Introduction

The drilling line is a machine. It is an assembly of precision parts, each can move independently, requires lubrication, is static until an external force is applied and it transmits energy.

The information that follows will guide you in the selection, care and use of drilling lines. Instructions are included for attaching wire rope clips, socketing wire rope, seizing wire rope, etc.

To keep the wire line costs at a minimum, the rig crews and all levels of operations management should know how to obtain maximum safe life from the drilling line. The following is basic to that objective.

A. Select the proper size and type line to meet the requirements.
B. Care for the line to prevent damage.
C. Compute the service obtained from the line in Ton-Miles.
D. Choose a cut-off program that best suits your conditions and follow it carefully. This will greatly increase the service obtained from the line.

When a new line is received, the reel number, make and description of the line should be recorded on the daily drilling report.

The ton-mile service should be computed daily and a record kept so cut-offs can be made after a proper interval of service.

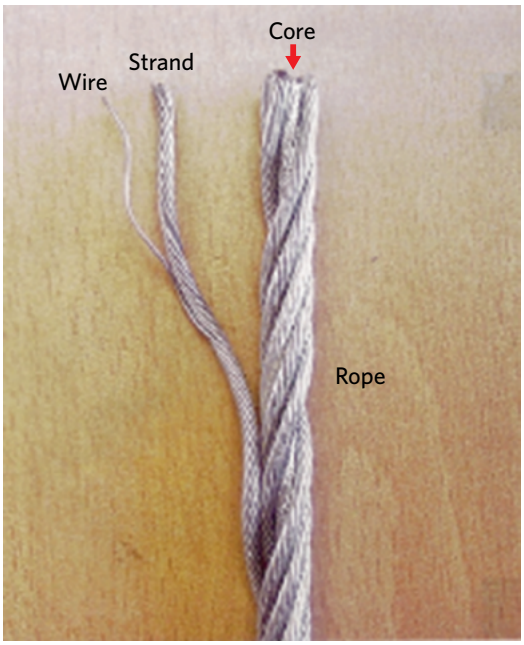

Figure WR-1: Anatomy of wire rope, showing core, strand and wire, which comprise the rope.

Definition

Drilling lines and wire lines are known as and are used interchangeably with the term "wire rope". Reference to all three of these terms will be prevalent throughout this manual.

Wire rope is an intricate network of close tolerance, precision made steel wires, much on the order of a machine, where each part has a job to do. Each part must work in a perfect relationship with the other part for the rope to properly function. Proper care and handling is mandatory to receive the highest service at the highest level of safety.

Nomenclature

Wire rope comprises just three parts—core, strand and wire (**Figure WR-1**).

Become familiar with each part; it is surprising how many times a "wire" is reported to be a "strand".

Each of the components are detailed later in this manual. Wire rope is described and identified with numerals and abbreviations. It is important to understand these terms and to relate them to the wire rope specified within our industry.

The following is an example description of a rotary drilling line; the identifying terms are translated and explained individually.

5,000 ft × 1 in. 6×19 S-IWRC EIP SZ (RR) PRF

5,000 ft	= Length of wire rope, ft
1 in.	= Nominal diameter of wire rope, in.
6	= Number of outer strands per wire rope
19	= Number of wires per outer strand
S	= Seale outer strand wire pattern
IWRC	= Independent wire rope core
EIP	= Extra improved plow steel
SZ (RR)	= Right regular lay
PRF	= Preformed strands

This translates to a 5,000 ft length of 1 in. diameter, 6-strand rope with 19 wires in each strand laid in a Seale pattern (S). The strands of the rope are laid around an Independent Wire Rope Core. The strength grade of the rope is Extra Improved Plow Steel (EIP). The strands are laid in a Right Regular Lay (SZ or RR) pattern and are preformed (PRF) in a helical shape prior to closing the rope.

Sizes and constructions diameter

Diameter measurements are correct only when made across the "crowns" of the rope strands so that the true diameter is the widest diameter of the rope. Always rotate the caliper on the rope—or rotate the rope inside the caliper to take the measurement.

