layers) to reduce internal abrasion, to exclude external moisture and delay corrosion. In service, the initial lubricant will tend to dry out and, therefore, it is desirable to lubricate all ropes at regular intervals. There are many methods of applying lubricant, such as vertical or horizontal grease boxes through which the rope runs, application by brush, leather gloves, drip or by spraying. Lubrication will fit in at least one of these methods and regular lubrication is a factor in prolonging the life of a wire rope.

6.1.2 *Lubricant* — The lubricant employed shall be similar and completed compatiable with the lubricants that has been used during manufacture of a rope. The lubricant employed should be free from all harmful substances, such as acids and alkalies. The lubricant should have good penetrability, high film strength, good resistance to corrosion, high drop point and softening point without becoming brittle and good water workout characteristics. The lubricants designed or approved for rope should be able to penetrate between the wires and strands. They should be non-soluble under the conditions where the rope operates and should have high film strength and should resist degradation. They should preferably be of mineral origin rather than animal or vegetable origin. For the latter tend to break down eventually and produce acids. However, lubricants based on lanolin (wool wax) are permissible for use with wire ropes. The lubricant used should satisfy the following minimum requirements as regards absence of corrosiveness:

a) The total acidity expressed in terms of SO_3 shall be less than 0·1 percent. The mineral or inorganic acidity shall be nil. The organic acidity (the difference between the above two values) expressed in terms of SO_3 shall be less than 0·1 percent;
b) The ash content shall be less than 0·1 percent, and
c) A polished silver panel immersed in a bath of lubricant maintained at 120°C for 50 hours should show no visible alteration in appearance. A polished mild steel test plate exposed to the action of the lubricant at 120°C for a period of 50 hours should not show any trace of corrosion.

The lubricant should be of a light grade that may penetrate between the wires and the strands of the rope before being wiped off or absorbed by surface dirt.

6.1.3 *Application* —It is very desirable that the rope be clean and dry before application of lubricant. A jet of air or wire brushing are some of the cleaning methods used preparatory to apply the lubricant.

6.1.3.1 An easy and effective method of applying lubricant is to brush the lubricant on to the rope. The brush is dipped into the lubricant and applied. In some cases a rag or piece of sheepskin is dipped in the lubricant and used to swab the lubricant on to the rope.

6.1.3.2 The lubricant may also be applied by hand with leather gloves. Leather is preferred to canvas, because of its greater protection and less penetration of the grease. This method is specially good where a heavy, non-flowing lubricant is applied. It is desirable to heat fhe lubricant slightly to get a smoother, better application.

6.1.3.3 A simple lubricating device is a wooden trough with sheave mounted on a shaft. The rope is run over the end of the trough, under the sheave, and out the other end so that the rope runs through the lubricant. A rag or swab held in place at the out-going end wipes off excess lubricant. Regular inspection of the rope with frequent applications of lubricant produces better results than heavy coatings less frequently applied.

6.1.3.4 *Periodicity of lubrication* — As a rule, 'it is better to lubricate lightly and frequently than heavily and rarely'. Though periodicity will depend upon the service conditions prevailing, yet fortnightly schedule of lubrication is recommended, as a rule.

7. Inspection

7.1 *Sheaves* — Sheaves should periodically be inspected and reconditioned groove contours should be checked for uneven wear. Sheaves that have worn out of round or have developed flat spots will set up vibration in the rope which will result in an early fatigue failure of the metal.

The depth and flare of the groove shall be examined to make sure that the rope does not rub against the flange of the sheave when entering and leaving the groove. Selection of proper sheave and correction of improper characteristics by means of regrooving or replacing the sheaves is an important function of every maintenance department, and will result in longer rope life as well as safer operation.

7.2 *Wire Ropes* — The life of a steel wire rope is solely dependent on its construction, grade, the surroundings in which it is being used and the manner of application alongwith maintenance procedure being adopted. It is possible by means of periodical inspection to increase 'the effective life span' of a steel wire rope.

