

Application, Care, and Use of Wire Rope for Oil Field Service

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Application, Care, and Use of Wire Rope for Oil Field Service

1 Scope

This recommended practice (RP) covers typical wire rope applications for the oil and gas industry.

Typical practices in the application of wire rope to oil field service are indicated in Table 1, which shows the sizes and constructions commonly used. Because of the variety of equipment designs, the selection of constructions other than those shown is justifiable.

In oilfield service, wire rope is often referred to as wire line or cable. For the purpose of clarity, these various expressions are incorporated in this recommended practice.

2 Field Care and use of Wire Rope

2.1 Handling on Reel

2.1.1 Use of Binding or Lifting Chain

When handling wire rope on a reel with a binding or lifting chain, wooden blocks should always be used between the rope and the chain to prevent damage to the wire or distortion of the strands in the rope.

2.1.2 Use of Bars

Bars for moving the reel should be used against the reel flange, and not against the rope.

2.1.3 Sharp Objects

The reel should not be rolled over or dropped on any hard, sharp object in such a manner that the rope will be damaged.

2.1.4 Dropping

The reel should not be dropped. This may cause damage to the rope as well as break the reel.

2.1.5 Mud, Dirt, or Cinders

Rolling the reel in or allowing it to stand in any medium harmful to steel such as mud, dirt, or cinders should be avoided. Planking or cribbing will be of assistance in handling the reel as well as in protecting the rope against damage.

2.1.6 Lifting the Reel

The preferred method for lifting a reel with slings is to use a spreader bar that is of sufficient length to keep the sling legs from contacting the reel. This will prevent the flanges of the reel from being bent, distorted, broken, or damaged in any way by the slings.

2.1.7 Shaft through Arbor Holes

When lifting reels of wire rope, care must be taken that the shaft through the reel is of adequate length for the task, plus its wall thickness and diameter are of sufficient strength and size respectively to safely support the weight without damaging the center holes of the two flanges of the reel.

Table 1—Typical Sizes and Construction of Wire Rope for Oilfield Service

Wire Rope Application	Wire Rope Diameter		Wire Rope Description ^a
	(in.)	(mm)	
Rod and tubing lines	1/2 through 1 1/8	13 through 29	6×26WS RR or LR IWRC 6×31WS swaged RR or LR IWRC
Rod hanger lines	1/4	6.5	6×19 RR FC
Sand lines	1/4 through 5/8	6.5 through 16	6×7 bright or galvanized RR FC 5×7 bright or galvanized RR FC 5×7 swaged bright or galvanized FC
Drilling lines	7/8 through 2 1/4	22 through 57	6×19 class RR IWRC 8×19 class RR IWRC
	1 1/2 through 2 1/4	38 through 57	6×36 class RR IWRC 8×36 class RR IWRC
Winch lines	5/8 through 1 1/8	16 through 29	6×26WS or 6×31WS or 6×36WS RR IWRC
Horsehead pumping-units lines	1/2 through 1 1/8	13 through 29	6×19 class or 6×36 class FC or IWRC
Offshore anchorage lines	7/8 through 2 3/4	22 through 70	6×19 class bright/galvanized/drawn galvanized RR IWRC
	1 3/4 through 4 3/4	35 through 122	6×36 class bright/galvanized/drawn galvanized RR IWRC
Mast raising lines	Up through 1 3/8	Up through 35	6×19 class RR IWRC
	Over 1 3/8	Over 35	6×36 class RR or RL IWRC 8×36 class compacted strand RR or RL IWRC
Guideline tensioner line	3/4	19	6×19 class RR IWRC
Riser tensioner lines	1 1/2 through 3	38 through 76	6×36 class RL IWRC 8×36 class RL IWRC

These are general recommendations and may be modified due to operating conditions, rig requirements and/or rope characteristics. Consult your rope supplier for assistance.

