National Safety Council
Data Sheet I-380 Rev. June 2006

Recommended loads for wire rope slings

Wire rope slings, the hazards surrounding their use, and safety measures or alternatives to avoid injury will be covered in this data sheet.

2. Wire rope made from improved plow steel and extra plow steel is recommended in the construction of slings. Conditions can affect or alter the strength and rated capacity of the wire rope, such as broken or frayed wire(s), corrosion, kinks, etc. Therefore, use only wire rope in manufactured approved condition in the construction of slings.

Wire rope, construction and size

3. It is preferable to make wire rope slings from improved plow steel or extra-improved plow steel, and from preformed wire rope with an independent wire rope core. This type increases the strength of the rope about 7-½ percent over wire rope with a fiber core. Wire core wire rope will withstand temperatures up to about 400° F for a limited time, but corrodes when exposed to acids and other chemicals. (OSHA regulation 1910.1 84[f][3] states "fiber core ropes of all grades shall be permanently removed from service if exposed to temperatures in excess of 200° F.")

4. Ropes used for slings vary in size from ¼ inch to 4 inches. Because flexibility is essential, the 6 by 19 classification is used when service requires a rope 1-⅛ inch or smaller. The 6 by 37 classification is used for slings made from larger rope. The larger wires in the 6 by 19 construction resist abrasion more effectively than the smaller wires in the 6 by 37 construction (Figure 1).

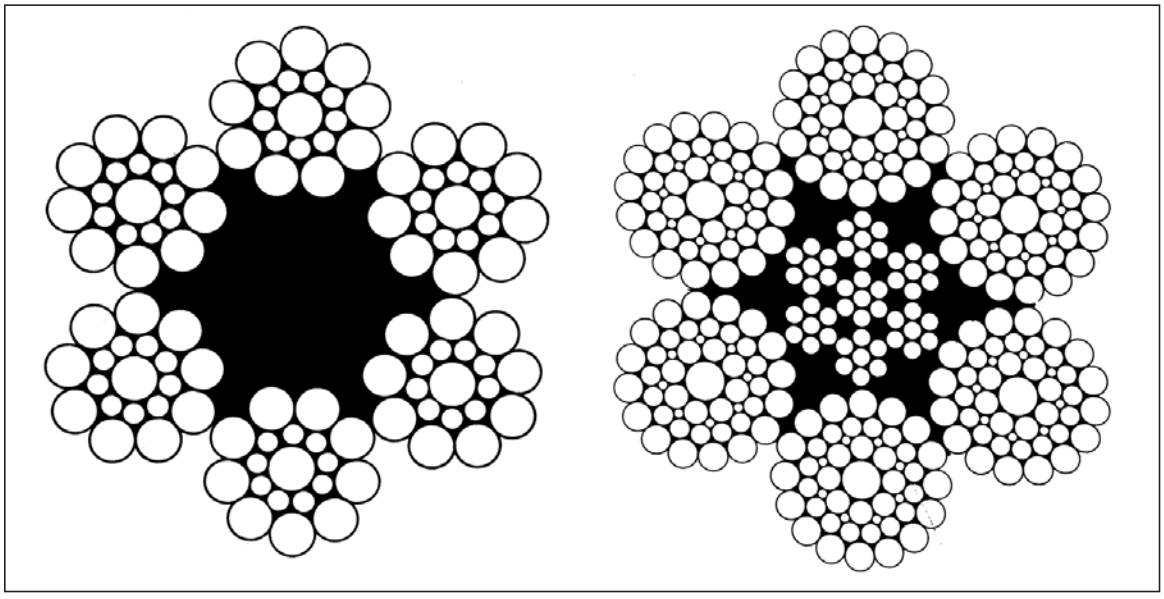

Figure 1. Wire rope is made from large numbers of individual wires, most of which are not exposed. This, plus the fact that wires are continuous in any given length of rope, accounts for the high degree of dependability and uniformity. Cross sections show usual 6 by 19 rope containing 114 wires (left) and 6 by 37 classification rope made up of 313 separate wires (at right).

(Courtesy John A. Roebling's Sons Co., Subsidiary of the Colorado Fuel and Iron Corp.)

Table 1. Number and spacing of clips for ropes of various sizes.