The wire ropes should be inspected at regular intervals depending on usable condition of the steel wire rope; inspection includes not only visual examination but also non-destructive examinations like electromagnetic testing. Close examination will not only indicate when it is time to put on a new rope but it will also reveal many other things about the way the rope does its work and whether it is suited to the job. For instance, wires breaking without showing wear indicate excessive bending, that is, sheave and drums are too small or rope construction is too coarse. Whenever a rope is cut for recapping, the cut off portion of the rope shall be specially examined. The findings during the inspection can be mentioned in a 'steel wire rope inspection card' of which a sample is given in Appendix C. The effective life span of the steel wire rope to be tested is then determined by means of the figures in the steel wire rope inspection card. By this way a better insight in the effective life span can be had. In inspection the places where as a rasult of the usable condition corrosion, wear and tear, fatigue or damage can be expected call for special attention. In the inspection we should always keep in mind that by visual examination only the external faults of the rope can be detected. Where internal faults of some significance can be expected, the wire rope must be inspected, for example, by judiciously turning open here.

8. Discard Criteria

8.1 A steel wire rope can be discarded on following grounds:

a) wear and tear,

b) corrosion,

c) fatigue,

d) external deformation,

e) action of heat,

f) type, position and number of wire ruptures,

g) abnormal stretching,

h) surface embrittlement,

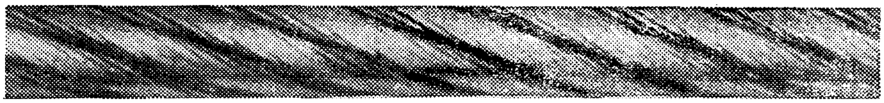
j) core collapse,

k) fitting time, and

m) accidental damage.

8.1.1 *Wear and tear* — The wear and tear of a wire rope is to be distinguished for the internal and external wear and tear by contact between the wire ropes. The condition in which a wire rope is found is examined at the external, and consequently, visible wear and tear. The normal external wear and tear is caused by the contact between the wire rope and the drum. Figure 10 gives an example of visible wear and tear of a cross lay wire rope and that of a Lang's lay wire rope.

Visible Wear and Tear of Cross Lay Wire Ropes



Visible Wear and Tear of Long Lay Wire Ropes

FIG. 10

8.1.1.1 While examining the external wear and tear of a wire rope one should keep in mind that the definite places of a wire rope show abnormally great wear and tear. This wear and tear can more or less be caused by:

a) scrubbing of the steel wire rope along the flanges of the top disc in the loaded condition during the swerving or in the hoist disc of the load (slanting rope pull) or by a very big hook of the steel wire rope with the plane perpendicular to the axis of the disc;
b) scrubbing of the steel wire rope along the parts of the implement;
c) scrubbing of the steel wire rope along the obstacle outside of the implement or over the ground (for example, along the shutter head of the disc); and
d) a drum with a speed too small for the rope or a disc with new grooves.

8.1.1.2 The internal wear and tear of steel wire rope consists of:

a) wear and tear of the wires common in a strand,
b) wear and tear between the strands in the same lay,
c) wear and tear between the strands of different lays, and
d) wear and tear between inner most laid strand and the steel core.

In application of Table 5, in which judgement figures for the external wear and tear are given, the calculation is at the same time bound normally to anticipate simultaneously appearing internal wear and tear as a result of friction of the strand along both, across each strand and across the core.

For the steel wire rope in which the internal, not directly observable, part of the wire represents a relatively big part of the metal surface and in which many strands contacts are present.

8.1.1.3 Under definite circumstances we should keep in mind that the internal wear and tear can be greater than those with which calculation in Table 5 is made. This abnormal internal wear and tear can be caused by:

a) unsuitable filling by improper construction and/or the pattern of the core,
b) corrosion of the steel core and/or the drying of the rope core, and
c) abnormally high temperature.

8.1.2 *Corrosion* — By the interaction of moisture, the presence of pollution in the air and the eventual direct contact with chemicals, a steel wire rope will, during use and sometimes even during storage, corrode. Thus corrosion is not an instantaneous effect. It is defined as the eating away of metal from the surface by chemical or electrochemical action. It will appear as loose red rust, dark discolouration or pitting. It results in a loss of wire area and consequently, of weight and strength without any loss of elasticity. By galvanizing of ropes that are liable for rusting in use and by good lubrication at frequent intervals from the time of installations, the corrosion can be fuel off for a long or short period, but can not be for ever. If corrosion has already appeared, it can not be stopped by external greasing.