Abbreviations:

FW	Filler wire	RR (sZ)	Right regular lay ^b	LL (sS)	Left lang lay ^c	FC	Fiber Core
S	Seale	LR (zS)	Left regular lay ^d	RA (aZ)	Right alternate lay ^e	IWRC	Independent wire rope core
WS	Warrington Seale	RL (zZ)	Right lang lay ^f	LA (aS)	Left alternate lay ^g		

^a Typical rope descriptions shown include those with compacted strands, plastic coated IWRC; plastic impregnated IWRC; and plastic impregnated rope.

^b Sometimes referred to as right-hand ordinary (designated RHO) and right regular lay (designated RRL).

^c Sometimes referred to as left-hand langs (designated LHL) or left lang lay (designated LLL).

^d Sometimes referred to as left-hand ordinary (designated LHO) and left regular lay (designated LRL).

^e Formerly designated RAL.

^f Sometimes referred to as right-hand langs (designated RHL) or right lang lay (designated RLL).

^g Formerly designated LAL.

2.2 Handling During Installation

2.2.1 Stringing of Blocks

Blocks should be strung to give a minimum of wear against the sides of sheave grooves.

2.2.2 Changing Lines and Cutoff

It is good practice in changing lines to suspend the traveling block from the crown on a single line. This tends to limit the amount of rubbing on guards or spacers, as well as chances for kinks. This practice is also very effective in pull-through and cut-off procedure.

2.2.3 Rotation of Reel

The reel should be set up on a substantial horizontal axis so that it is free to rotate as the rope is pulled off, and in such a position that the rope will not rub against derrick members or other obstructions while being pulled over the crown. A snatch block with a suitable size sheave should be used to hold the rope away from such obstructions.

2.2.4 Jacking

The use of a suitable apparatus for jacking the reel off the floor and holding it so that it can turn on its axis is desirable.

2.2.5 Tension on Rope

For proper spooling, new ropes shall be installed under tension. This will reduce rope crushing and, if the tension is sufficient, prevent the "pulling-in" of upper layers in multiple layer spooling.

2.2.6 Twist in Rope

When installing a new rope, it is important that twist or torque not be in the installed rope. If twist or torque is apparent, the twist should be removed before the rope is anchored.

2.2.7 Kinking

Care should be taken to avoid kinking a wire rope since a kink is cause for removal of the wire rope or damaged section.

2.2.8 Striking with Hammer

Wire ropes should not be struck with any object such as a steel hammer, derrick hatchet, or crow bar which may cause wire displacement and distortion. Even when a soft metal hammer is used, it should be noted that a rope can be damaged by such blows. Therefore, when it is necessary to crowd wraps together, any such operation should be performed with the greatest of care; and a block of wood should be interposed between the hammer and rope.

2.2.9 Cleaning

The use of solvent may be detrimental to a wire rope. If a rope becomes covered with dirt or grit, it should be cleaned with a brush and followed by appropriate lubrication as necessary.

2.2.10 Excess or Dead Wraps

After properly securing the wire rope in the drum socket, the number of excess or dead wraps or turns specified by the equipment manufacturer should be maintained. For rigs with motion compensating equipment, enough additional rope shall be spooled on the drum to maintain the minimum number of dead wraps when the rope required by the compensator is at its maximum.

2.2.11 New Wire Rope

Whenever possible, a new wire rope should be run under controlled loads and speeds for a short period after it has been installed. This will help seat the strands around the core and adjust the rope to working conditions.

2.2.12 New Coring or Swabbing Line

If a new coring or swabbing line is excessively wavy when first installed, two to four sinker bars may be added on the first few trips to straighten the line.

2.3 Care of Wire Rope

2.3.1 Handling

The recommendations for handling as given in 2.1 and 2.2, inclusive, should be observed at all times during the life of the rope.

2.3.2 Storage

The storage reel shall be protected from weather, chemical fumes, steam, brine, and any other corrosive agents. The rope on the storage reel should not be in direct contact with the deck or the ground.