Diameter of Rope (inches)	Minimum Number of Clips	Length of Rope Turned Back Exclusive of Eye (inches)	Torque (ft-lb)
⅛	2	3 ¼	-
¼	2	3 ¼	-
½	3	11 ½	65
⅝	3	12	95
¾	4	18	130
⅞	4	19	225
1	5	36	225
1 ⅛	6	34	225
1 ¼	7	44	360
1 ⅜	7	44	360
1 ½	8	54	360
1 ⅝	8	58	430
1 ¾	8	61	590
2	8	71	750
2 ¼	8	73	750

The above was taken from the National Safety Council's "Accident Prevention Manual, 9th ed."

5. Preformed wire rope does not unravel, and therefore has advantages for use in slings. It is less likely to set or kink, and broken wires do not "wicker" or stick out, creating a hazard to hands when handling the slings. However, closer inspection is necessary to detect broken wires in preformed wire rope.

6. Braided slings are achieving wide popularity in a large number of industries as a safe, economical and satisfactory type of sling for many different uses (Figure 2). By the nature of its construction, the braided sling is flexible and resistant to kinking. These characteristics make it easy to handle, especially in the larger sizes. The construction of the braided sling allows easy and thorough inspection of its parts, so its condition can be readily known, with greater assurance of safety. Another feature of these slings is they have little tendency to twist when free-end loads are handled.

Figure 2. Braided slings are resistant to kinking. Be sure loads are hoisted uniformly and all slings have a minimum safety factor of five.

Method of attachment

7. The method of connecting the rope to fittings such as sockets, clips and thimbles is an important element in the strength of

a sling (Figure 3). When properly made, various types of attachments develop from 70-100 percent of the breaking strength of the rope (Figure 4). A rope may have a breaking strength of 11.5 tons, but the attachment may be of a type that generally fails when the load is 9.2 tons, giving the attachment an efficiency of 80 percent. Manufacturers also specify fittings of suitable size and design for ropes of different sizes. The strength of an attachment is attained only when the connection is made exactly to the manufacturer's instructions.

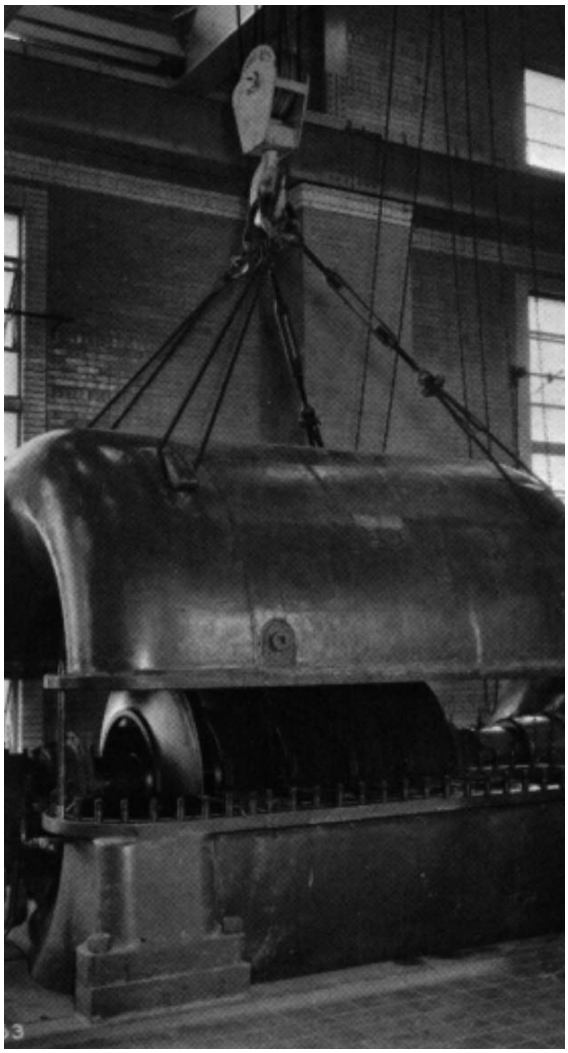

Figure 3. This method of lifting turbine covers provides strength to the sling.
(Courtesy John A Roebling's Sons Co.)

8. Several methods of attachment have developed the full strength of the rope and have the additional advantages of compactness. One of the most common methods is socketing the rope in a fitting with zinc. The socketing should be done exactly to the manufacturer's directions to develop 100 percent strength, equal to the rope. There are also several kinds of swaged (compression) fittings that are 100 percent effective and very compact; they are made only by the manufacturer (Figure 5).

9. Hand-tucked splices, depending on the type, typically develop 80 percent of the nominal strength of rope in sizes up to 7/8 inch in diameter. The efficiency of the splice for ropes larger than 7/8 inch in diameter remains constant at 80 percent. This type of splice also is preferably made at the factory. Do not allow a hand-tucked splice to contact the load or be used as a choker.

