ROTARY DRILLING

The Blocks and Drilling Line

Third Edition, Rev.

UNIT I • LESSON 5

ROTARY DRILLING SERIES

Unit I: The Rig and Its Maintenance

Lesson 1: The Rotary Rig and Its Components
Lesson 2: The Bit
Lesson 3: Drill String and Drill Collars
Lesson 4: Rotary, Kelly, Swivel, Tongs, and Top Drive
Lesson 5: The Blocks and Drilling Line
Lesson 6: The Drawworks and the Compound
Lesson 7: Drilling Fluids, Mud Pumps, and Conditioning Equipment
Lesson 8: Diesel Engines and Electric Power
Lesson 9: The Auxiliaries
Lesson 10: Safety on the Rig

Unit II: Normal Drilling Operations

Lesson 1: Making Hole
Lesson 2: Drilling Fluids
Lesson 3: Drilling a Straight Hole
Lesson 4: Casing and Cementing
Lesson 5: Testing and Completing

Unit III: Nonroutine Operations

Lesson 1: Controlled Directional Drilling
Lesson 2: Open-Hole Fishing
Lesson 3: Blowout Prevention

Unit IV: Man Management and Rig Management

Unit V: Offshore Technology

Lesson 1: Wind, Waves, and Weather
Lesson 2: Spread Mooring Systems
Lesson 3: Buoyancy, Stability, and Trim
Lesson 4: Jacking Systems and Rig Moving Procedures
Lesson 5: Diving and Equipment
Lesson 6: Vessel Inspection and Maintenance
Lesson 7: Helicopter Safety
Lesson 8: Orientation for Offshore Crane Operations
Lesson 9: Life Offshore
Lesson 10: Marine Riser Systems and Subsea Blowout Preventers

Contents

Units of Measurement

Throughout the world, two systems of measurement dominate: the English system and the metric system. Today, the United States is one of only a few countries that employ the English system.

The English system uses the pound as the unit of weight, the foot as the unit of length, and the gallon as the unit of capacity. In the English system, for example, 1 foot equals 12 inches, 1 yard equals 36 inches, and 1 mile equals 5,280 feet or 1,760 yards.

The metric system uses the gram as the unit of weight, the metre as the unit of length, and the litre as the unit of capacity. In the metric system, 1 metre equals 10 decimetres, 100 centimetres, or 1,000 millimetres. A kilometre equals 1,000 metres. The metric system, unlike the English system, uses a base of 10; thus, it is easy to convert from one unit to another. To convert from one unit to another in the English system, you must memorize or look up the values.

In the late 1970s, the Eleventh General Conference on Weights and Measures described and adopted the Systeme International (SI) d'Unites. Conference participants based the SI system on the metric system and designed it as an international standard of measurement.

The Rotary Drilling Series gives both English and SI units. And because the SI system employs the British spelling of many of the terms, the book follows those spelling rules as well. The unit of length, for example, is metre, not meter. (Note, however, that the unit of weight is gram, not gramme.)

To aid U.S. readers in making and understanding the conversion system, we include the table on the next page.