2.3.3 Design Factor

2.3.3.1 The design factor is determined by the following formula:

$$\text{Design Factor} = \frac{B}{W} \quad (1)$$

where

B is the minimum breaking force (MBF) of the new wire rope, lb;

W is the fast line tension, lb (see 2.3.3.4).

2.3.3.2 When a wire rope is operated close to the minimum design factor, care should be taken that the rope and related equipment are in good operating condition. At all times, the operating personnel should use diligent care to minimize shock, impact, and acceleration or deceleration of loads. Successful field operations indicate that the design factors in Table 2 should be regarded as minimum.

Table 2—Minimum Design Factors

Operation	Minimum Design Factor
Sand line	3
Rotary drilling line	3
Hoisting service other than rotary drilling	3
Mast raising and lowering line	2.5
Rotary drilling line when setting casing	2
Pulling on stuck pipe, setting the BOP with the drilling line, and similar infrequent operations	2



2.3.3.3 Wire rope life varies with the design factor; therefore, longer rope life can generally be expected when relatively high design factors are maintained.

2.3.3.4 To calculate the design factor for multipart string-ups, use Figure 1 and Figure 2 to determine the value of W in Equation (1). W is the fast line tension and equals the fast line factor times the hook load or weight indicator reading.

NOTE The fast line factor is calculated considering the tensions needed to overcome sheave-bearing friction.

EXAMPLE

Drilling Line = 1³/₈ in. (35 mm) EIPS
 Number of Lines = 10
 Hook Load = 400,000 lb (181.4 t)

Sheaves are roller bearing type. From Figure 1, Case A, the fast line factor is 0.123. The fast line tension is then 400,000 lb (181.4 t) 0.123 = 49,200 lb (22.3 t) W . Following the formula in Equation (1), the design factor is then the nominal strength of 1³/₈ in. (35 mm) EIPS drilling line divided by the fast line tension, or 192,000 lb (87.1 t) ÷ 49,200 lb (22.3 t) = 3.9.

2.3.3.5 Consideration should be given to the efficiencies of wire rope bent around sheaves, fittings, or drums. Figure 3 shows how rope can be affected by bending. Section 3.7 should be consulted for sheave diameter variations for different service applications.

EXAMPLE

Mast Raising Bridle Line = 1¹/₄ in. (31.75 mm) EIPS, 6X19 Class IWRC, bright (nongalvanized)
 Equalizer Sheave Tread Diameter = 33³/₄ in. (857.25 mm)
 Bridle Line Tension = 60,000 lb (27.2 t)

EXAMPLE Sheave D/d is 33.75 in. (857.25 mm) ÷ 1.25 in. (31.75 mm) = 27. From Figure 3, the wire rope efficiency = 0.96 for a 27 D/d. Following the formula in Equation (1), the design factor is then the nominal strength of 1¹/₄ in. (31.75 mm) EIPS bridle line divided by the bridle line tension and multiplied by the wire rope efficiency, or (159,800 lb (72.5 t) ÷ 60,000 lb (27.2 t)) × 0.96 = 2.55.

NOTE If a load is applied sufficiently slowly, the inertia forces (Newton's first law of motion) can be ignored and the analysis can be simplified as a static analysis.

2.3.4 Winding on Drums

Rope should be kept tightly and evenly wound on the drums. Sufficient tension must be applied to the dead wraps on the drill line after making a cut or during installation to prevent it being forced from the lagging and crushed or damaged.

2.3.5 Application of Loads

Sudden, severe stresses are injurious to wire rope, and such applications should be reduced to a minimum. Application of severe shock or jerking load(s) can have (but are not limited to) the following consequences: reduced working life, loss of strength, permanent wire rope damage, and/or sudden failure due to overload.

2.3.6 Operating Speed

Experience has indicated that wear increases with speed; economy results from moderately increasing the load and diminishing the speed.