Always measure the diameter of any rope at its widest point by turning the caliper on the rope. Measurements for

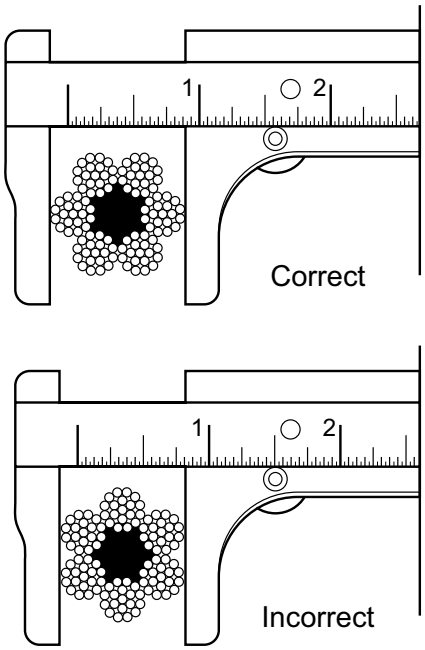

Figure WR-2: Wire diameter measurement.

diameter shall be taken on a straight portion of the rope at two positions spaced at least three feet apart. Two diameters shall be measured at each position at right angles from each other. The average of these four measurements shall be the reported diameter.

Most ropes are manufactured larger than the nominal diameter. When first placed in operation, strands of new unused rope will "seat in" and "pull down" from its original diameter. Therefore, measurements recorded for future reference and comparison should be taken after the rope has been in service for a short period of time. See **Table WR-1** for rope diameter vs. tolerances.

Table WR-1: Rope diameter vs. tolerance.

Rope Diameter Inches	**Steel wire ropes with IWRC**		**Steel wire ropes with fiber core**	
	Tolerance (percent)		**Tolerance** (percent)	
	UNDER	**OVER**	**UNDER**	**OVER**
d < 3/16	0	8	0	9
3/16 ≤ d < 1/4	0	7	0	9
1/4 ≤ d < 3/8	0	6	0	8
3/8 and larger	0	5	0	7

Table WR-2: The number of strands and number of wires per strand determine a rope's classification.

Classification	**Number of strands**	**Wires per strand**
6×7	6	7
6×19	6	16 through 26
6×36	6	27 through 49
8×19	8	16 through 26

Wire rope differs in the number of strands and the number and pattern of wires per strand. Most common wire rope constructions are grouped into four standard classifications based on the number of strands and wires per strand, as shown in **Table WR-2**.

Within each classification there are specific rope constructions. For example, in the 6×19 class, some of the rope constructions are 6×25 FW (filler wire), 6×119 S (Seale) and 6×26 WS (Warrington Seale).

Characteristics, such as fatigue resistance and resistance to abrasion, are directly affected by the design of strands. As a general rule, a strand made up of a few large wires will be more abrasion-resistant and less fatigue-resistant than a strand of the same size made up of many smaller wires.

Basic strand constructions

Single layer

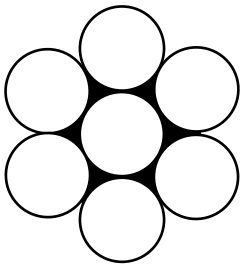

Figure WR-3: Example of a single-layer strand.

The "Single Layer Principle" is the basis of this strand construction. The most common example is a single wire center with six wires laid around it. It is called a 7-wire (1–6) strand (**Figure WR-3**).

Filler wire

This construction has two layers of the same-sized wires around a center wire, with the inner layer having half the number of wires as the outer layer. Small filler wires, equal in number to the inner layer, are laid in the valleys of the inner layer.