10. Clips and clamps are made to fit ropes of different sizes and have the advantage of being readily applied in the field when improvising a sling becomes necessary. However, this method of attachment is less efficient than the hand-tucked splice. Its holding power and efficiency depend on the type and number of slips used, and whether the clips are inspected and tightened regularly (Table 1). Plate clamps of special types often are used for handling steel plate, flanged castings and similar products. The horizontal type equals the lifting capacity of other brindle slings. However, the use of vertical clamps reduces the capacity of the sling by one-third.

11. Square and other types of knots have very low efficiency, and the use of knots in an improvised sling in the field is highly dangerous and not recommended.

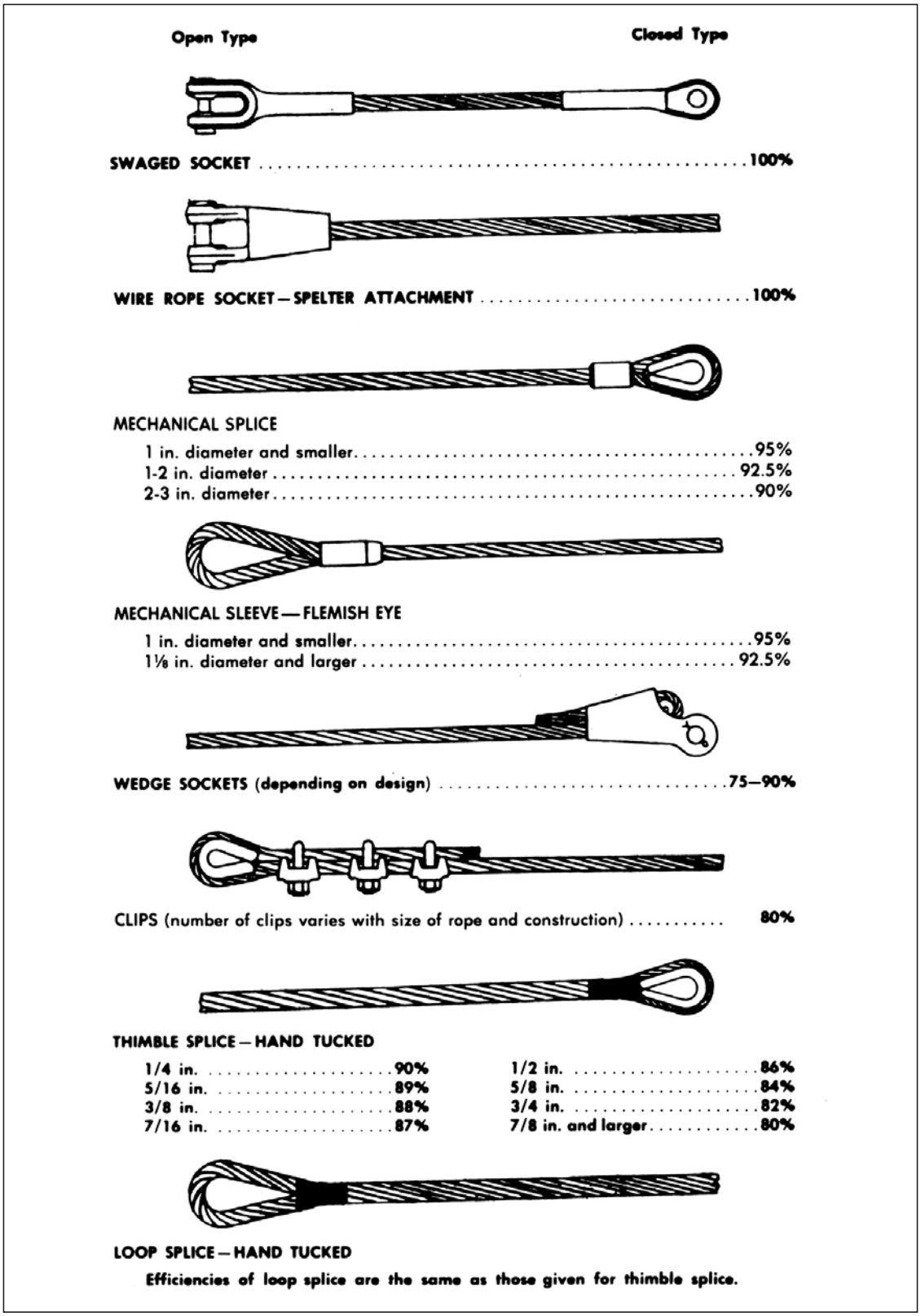

Figure 4. Varying efficiencies of attaching wire rope to fittings are shown in percentage strength of rope.