TABLE 5 JUDGEMENT OF STEEL WIRE ROPES

Evaluation Figure	Visible Wire Breaking*				Wear and Tear on External Wires (In Percentage of the Surface Section of Wire)		Corrosion: External and Internal (Locally Corroded or Uniform Attack)		Decrease in Steel Wire Rope Diameter
	6 and 8 Strands		18 Strands						
	Cross lay	Lang's lay	Cross lay	Lang's lay					
None	0%	0%	0%	0%	2·5%		Wire surface not attacked. Light rusting condition.		3%
Moderate	5%	2½%	4%	2%	10%		Wire surface lightly attacked. No significant decrease in the wire diameter.		6%
Strong	10%	5%	8%	4%	20%		Wire surface attacked. Significant decrease in wire diameter. Little looseness among external wires.		9%
Very Strong	15%	7½%	12%	6%	30%		Wire surface strongly attacked. Distinct looseness among external wires.		12%
Discarding	20%	10%	16%	8%	40%		Wire surface strongly attacked. Significant decrease in wire diameter.		15%

Measured length = 30X wire rope diameter.

Method of judgement = The judgement of a wire rope must always be made over the worst part of wire rope. For each of the judged length the sum of the evaluation figures should be determined.

Discarding = The sum thus fixed may be 6 for not a single judged wire rope part. Moreover none of the evaluation figures may be separately equal to 4.

*The percentage of wire breaking has taken into account the total number of wires in the rope outside the core.

In the case of corrosion, a difference should be made between the external (visible) and internal (invisible) corrosion. According to this, the wire rope is examined for visible corrosion. The internal corrosion must always be taken into consideration because it may exercise great influence on the bedding and thus on the fulfilment of the task of the wires and the strands in the wire rope.

In case of any doubt the presence of abnormal internal corrosion, the steel wire rope should be inspected immediately against that doubt.

A seriously corroded rope, the corrosion being external or internal or both, should be considered for removal immedietely even if the corrosion is local and not spread to the entire length of the rope if the corroded portion cannot be cut off and removed. Any wear and tear of broken wire will add to the discard factor (*see* Table 5, col 4).

Moreover attention should be paid to the corrosives in the case of wire ropes used for a longer period.

8.1.3 *Fatigue* — Fatigue is the outcome of repeated reversal of stresses on a wire due to which the wire shows the tendency to fracture by means of a progressive crack which appears first on the surface and progresses in inward direction. The fracture occurs at a stress much below the ultimate tensile strength. Sharp edged surface irregularities, such as small but relatively deep corrosion pits, narrow scratches and surface cracks encourage fatigue failure because the stresses at the bottom or root of the irregularity is always greater than in other parts of the wire.

Reversal of stress occurs when rope is bent. Small radius bends have greater fatigue effect than large. Fatigue may be prevented if precautions are taken to avoid large winding shocks, sharp bending of the ropes around pulleys and drums of insufficient size, loosening of the lay of the rope with consequent accentuation of secondary bending and faults in rope design. When secondary bending is the cause of fatigue, consideration should be given to employing ropes of equal lay because equal lay ropes do not cross over one another and, therefore, are virtually free of all secondary bending. Figure 11 shows the stages in the breaking of a wire at a fatigue crack. While designing a wire rope, proper consideration should be given to endurance limit of the material of the wire being used.