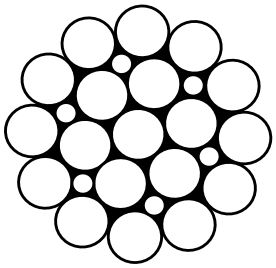

Figure WR-4: Filler wire has two layers of the same-sized wires around a center wire. This is a 25 filler wire (1-6-6f-12) strand.

Seale

The Seale construction has two layers of wires around a center wire with the same number of wires in each layer. All wires in each layer are the same diameter and the strand is designed so that the larger outer wires rest in the valleys between the smaller inner wires.

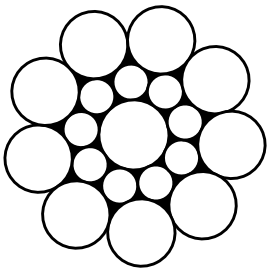

Figure WR-5: Seale construction features two layers of wires around a center wire, with the same number of wires in each layer. This example is 19 Seale (1-9-9) strand.

Warrington

The Warrington construction has 2 layers of wires. The inner layer is a single size of wire and the outer layer has two diameters of wire, alternating large and small. The larger outer-layer wires rest in the valleys and the smaller ones on the crowns of the inner layer.

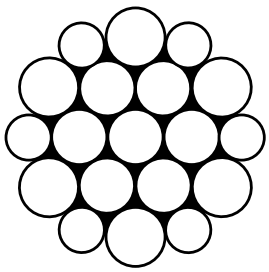

Figure WR-6: Warrington construction features two layers of wires. The inner is a single size wire, and the outer has two wire diameters, alternating large and small. Drawing is of 19 Warrington (1-6-(6+6) strand.

Combined patterns

When a strand is formed in a single operation using two or more of the foregoing constructions, it is referred to as a "combined pattern". Beginning from the center wire, the first two layers constitute a Seale pattern. The third layer, with two different wire sizes is a Warrington pattern. The fourth layer of the same diameter wires forms a Seale pattern.

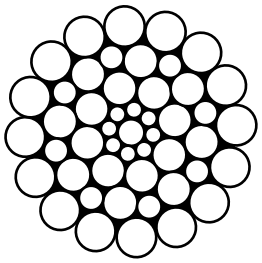

Figure WR-7: Strands formed in a single operations using two or more of the foregoing constructions is called a "combined pattern." Above is 49 Seal Warrington Seale (1-8-8-(8+8)-16) strand.

Preforming

Preforming is a process by which strands are helically formed into the shape they will assume in the finished rope.

Preforming improves fatigue resistance, ease of handling, and resistance to kinking in a rope by equalizing the load among the strands and among the individual wires of strands.

When a preformed rope is cut, the end does not unlay. If strands are unlayed from the rope, they retain their helical shape. When a non-performed rope is cut, it will open up or "broom" unless the end has been secured (seized) before cutting.

The superior qualities of preformed ropes result from wires and strands being "at rest" in the rope which minimizes internal stresses within the rope. Because wires and strands are free to move and slide in relation to each other when the rope bends, the rope can adjust more easily while operating on sheaves or drums. Unless otherwise indicated in the rope description, ropes are preformed.

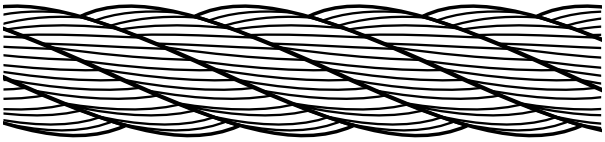

Figure WR-8: Right lay, regular lay.

Lay

The first element in describing Lay is the DIRECTION of strands lay in the rope—Right or Left. When you look along a rope, strands of a Right Lay rope spiral to the right. Left Lay rope spirals to the left.

The second element in describing lay is the relationship between the direction the strands lay in the rope and direction the wires lay in the strands.

In Regular Lay, wires are laid opposite the direction the strands lay in the rope. In appearance, the wires in Regular Lay are parallel to the axis of the rope.