2.3.7 Rope Speed

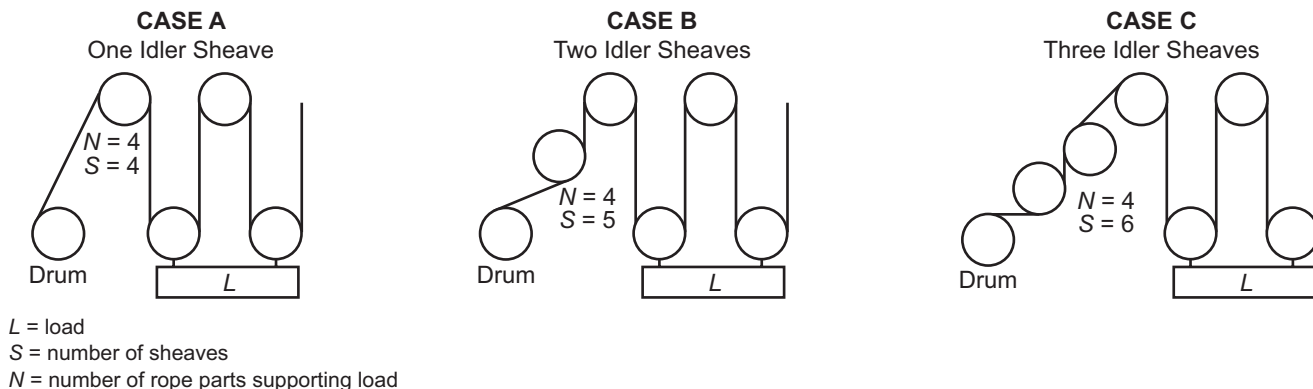
High speeds when running blocks under light load may cause damage to the wire rope. “Whipping” of the wire rope may cause contact with sheave guards or other structural members.

2.3.8 Lubrication of Wire Rope

Wire ropes are well lubricated when manufactured; however, the lubrication will not last throughout the entire service life of the rope. Periodically, therefore, the rope will need to be field lubricated. When necessary, lubricate the rope with a compatible lubricant which will penetrate and adhere to the rope, and which is free from acid or alkali.

2.3.9 Clamps and Rotary Line Dead-End Tie Down

The clamps used to fasten lines for dead-ending shall not kink, flatten, or crush the rope. The rotary line dead-end tie down is equal in importance to any other part of the system. The deadline anchorage system shall be equipped with a drum and clamping device strong enough to withstand the loading, and designed to prevent damage to the wire line that would affect service over the sheaves in the system. Consideration should be given to adding a second clamp at the deadline anchor when a plastic filled drill line is used to further reduce the likelihood of slippage.



$$\text{Fast Line Tension} = \text{Fast Line Factor} \times \text{Load}$$

1	2	3	4	5	6	7	8	9	10	11	12	13
N	Plain Bearing Sheaves $K = 1.09^a$						Roller Bearing Sheaves $K = 1.04^a$					
	Efficiency			Fast Line Factor			Efficiency			Fast Line Factor		
	Case A	Case B	Case C	Case A	Case B	Case C	Case A	Case B	Case C	Case A	Case B	Case C
2	0.880	0.807	0.740	0.568	0.620	0.675	0.943	0.907	0.872	0.530	0.551	0.573
3	0.844	0.774	0.710	0.395	0.431	0.469	0.925	0.889	0.855	0.360	0.375	0.390
4	0.810	0.743	0.682	0.309	0.336	0.367	0.907	0.873	0.839	0.275	0.287	0.298
5	0.778	0.714	0.655	0.257	0.280	0.305	0.890	0.856	0.823	0.225	0.234	0.243
6	0.748	0.686	0.629	0.223	0.243	0.265	0.874	0.840	0.808	0.191	0.198	0.206
7	0.719	0.660	0.605	0.199	0.217	0.236	0.857	0.824	0.793	0.167	0.173	0.180
8	0.692	0.635	0.582	0.181	0.197	0.215	0.842	0.809	0.778	0.149	0.154	0.161
9	0.666	0.611	0.561	0.167	0.182	0.198	0.826	0.794	0.764	0.134	0.140	0.145
10	0.642	0.589	0.540	0.156	0.170	0.185	0.811	0.780	0.750	0.123	0.128	0.133
11	0.619	0.568	0.521	0.147	0.160	0.175	0.796	0.766	0.736	0.114	0.119	0.123
12	0.597	0.547	0.502	0.140	0.152	0.166	0.782	0.752	0.723	0.107	0.111	0.115

Figure 1—Efficiency of Wire Rope Reeving for Multiple Sheave Blocks Cases A, B, and C (Fast Line and Efficiency Factors for Derricks, Booms, etc.)