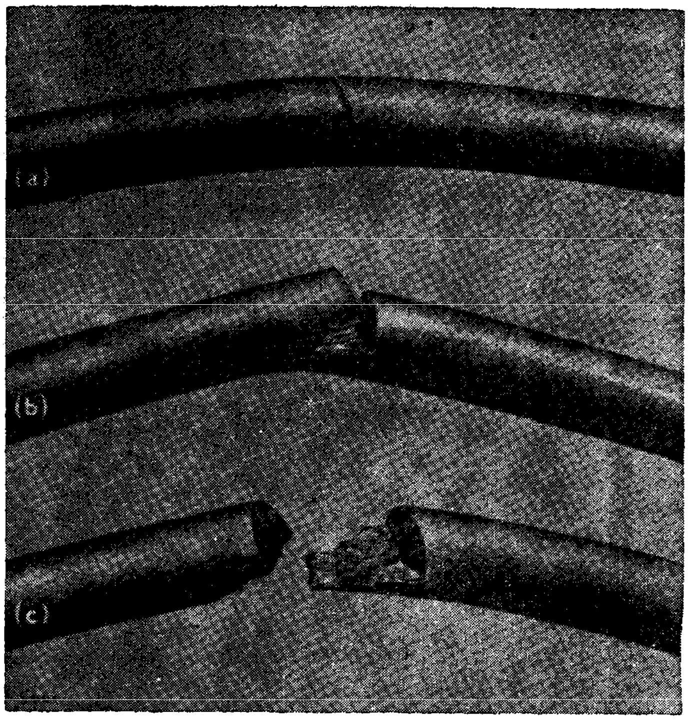


FIG. 11 STAGES IN THE BREAKING OF A WIRE AT A FATIGUE CRACK

8.1.4 *External deformation* — External deformations of the wire ropes are visible changes in the rope bends. According to appearance, most important of them can be enlisted hereunder:

a) corkscrew deformation (*see* Fig. 12)
b) cage formation (*see* Fig. 13)
c) looping of wires (*see* Fig. 14)
d) loosening of individual wires or strands (*see* Fig. 15)
e) knots (see Fig. 16)
f) construction (*see* Fig. 17)
g) flattening (*see* Fig. 18)
h) curling
j) puffing (*see* Fig. 19)
k) kinks (*see* Fig. 20)