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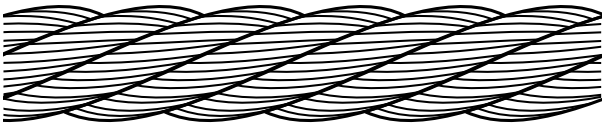

Figure WR-9: Left lay, regular lay.

In Lang Lay, wires are laid the same direction as the strands lay in the rope and the wires appear to cross the rope axis at an angle.

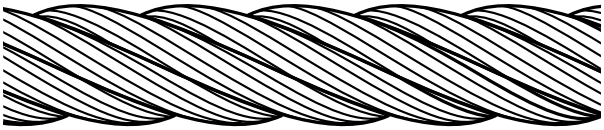

Figure WR-10: Right lay, lang lay.

The third element in describing lay is that one rope lay is the length along the rope axis which one strand uses to make one complete helix around the core.

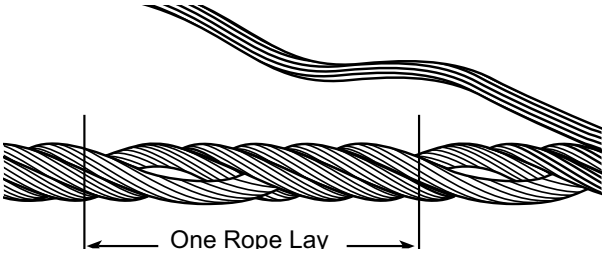

Figure WR-11: One rope lay.

Grades

Today the greatest portion of all wire rope is made in two grades: Extra Improved Plow Steel (EIP) and Extra Extra Improved Plow Steel (EEIP)

The grade of rope refers to the strength of a new unused wire rope. Standard 6 strand EEIP ropes within the same classification and having an IWRC have a nominal strength about 10% higher than EIP ropes.

Galvanized ropes are those in which the individual wires have had a zinc coating applied to their surface to provide increased corrosion resistance. The proper grade of rope to use depends on the specific characteristics of the application.

Cores

The primary purpose of a core in wire rope is to provide a foundation or support for the strands. Approximately 7 ½% of the nominal strength of a 6-strand IWRC rope is attributed to the core.

Wire rope cores are usually one of three types (**Figure WR-12**). The first, fiber core (top) is either of natural fiber, such as sisal or man-made fiber, such as polypropylene. The second, independent wire rope core (center) is literally an independent wire rope called IWRC. Finally, strand core (bottom) is a strand composed of wires.

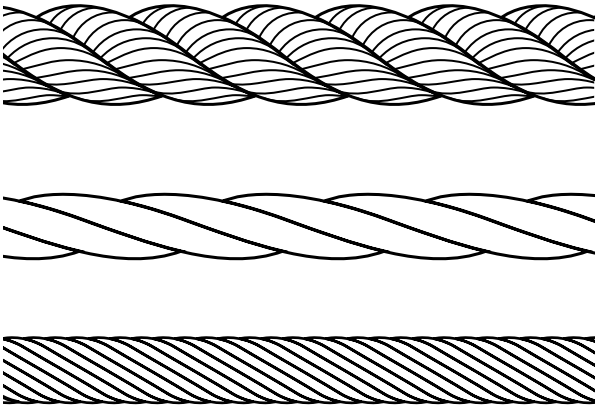

Figure WR-12: Examples of rope cores (from top)—fiber core (FC); independent wire rope core, center; strand core, bottom.

Table WR-3: Lay designations.

Lay type	Preferred designations	Other designations
Right hand ordinary lay	RR, sZ	RHOL, RRL
Left hand ordinary lay	LL, zS	LHOL, LRL
Right hand langs lay	RL, zZ	RHLL, RLL
Left hand langs lay	LL, sS	LHLL, LLL
Right hand alternate lay	RA, aZ	RHAL, RAL
Left hand alternate lay	LA, aS	LHAL, LAL

Table WR-4: Typical sizes and constructions of wire rope for oilfield service.