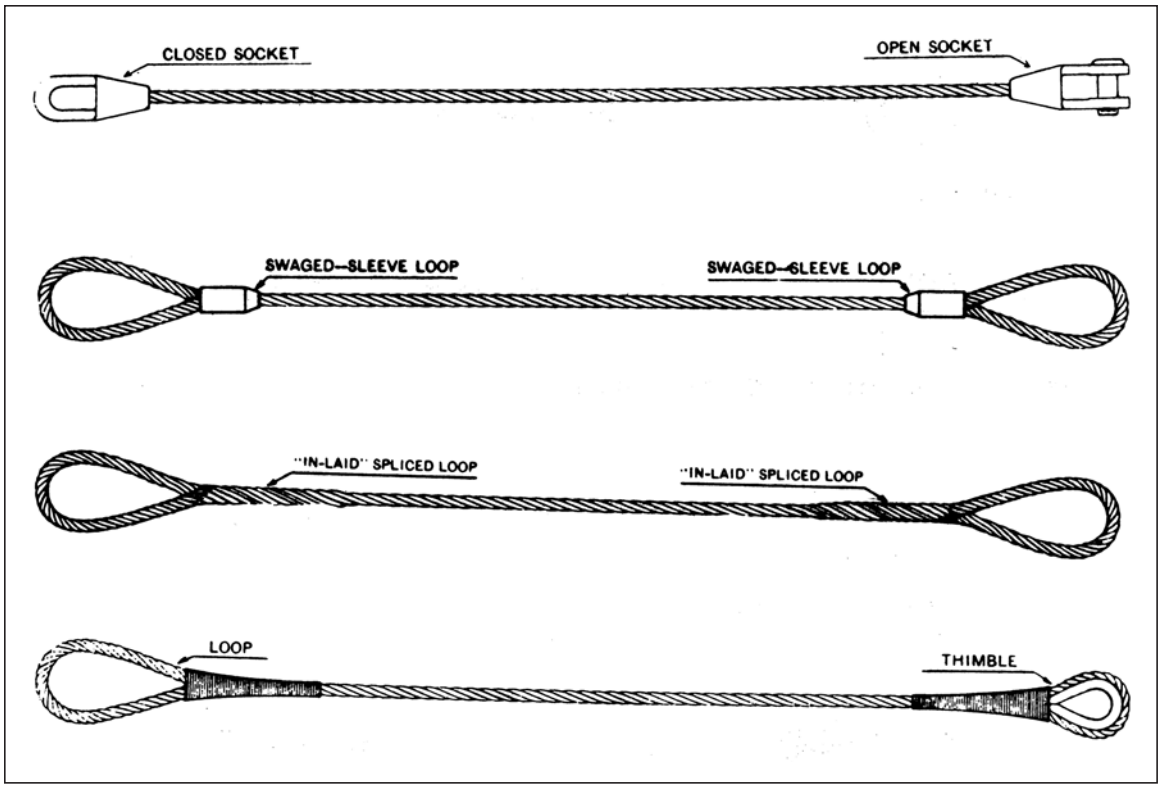

Figure 5. Standard single wire rope slings showing various methods of attachment to different end fittings *(Courtesy A. Leschen & Sons Rope Co.)*

Hitches

12. In addition to the strength of the rope and the efficiency of the attachment, the rated capacity limit of a sling depends on the hitch or method of applying a sling to the load. The rated capacity of a single rope sling with link, hook ends and compression fittings is approximately 2.3 tons. If two such slings are used with a spreader, the safe load is doubled, or 4.6 tons.

13. The kind of hitch depends on the kind of material to be lifted; the type, length and safe load limit of the sling; whether lugs are available on the load; headroom; and many other factors. The most desirable type of hitch eliminates contact between the rope and the load, or permits contact with a smooth rounded surface. Pads or saddles between sharp corners of the load and rope greatly help to eliminate severe bending stresses. Avoid sharp edges together with abrupt bends in hitching.