13	0.576	0.528	0.485	0.134	0.146	0.159	0.768	0.739	0.710	0.100	0.104	0.108
14	0.556	0.510	0.468	0.128	0.140	0.153	0.755	0.725	0.698	0.095	0.098	0.102
15	0.537	0.493	0.452	0.124	0.135	0.147	0.741	0.713	0.685	0.090	0.094	0.097
16	0.520	0.477	0.437	0.120	0.131	0.143	0.728	0.700	0.673	0.086	0.089	0.093
17	0.503	0.461	0.423	0.117	0.128	0.139	0.716	0.688	0.662	.0082	0.085	0.089
18	0.486	0.446	0.409	0.114	0.124	0.136	0.703	0.676	0.650	0.079	0.082	0.085
19	0.471	0.432	0.396	0.112	0.122	0.133	0.691	0.665	0.639	0.076	0.079	0.082
20	0.456	0.419	0.384	0.110	0.119	0.130	0.680	0.653	0.628	0.074	0.077	0.080

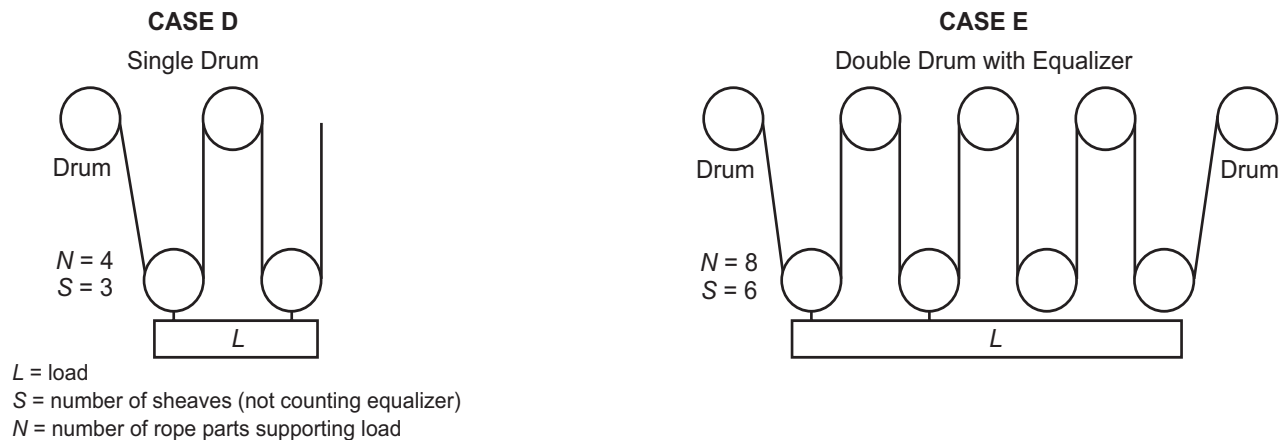
NOTE These cases apply also where the rope is dead ended at the lower or traveling block or derrick floor after passing over a dead sheave in the crown.

^a In these tables, the K-factor for sheave friction is 1.09 for plain bearings and 1.04 for roller bearings. Other K-factors can be used if recommended by the equipment manufacturer.

$$\text{Efficiency} = \frac{K^N - 1}{K^S N (K - 1)}$$

$$\text{Fast Line Factor} = \frac{1}{N \times \text{Efficiency}}$$

Figure 1—Efficiency of Wire Rope Reeving for Multiple Sheave Blocks Cases A, B, and C (Fast Line and Efficiency Factors for Derricks, Booms, etc.)