Service and well depth	Wire rope inches	Wire rope description
Rod & Tubing Pull Lines		
Shallow	½ to ¾ incl.	6×26 WS or 6×31 WS
Intermediate	¾, ⅞	RRL or LRL IPS,EIP or EEIP, IWRC
Deep	⅞ to 1⅛ incl.	
Rod Hanger Lines	¼	6×19, RRL, IPS, FC
Sand Lines		
Shallow	¼ to ½ incl.	
Intermediate	½, 9⁄16	6×7 or 5×7 or 5×7 Swaged Bright or Galv.[2], RRL IPS, FC
Deep	9⁄16, ⅝	
Drilling Lines—Cable Tool (Drilling & Cleanout)		
Shallow	⅝, ¾	
Intermediate	¾, ⅞	6×21 FW, RRL or LRL, PS or IPS, FC
Deep	⅞, 1	
Casing Lines—Cable Tool		
Shallow	¾, ⅞	
Intermediate	⅞, 1	6×25 FW, RRL, IPS, FC or IWRC
Deep	1, 1 ⅛	6x25 FW, RRL, IPS or EIP, IWRC
Drilling Line—Coring and Slim-Hole Rotary Rigs		
Shallow	⅞, 1	6×26 WS, RRL, IPS or EIP, IWRC
Intermediate	1, 1 ⅛	6×19 S or 6×26 WS, RRL, EIP or EEIP, IWRC May have compacted strands or be plastic impregnated.
Drilling Lines—Large Rotary Rigs		
Shallow	1, 1⅛	6×19 S or 6×21 S or 6×26WS, RRL, EIP or EEIP, IWRC. May have compacted strands or be plastic impregnated
Deep	1¼ to 2 incl.	
Winch Lines—Heavy Duty	⅝ to ⅞ incl.	6×26 WS or 6×31 WS, RRL, IPS EIP or EEIP, IWRC
	⅞ to 1⅛ incl.	6×36 WS, PF, RRL, IPS EIP or EEIP, IWRC
Horsehead Pumping—Unit Lines		
Shallow	½ to 1⅛ incl.[4]	6×19 Class or 6×36 Class or 19×7, IPS, FC or IWRC
Intermediate	⅝ to 1⅛ incl.[3]	6×19 Class or 6×36 Class, IPS, FC or IWRC
Offshore Anchorage Lines	⅞ to 2¾ incl.	6×19 Class, Bright or Galv., RRL, EIP or EEIP, IWRC
	1⅜ to 4¾ incl.	6×36 Class, Bright or Galv., RRL, EIP or EEIP, IWRC
	3¾ to 4¾ incl.	6×61 Class, Bright or Galv., RRL, EIP or EEIP, IWRC
Mast Raising Lines[5]	1⅜ and smaller	6×19 Class, RRL, EIP or EEIP, IWRC
	1½ and larger	6×36 Class, RRL, EIP or EEIP, IWRC
Guideline Tensioner Line	¾	6×25 FW, RRL, IPS or EIP, IWRC
Riser Tensioner Lines	1½ and larger	6×36 WS or 6×41 WS or 6×41 SFW or
		6×49 SWS, RRL, IPS or EIP, IWRC or
		8×36 class RL IWRC May have compacted strands and/or be plastic impregnated.

Abbreviations

WS	Warrington Seale
S	Seale
FW	Filler-Wire
PS	Plow Steel

IPS	Improved Plow Steel
EIPS	Extra Improved Plow Steel
PRF	Preformed
NPF	Non-preformed

RRL	Right Lay
LRL	Left Lay
FC	Fiber Core
IWRC	Independent Wire Rope Core

[2] Bright wire sand lines are regularly finished; galvanized finish is sometimes required.
[3] Applies to pumping units having one piece of wire rope looped over an ear on the horsehead and both ends fastened to a polished rod yoke.
[4] Applies to pumping units having two vertical lines (parallel) with sockets at both ends of each line.
[5] See API Spec. 4E – Specification for Drilling and Well Servicing Structures.