Safety factors

14. If the end of a single rope sling is attached to the hook of a crane and the other end is attached to the load, such as by hook, the recommended load is nominally one-fifth of the breaking strength of the rope providing the method of attachment is less than 100 percent, then the rated capacity can be found by using the following equation:

$$S = \frac{BXE}{5^*}$$

Where: S = safe load limit
B = breaking strength
E = efficiency of attachment

** Safety factor for wire rope slings under ordinary conditions of use, as adopted by the Wire Rope Technical Board.*

15. The frequently used choker hitch requires a reduction of approximately 25 percent in the rated capacity of a sling. This hitch is made by passing one end of a sling around the load, through the loop or thimble of the other end and then over the hook of the crane. Fittings may be obtained to reduce the severe bending and wear due to the choking action at the end.

Types of slings

16. Two, three or four single-leg slings make up a bridle sling. The safe lifting capacity depends on the number of legs and the angle formed by the legs. The capacity of a two-leg sling, with each leg vertical, is twice the load for a similar single-leg vertical lift. A basket hitch (made by attaching one end of a single rope sling to the crane hook, passing the sling around the load and then attaching the other end to the crane hook) has equal capacity when both legs form a U, providing the minimum radius of bend in the rope at the point of load contact is 20 times the diameter of the rope (Figure 6).

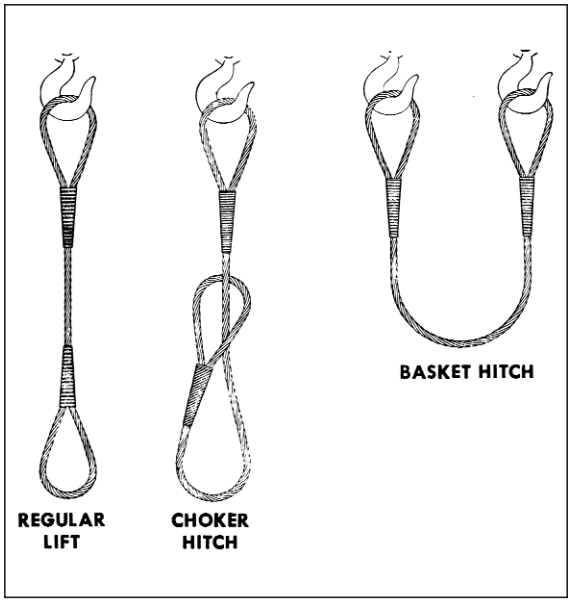

Figure 6. Frequently used hitches. Allowances in load capacity of sling should be made for different types of hitches.
(Courtesy Bethlehem Steel Co.)

17. The larger the spread of the legs of a two-leg bridle sling or basket hitch, the greater the stress on each leg and, therefore, the lower the capacity. If the spread of either sling is 60 degrees, each leg forms a 30-degree angle with a line projected vertically downward through the hook.

18. The safe load limit for the 30-degree angle is 13 percent less than if both legs were vertical. The safe load limit drops 29 percent when the vertical angle formed by a leg and vertical line through the crane hook is 45 degrees. For a spread of 120 degrees or a vertical angle of 60 degrees the safe load limit is decreased 50 percent. Safe load limits for any angle from vertical may be found from the following list:

Vertical Angle (One leg and vertical line thru crane hook) (degrees)	Percentage decrease in safe load limit (percent)
10	2
20	6
30	13
40	23
50	36
60	50
70	66
80	83

19. It is advisable to increase by about one-fourth the percentage decreased in safe loads when a basket hitch is used on an angular load that produces sharp bends in the rope and, therefore, larger bending stresses.

20. Excessive angles can be avoided by using longer slings, if headroom permits. Thus, increased loads can be handled.

21. The recommended load for a three-leg sling is 50 percent more than the safe load

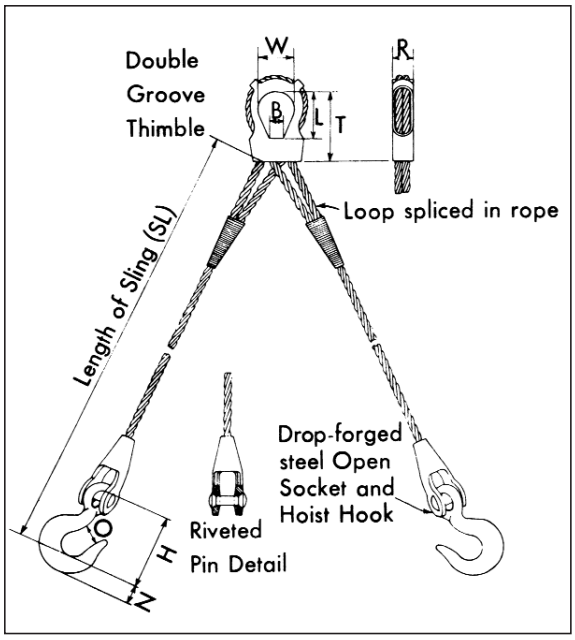

Figure 7. Essential dimensions should be given when ordering slings.
(Courtesy Bethlehem Steel Co.)

limit for a two-leg sling at the same angle. For a four-leg sling, the recommended load is 100 percent more than that of a two-leg sling at the same angle (Figure 7).