	Efficiency		Fast Line Factor		Efficiency		Fast Line Factor	
N	Case D	Case E	Case D	Case E	Case D	Case E	Case D	Case E
2	0.959	1.000	0.522	0.500	0.981	1.000	0.510	0.500
3	0.920	—	0.362	—	0.962	—	0.346	—
4	0.883	0.959	0.283	0.261	0.944	0.981	0.265	0.255
5	0.848	—	0.236	—	0.926	—	0.216	—
6	0.815	0.920	0.205	0.181	0.909	0.962	0.183	0.173
7	0.784	—	0.182	—	0.892	—	0.160	—
8	0.754	0.883	0.166	0.142	0.875	0.944	0.143	0.132
9	0.726	—	0.153	—	0.859	—	0.129	—
10	0.700	0.848	0.143	0.118	0.844	0.926	0.119	0.108
11	0.674	—	0.135	—	0.828	—	0.110	—
12	0.650	0.815	0.128	0.102	0.813	0.909	0.102	0.092

Figure 2—Efficiency of Wire Rope Reeving for Multiple Sheave Blocks Cases D and E (Fast Line and Efficiency Factors for Derricks, Booms, etc.)

13	0.628	—	0.123	—	0.799	—	0.096	—
14	0.606	0.784	0.118	0.091	0.785	0.892	0.091	0.080
15	0.586	—	0.114	—	0.771	—	0.086	—
16	0.566	0.754	0.110	0.083	0.757	0.875	0.083	0.071
17	0.548	—	0.107	—	0.744	—	0.079	—
18	0.530	0.726	0.105	0.077	0.731	0.859	0.076	0.065
19	0.513	—	0.103	—	0.719	—	0.073	—
20	0.498	0.700	0.101	0.071	0.707	0.844	0.071	0.059

NOTE The above cases apply also where the rope is dead ended at the lower or traveling block or derrick floor after passing over a dead sheave in the crown.

^a In these tables, the K -factor for sheave friction is 1.09 for plain bearings and 1.04 for roller bearings. Other K -factors can be used if recommended by the equipment manufacturer.

$$\text{Case D Efficiency} = \frac{(K^N - 1)}{K^S N (K - 1)} \quad \text{Case E Efficiency} = \frac{2 \left(K^{\frac{N}{2}} - 1 \right)}{K^{\frac{S}{2}} N (K - 1)}$$

$$\text{Fast Line Factor} = \frac{1}{N \times \text{Efficiency}} \quad \text{Fast Line Factor} = \frac{1}{N \times \text{Efficiency}}$$

Figure 2—Efficiency of Wire Rope Reeving for Multiple Sheave Blocks Cases D and E (Fast Line and Efficiency Factors for Derricks, Booms, etc.)

2.3.10 Wire Breakage from Martensite in Drilling Lines

Care should be taken to maintain proper winding of rotary drilling lines on the drawworks drum in order to avoid excessive friction which may result in the formation of martensite. Martensite may be formed by excessive friction at kick over points on the drum, in worn grooves of sheaves, slippage in sheaves, or friction resulting from rubbing against a derrick member. A line guide should be employed between the drum and the fast line sheave to reduce vibration and keep the drilling line from rubbing against the derrick. On rigs with motion compensations, the high line speeds and sudden direction reversals can cause rope slippage in sheave grooves which can result in martensite formation.

NOTE 1 Martensite is a hard, nonductile micro constituent that is formed when steel is heated above its critical temperature and cooled rapidly. In the case of steel of the composition conventionally used for rope wire, martensite can be formed if the wire surface is heated to a temperature near or somewhat excess of 1400 °F (760 °C), and then cooled at a comparatively rapid rate. The presence of a martensite film at the surface of the outer wires of a rope that has been in service is evidence that sufficient frictional heat has been generated on the crown of the rope wires to momentarily raise the temperature of the wire surface to a point above the critical temperature range of the steel. The heated surface is then rapidly cooled by the adjacent cold metal within the wire and the rope structure and effective quenching results.