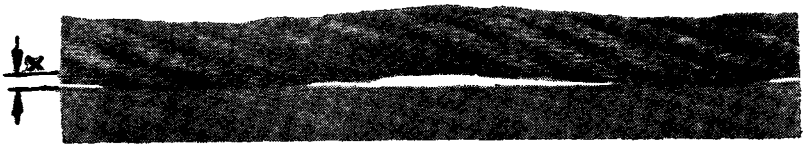


FIG. 12 WIRE ROPE WITH CORKSCREW DEFORMATION

FIG. 13 WIRE ROPE WITH CAGE FORMATION

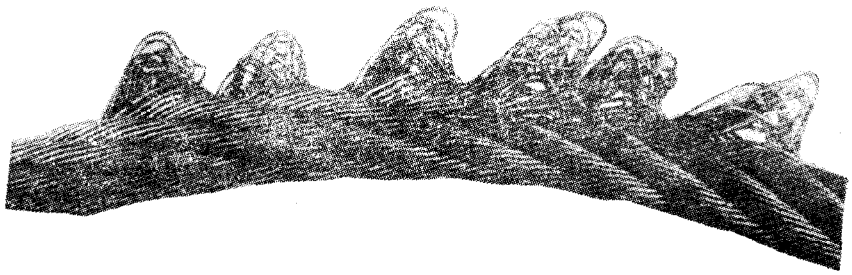


FIG. 14 WIRE ROPE WITH LOOPING OF WIRES

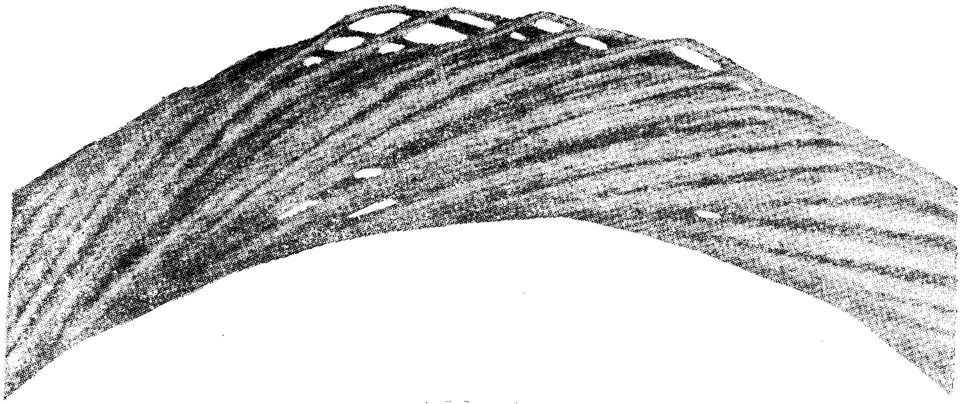


FIG. 15 WIRE ROPE WITH WIRE LOOSENED BECAUSE OF CORROSION AND WEAR

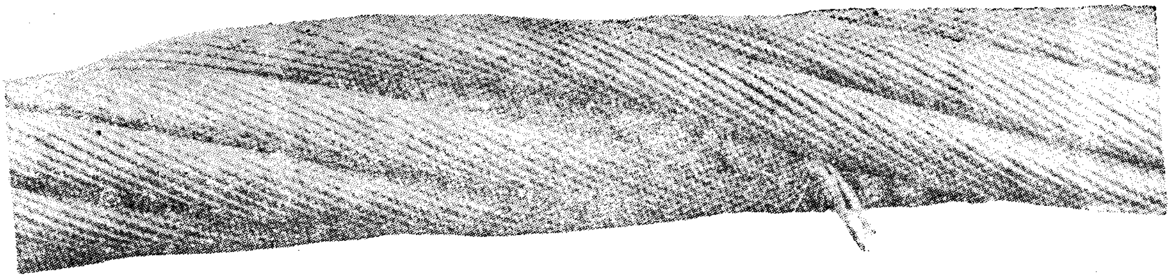


FIG. 16 WIRE ROPE WITH KNOTS

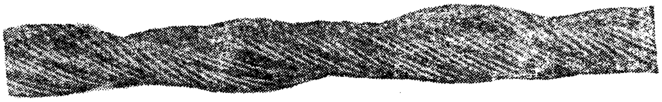


FIG. 17 WIRE ROPE WITH CONSTRUCTION

FIG. 18 WIRE ROPE WITH FLATTENING DUE TO CRUSHING

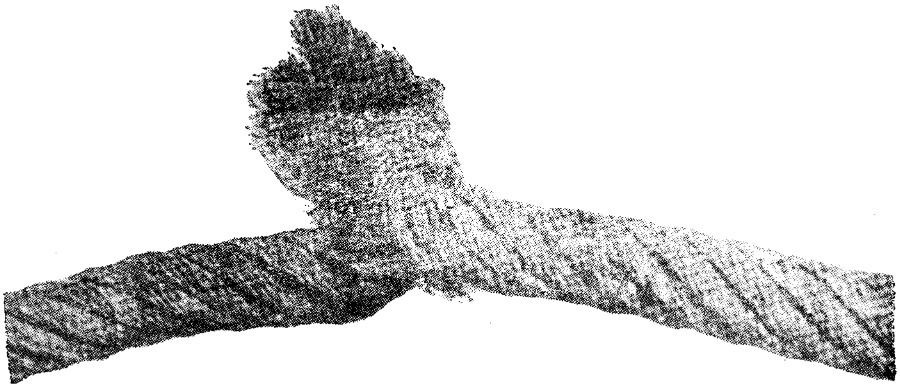


FIG. 19 WIRE ROPE WITH PUFF

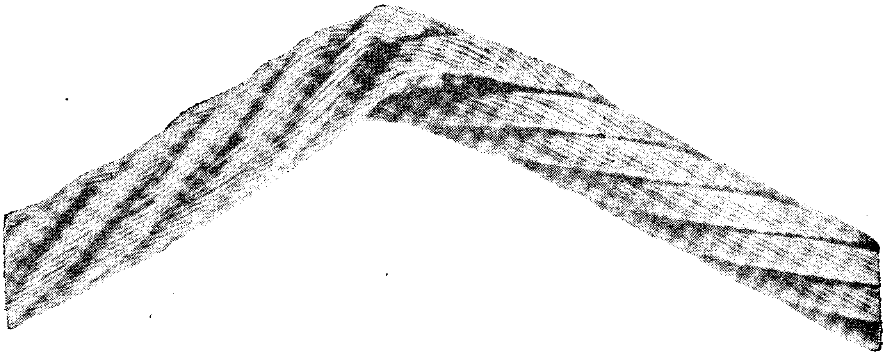


FIG. 20 WIRE ROPE WITH KINK

Deformations also imply the loosening of the rope structure, at least in the neighbourhood of the place of deformation.