Acknowledgment

This data sheet was revised by the Construction Division of the National Safety Council, 1121 Spring Lake Drive, Itasca, IL 60143.

Sources of information

"WRTB Sling Manual," Wire Rope Technical Board, 801 N. Fairfax St., Suite 211, Alexandria, VA 22314.

American National Standards Institute, 1819 L Street, N.W., 6th Floor Washington, DC 20036:

Safety Code for Cranes, Derricks, Hoists, Jacks and Slings, B30 Series.

Safety Code for Elevators. Dumbwaiters, Escalators and Moving Walks, A17.l

Safety Color Code for Marking Physical Hazards, Z53. l

Table 2. Nominal breaking strength in tons of steel (EIPS) ropes improved plow steel (IPS) and extra improved plow

Diameter (in.)	6x19 & 6x37			8x19			19x7	
	IPS[1]		EIPS[2]	IPS		EIPS	IPS	EIPS
	FC[3]	IWRC[4]	IWRC	FC	IWRC	IWRC	FC	IWRC
3/8	6.10	6.56	7.55	5.24	5.76	6.63	5.59	6.15
7/16	8.27	8.89	10.2	7.09	7.80	8.97	7.58	8.33
1/2	10.7	11.5	13.3	9.23	10.1	11.6	9.85	10.8
9/16	13.5	14.5	16.8	11.6	12.8	14.7	12.4	13.6
5/8	16.7	17.9	20.6	14.3	15.7	18.1	15.3	16.8
3/4	23.8	25.6	29.4	20.5	22.5	25.9	21.8	24.0
7/8	32.2	34.6	39.8	27.7	30.5	35.0	29.5	32.5
1	41.8	44.9	51.7	36.0	39.6	45.5	38.3	42.2
1 1/8	52.6	56.5	65.0	45.3	49.8	57.3	48.2	53.1
1 1/4	64.6	69.4	79.9	55.7	61.3	70.5	59.2	65.1
1 3/8	77.7	83.5	96.0	67.1	73.8	84.9	71.3	78.4
1 1/2	92.0	98.9	114	79.4	87.3	100	84.4	92.8
1 5/8	107	115	132					
1 3/4	124	133	153					
1 7/8	141	152	174					
2	160	172	198					
2 1/8	179	192	221					
2 1/4	200	215	247					

IPS[1] = Improved plow steel **EIPS[2] = Extra improved plow steel**
FC[3] = Fiber core **IWRC[4] = Independant wire rope core**

The above was taken from the National Safety Council's "Accident Prevention Manual for Business & Industry. Engineering & Technology, 10th Ed."

Specifications for the Use of Wire Ropes for Mines. MI 1.1

American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005: Recommended Practice on *Application. Care and Use of Wire Rope for Oil-Field Service,* Code No. API-RP-9B.

Broderick & Bascom Rope Co., 10440 Trenton Ave., St. Louis, MO 63132:

Riggers' Handbook, current edition.

Wire Rope Handbook, current edition.

Electric Controller and Manufacturing Co., 2759 Old Belleville Road, St. Matthews, SC 29135: *"How To Operate a Crane,"* Booklet 920.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169.

National Electrical ANSI/NFPA 70.

Flammable and Combustible Liquids Code, NFPA 30.

National Safety Council: *"Accident Prevention Manual for Business & Industry, Engineering & Technology, current edition".*

Code of Federal Regulations, Title 29 – Labor, Part 1910. Washington, DC: U.S. Government Printing Office.

Rossnagel. W.E., *"Handbook of Rigging,"* New York: McGraw-Hill.

U. S. Department of the Interior, Washington, DC 20240. *Recommended Procedures for Mine Hoists and Shaft Installation, Inspection and Maintenance,* Information Circular 8031.

American Iron and Steel Institute, Committee of Wire Rope Producers, 1140 Connecticut Ave., N.W., Washington, DC 20036.