NOTE 2 Detail A of Figure 4 shows a rope, which has developed fatigue fractures at the crown in the outer wires, and Detail B of Figure 4 shows a photomicrograph (100× magnification) of a specimen cut from the crown of one of these outer wires. This photomicrograph clearly shows the depth of the martensitic layer and the cracks produced by the inability of the martensite to withstand the normal flexing of the rope. The initial cracks in the martensitic layer cause the failures appearing on the crown of the outer wires of this rope. The result is a disappointing service life for the rope. Most outer wire failures may be attributed to the presence of martensite, if this hard constituent is known to have been formed.

2.3.11 Worn Sheave and Drum Grooves

Worn sheave and drum grooves cause excessive wear on the rope.

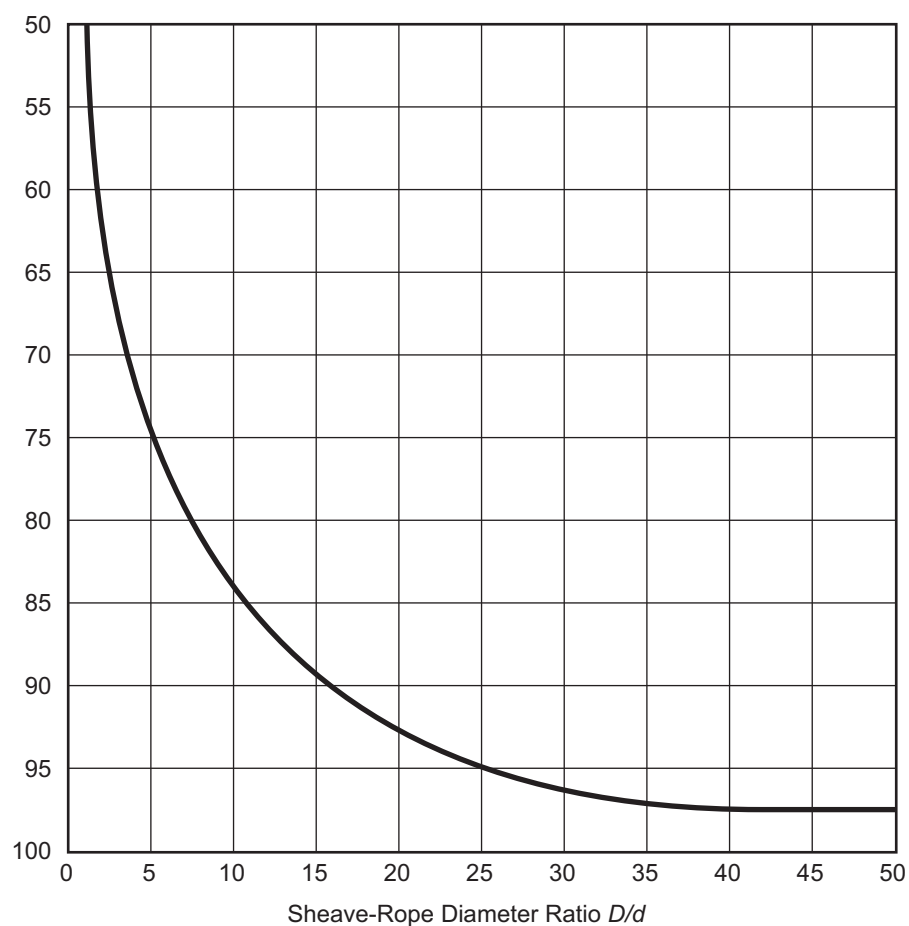
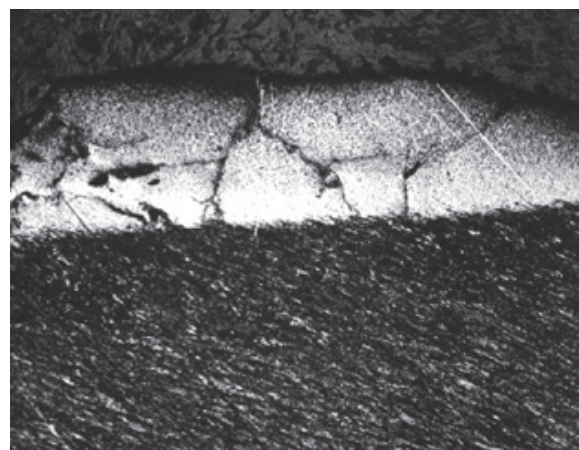
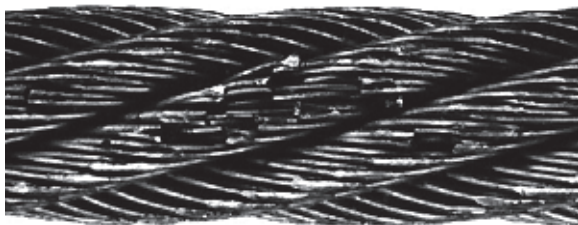