In the case of corkscrew type of deformation, the axis of the unloaded wire rope takes the form of a helix. This type of deformation in the first instance, does not lead to a weakening of the wire rope. However, due to this deformation, the wire rope can run noisely. After a load period of working this can lead to excessive wear and rupture of the wire rope. The wire rope shall be taken out if the deformation as in Fig. 12 at the most undeformable place is one third of the rope nominal diameter or more. The deformation shall be measured without load but with the weight of carrying device (supporting device) if it is less than 30 percent of the load capacity.

Cage formation can occur in the case of wire ropes with steel filler if the outer layer of wires are loose or the outer strands longer than the inside ones. Due to the displacement of the outer layers of wires and strands with respect to the inner, the extra length is pushed at one plate. Simultaneously, this can cause at another place of the wire rope an extra length of the filler with respect to the outer strands, thus buckling the filler or making it come out of the wire rope. In the case of cage formation, the wire rope shall be discarded.

In the case of loop formation of wires, individual wires or groups of wires come out of the wire rope in the form of hairpins on the side opposite to the seating groove. Usually the loops are in several strands one behind the other. If the rope binding is considerably altered due to loop formation of the constituent wires, the wire rope shall be discarded.

If the individual wires or strands get loose the outer wires of the loaded wire rope or a few strands can be displaced. They, therefore, do not take up their part of the load and the other wires or strands are excessively loaded. In the running over pulleys, therefore, very high bending stresses can be generated leading to premature rupture of the wires. If the loosening of wires is caused by rust or wear, the wire rope should be discarded. If the loosening is due to other causes, the rope can be discarded according to the resulting rupture of the wires.

Knots are thickenings that occur repeatedly over long stretches of wire rope. At the thickened places the filler usually comes out of the wire rope. At the thin places the strands are supported against each other forming an arch and this can cause rupture of the wires. When there are knots, the wire ropes make additional movements. Wire ropes with excessive knot formation shall be discarded.

Constrictions are reductions of the wire rope diameter over short lengths. Portions of the rope immediately before the end fixing should be checked carefully, particularly for constrictions which are difficult to identify at these places. If there is much of constriction, the wire rope shall be discarded.

Flattenings are permanent deformation of the rope caused by crushing and cause high incidence of ruptures.

Curling deformation occurs when a loaded rope is drawn over an edge. Ropes with curly deformation shall be discarded.

Puffs are deformations of the wire rope caused by the fact that an eye-shaped rope sling is pulled in a straight line without the wire rope being able to take up the deformation by turning in its axis. Wire rope with one or more puffs shall be discarded.

Kinks are deformations of the wire rope caused by powerful external action. Wire rope with kinks shall be discarded.

8.1.5 *Action of heat* — Wire ropes that have been exposed to excessive heat (recognizable externally by tempering colour) (oxidation tint) shall be discarded. Wire ropes which are exposed to severe heat, for example, in steel works or foundries can become dried out internally which leads to a risk of internal wire rupture. In such cases the inspector should in each particular case, preferably after examination of similar ropes condemned earlier, determine the period for which the rope may be allowed to remain in use.

8.1.6 *Type, position and number of wire ruptures* — Wire ropes are bound to deteriorate when used and the wires do get ruptured. A wire rope should be discarded latest when at any place the number of visible wire ruptures reaches the values specified in Table 6.

On the occurrence of nests of wire ruptures the wire rope should be discarded. If one strand breaks, the wire rope should be immediately discarded.

8.1.7 *Abnormal stretching* — This results from untwisting of the rope, resulting in parallelling of the strand.