Figure 3—Efficiencies of Wire Ropes Bent Around Stationary Sheaves (Static Stresses Only)



NOTE See 2.3.11.

Figure 4—Fatigue Fractures in Outer Wires Caused by the Formation of Martensite

2.3.12 Sheave Alignment

All sheaves should be in proper alignment. The fast sheave should line up with the center of the hoisting drum. Proper alignment is achieved when fleet angles between sheaves and the ends of the wire rope drums are between 0.5° and 1.5° (see 2.7.1).

2.3.13 Sheave Grooves

From the standpoint of wire rope life, the condition and contour of sheave grooves are important and should be checked periodically. The sheave groove should have a radius not less than that in Table 7; otherwise, a reduction in rope life can be expected. Reconditioned sheave grooves should conform to the recommended radii for new sheaves as given in Table 7. Each operator should establish the most economical point at which sheaves should be re-grooved or replaced by considering the loss in rope life which will result from worn sheaves as compared to the cost involved. Consult the sheave manufacturer for guidance on the re-grooving of their sheaves.

2.3.14 Installation of New Rope

When a new rope is to be installed on used sheaves, it is particularly important that the sheave grooves be checked as recommended in 2.3.13.

2.3.15 Lubrication of Sheaves

To ensure a minimum turning effort and smooth rotation, all sheaves should be kept properly lubricated.

2.3.16 Sheave Bearings

Sheave bearings must maintain sheave alignment.

2.4 Seizing

2.4.1 Seizing Prior to Cutting

Prior to cutting, a wire rope should be securely seized on each side of the cut by serving with soft wire ties. For socketing, at least two additional seizings should be placed at a distance from the end equal to the length of the basket of the socket. The total length of the seizing should be at least two rope diameters and securely wrapped with a seizing iron. This is very important, as it prevents the rope from untwisting and insures equal tension in the strands when the load is applied.

2.4.2 Procedure

A recommended procedure for seizing a wire rope is as follows and is illustrated in Figure 5.

- a) The seizing wire should be wound on the rope by hand as shown in Detail 1. The coils should be kept together and considerable tension maintained on the wire.
- b) After the seizing wire has been wound on the rope, the ends of the wire should be twisted together by hand in a counterclockwise direction so that the twisted portion of the wires is near the middle of the seizing (see Detail 2).
- c) Using "Carew" cutters, the twist should be tightened just enough to take up the slack (see Detail 3). Tightening the seizing by twisting should not be attempted.
- d) The seizing should be tightened by prying the twist away from the axis of the rope with the cutters as shown in Detail 4.
- e) The tightening of the seizing as explained in c and d above should be repeated as often as necessary to make the seizing tight.
- f) To complete the seizing operation, the ends of the wire should be cut off as shown in Detail 5, and the twisted portion of the wire tapped flat against the rope. The appearance of the finished seizing is illustrated in Detail 6.