TABLE 6 DISCARDING OF WIRE ROPES ON THE BASIS OF WIRE RUPTURES

(*Clause* 8.1.6)

Number of Load Bearing Wires in the Outer Strand of the Rope	No. of Visible Wire Ruptures When Ready for Discarding			
	Ordinary Lay		Lang's Lay	
	Over a length of		Over a length of	
n	6*d*	38*d*	6*d*	30*d*
Up to 50	2	4	1	2
51 to 75	3	6	2	3
76 to 100	4	8	2	4
101 to 120	5	10	2	5
121 to 140	6	11	3	6
141 to 160	6	13	3	6
161 to 180	7	14	4	7
181 to 200	8	16	4	8
201 to 220	9	18	4	9
221 to 240	10	19	5	10
241 to 260	10	21	5	10
261 to 280	11	22	6	11
281 to 300	12	24	6	12
Above 300	·04 × *n*	·08 × *n*	·02 × *n*	·04 × *n*

In the case of rope constructions with specially thick wires in the outer layer of the outer strands, for example, round strand rope 6 × 19 Seale or round strand rope 8 × 19 Seale, the number of visible wire ruptures for discarding shall be 2 rows lower than the table values.

Filler wires are not considered as bearing wires. In the case of wire ropes with several strand layers, only the outer layer strands are considered as 'outer strands'. In the case of wire ropes with steel filler, the filler is considered as inner strand. The calculated numbers shall be rounded off in accordance with IS : 2 - 1960 'Rules for rounding off numerical values (*revised*)'.

'*d*' is wire rope diameter.

Note — Number of broken wires above is not the only factor in discarding a wire rope.

8.1.8 *Surface embrittlement* — The surface embrittlement refers to the embrittlement of the worn surfaces of the outer wires of a rope. It may be due to work hardening of the wire surface also known as 'plastic-wear embrittlement' or due to the formation of a martensitic skin. When a moving rope rubs heavily or some hard object, the resulting friction heat can bring the outer surface of each rope wire above the temperature of the martensite formation. When the rubbing stops, the surface will be suddenly cooled as the remainder of the wire taking the heat away. This causes a very thin layer of martensite of the order of about 3 microns to be formed on the rubbed crowns of the wire. First time the wire is bent, the martensitic surface will develop a series of cracks along or near the base central line, each mark running across the worn crown of the wire. These cracks are perfect examples of sharp edged surface irregularities and they will certainly become fatigue cracks, it is only a matter of time. Further the cracks are formed in the wire itself, not in an overhanging fin as in the case of plastic-wear cracks and, consequently, the wire is certain to break in fatigue when the fatigue crack has extended far enough into the depth of the wire. This martensitic embrittlement is an extremely dangerous form of deterioration. Fortunately it does not often affect winding ropes, because they do not normally rub against obstructions, but is relatively common in haulage ropes.

8.1.9 *Core collapse* — This seems to be of infrequent occurrence. An incipient sign would be the departure from circular shape of a rope when bent. An advanced sign would be a depressed strand. The first calls for investigation, the second for discard if the rope cannot be repaired by replacing the collapsed core.

8.1.10 *Fitting time* — If sufficienf experience is available it is possible to predict the time when the rope will require to be replaced. However, the time of replacement is determined by the criteria given in **8.1.1** to **8.1.9** explained above.

8.2 *Discarding a Wire Rope* — No rope should remain in service when it is considered that:

a) The factor of safety has become too low (when the reserve of strength is no longer sufficient to ensure that the rope can safely withstand the repeated shock loads, bends, etc).

b) The loss in rope strength due to wear, corrosion, or both is approaching one-sixth or 16 percent of the original strength (or any lower value set by the concerned engineer).

c) The loss in rope strength due to fatigue, corrosion-fatigue, or surface embrittlement or due to cracked or broken wires of any kind, is approaching one tenth of the original strength (or any lower value set by the concerned engineer).

d) The outer wires have lost about one third of their depth as a result of any form of deterioration.

e) The outer wires are becoming loose and displaced for any reason.

f) The rope has become kinked or otherwise deformed, distorted or damaged, and the affected part cannot be cut out.

g) The rope has been subjected to a severe overwind or overload or to severe shock loading, as a result of an accident if the portion of the rope so subjected cannot be cut off (as in the case of overwind above banking level).

h) The examination of the rope leaves any doubt to its safety on any grounds.

j) A rope, which is still in good condition, reaches the maximum life for its type prescribed by the manufacturer or as laid down in Regulations, if any.

APPENDIX A

(*Clause* 3.1)

INFORMATION TO BE GIVEN WITH THE ENQUIRY OR ORDER

A-1. The following particulars should be given with the enquiry or order:

a) Lengths and exact points between which the measurement is made (in the case of rope with terminal fittings);

b) Diameter;

c) Construction of rope;

d) The type of galvanizing required;

e) Preformed or non-preformed;

f) Tensile strength of wire;

g) Breaking strength of rope;

h) Whether ordinary lay or Lang's lay, right-hand or left-hand;

j) Particulars of ends and fittings, whether spliced, socketed or plain, with dimensioned sketches if limiting conditions apply;

k) Particulars of inspection and tests required;

m) Whether to be delivered on reels or in coils; and

n) No. of Indian Standard.

A-2. If the purchaser is uncertain about any of these particulars, reference should be made to the rope maker, giving detail of the use to which the rope will be put.

APPENDIX B

(*Clause* 3.1.2)

DESIGNATION OF WIRE ROPE CONSTRUCTION

B-1. A wire rope is made up of strands and a strand is made up of one or more layers of wire. The rope construction refers to the number and arrangement of strands and wires and a type of core used and is the means of adopting the rope to the particular work that will be required of it. The method discribed in **B-2** has been adopted in designating the wire rope construction in Indian Standards.

B-2. Wire rope is generally designated by the number of strands and by the number of wires in the strand. (The filler wires are not taken into account in 6 × 19 construction). It is not usual to indicate the core of the wire rope unless it is the wire main core or the independent wire rope core when the abbreviation WMC or IWRC are given after the wire rope designation. The number of strands and the number of wires are separated by a multiplication sign. Many times it is not sufficient if the number of wires in the strand are given but details of the strand construction is also required. In this case, the following procedure is adopted:

After the multiplication sign, the number of wires in each layer of the strand are given, separated by oblique sign. If the filler wires are there in the strand the number of filler wires is also indicated by separating it from the number of wires in the outer layer to that of the filler wires by a plus sign and following the number of filler wires with the letter 'F'. If the Warrington construction is used (alternatively large and small wires are used for the outer layer of the strands) the numbers indicating the number of wires in different layers are separated by word 'and'. A few examples are given in Table 4 to illustrate the procedure employed to designate the wire rope construction.

APPENDIX C

(*Clause* 7.2)

STEEL WIRE ROPE INSPECTION CARD

Implement	Application
Constructions : *Mode of lay pattern* : right/left/cross/Lang's lay *Nominal diameter*: *Tensile designation*: *White/galvanized/galvanized and traced*: *Core material*: *Well/not pre-formed or post formed*: *Rope wire length*: *Finish of rope ends*:	*Date of use*: *Date of discarding*: *True*: *Breaking load*: *Working load*: *Measured diameter*: *With a load of*:

Visible Wire Breaking	Wear and Tear of External Wire	Corro-sion	Decrease of Wire Rope Diameter	Measured and Observed Place (S)	Total Evalua-tion	Damage and Defor-mation	Date	Initials

Supplier:

Remarks:

No. of twist:

Reason for discarding:

EXPLANATORY NOTE

Wire ropes find extensive application in industry for hoisting, haulage, material handling, power transmission and other uses. To suit the work which is expected of the wire rope it is necessary that the proper type of wire rope is selected and to ensure efficient service, it is necessary that these wire ropes are installed and maintained properly.

Originally this standard was published in 1967 covering recommendations on the selection, installation and maintenance of round strand wire ropes. In the the original standard discarding factors were not explained properly which are of paramount importance in proper functioning and maintenance of wire ropes. This revision is mainly to overcome this shortcoming along with few other changes based on the revision of referred standard.

In the preparation of this standard, considerable assistance has been derived from the following publications:

a) The Ropeman's Hand Book, published by the National Coal Board of United Kingdom

b) DIN 15020 14 Blatt 2 April 1974 'Principles relating to rope drives, supervision during operation' issued by Deutsches Institut für Normung.

c) NEN 3233-1968 'Discarding of steel wireropes' issued by Nederlandse Norm.

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