English-Units-to-SI-Units Conversion Factors

Quantity or Property	English Units	Multiply English Units By	To Obtain These SI Units
Length, depth, or height	inches (in.)	25.4	millimetres (mm)
		2.54	centimetres (cm)
	feet (ft)	0.3048	metres (m)
	yards (yd)	0.9144	metres (m)
	miles (mi)	1609.344	metres (m)
		1.61	kilometres (km)
Hole and pipe diameters, bit size	inches (in.)	25.4	millimetres (mm)
Drilling rate	feet per hour (ft/h)	0.3048	metres per hour (m/h)
Weight on bit	pounds (lb)	0.445	decanewtons (dN)
Nozzle size	32nds of an inch	0.8	millimetres (mm)
Volume	barrels (bbl)	0.159	cubic metres (m^3)
		159	litres (L)
	gallons per stroke (gal/stroke)	0.00379	cubic metres per stroke (m^3/stroke)
	ounces (oz)	29.57	millilitres (mL)
	cubic inches ($in.^3$)	16.387	cubic centimetres (cm^3)
	cubic feet (ft^3)	28.3169	litres (L)
		0.0283	cubic metres (m^3)
	quarts (qt)	0.9464	litres (L)
	gallons (gal)	3.7854	litres (L)
	gallons (gal)	0.00379	cubic metres (m^3)
	pounds per barrel (lb/bbl)	2.895	kilograms per cubic metre (kg/m^3)
	barrels per ton (bbl/tn)	0.175	cubic metres per tonne (m^3/t)
Pump output and flow rate	gallons per minute (gpm)	0.00379	cubic metres per minute (m^3/min)
	gallons per hour (gph)	0.00379	cubic metres per hour (m^3/h)
	barrels per stroke (bbl/stroke)	0.159	cubic metres per stroke (m^3/stroke)
	barrels per minute (bbl/min)	0.159	cubic metres per minute (m^3/min)
Pressure	pounds per square inch (psi)	6.895	kilopascals (kPa)
		0.006895	megapascals (MPa)
Temperature	degrees Fahrenheit (°F)	$\frac{°F - 32}{1.8}$	degrees Celsius (°C)
Mass (weight)	ounces (oz)	28.35	grams (g)
	pounds (lb)	453.59	grams (g)
		0.4536	kilograms (kg)
	tons (tn)	0.9072	tonnes (t)
	pounds per foot (lb/ft)	1.488	kilograms per metre (kg/m)
Mud weight	pounds per gallon (ppg)	119.82	kilograms per cubic metre (kg/m^3)
	pounds per cubic foot (lb/ft^3)	16.0	kilograms per cubic metre (kg/m^3)
Pressure gradient	pounds per square inch per foot (psi/ft)	22.621	kilopascals per metre (kPa/m)
Funnel viscosity	seconds per quart (s/qt)	1.057	seconds per litre (s/L)
Yield point	pounds per 100 square feet (lb/100 ft^2)	0.48	pascals (Pa)
Gel strength	pounds per 100 square feet (lb/100 ft^2)	0.48	pascals (Pa)
Filter cake thickness	32nds of an inch	0.8	millimetres (mm)
Power	horsepower (hp)	0.75	kilowatts (kW)
Area	square inches ($in.^2$)	6.45	square centimetres (cm^2)
	square feet (ft^2)	0.0929	square metres (m^2)
	square yards (yd^2)	0.8361	square metres (m^2)
	square miles (mi^2)	2.59	square kilometres (km^2)
	acre (ac)	0.40	hectare (ha)
Drilling line wear	ton-miles (tn•mi)	14.317	megajoules (MJ)
		1.459	tonne-kilometres (t•km)
Torque	foot-pounds (ft•lb)	1.3558	newton metres (N•m)

Introduction

In this chapter:

- The difference between a derrick and a mast
- The drawworks and crown block
- How a top-drive system works
- The central function of the blocks and drilling line
- Lifting loads and stresses

Lifting, or hoisting, subsurface equipment is a basic part of drilling. Crewmembers run and pull core samples, fishing tools, and testing tools. They also run and pull casing, drill bits, and thousands of feet (metres) of drill pipe as the hole gets deeper. Without a hoisting system, rotary drilling could not happen. Several key components make up the hoisting system: drawworks, a mast or a derrick, a crown block, a traveling block, and a wire-rope drilling line—all work in conjunction to drill a hole (fig. 1).

The hoisting system helps the crew to run and pull:
- Core samples
- Fishing tools
- Testing tools
- Casing
- Drill bits
- Drill pipe

Derricks Versus Masts

A *derrick* (a standard derrick) is a tower that crewmembers assemble piece by piece. A *mast*, on the other hand, is a portable derrick that a manufacturer assembles once and sells as a one-piece unit. Most drilling rigs use a mast. Almost everybody in the drilling industry, however, calls a mast a derrick. This book does the same.

Installing the Line

In this chapter:

- Drilling line and its parts: fastline and deadline
- How to use the hoisting system
- Reeving the drilling line, crown block, and traveling block
- Securing the deadline to the anchor

Reeving means to *string up*, or thread, the drilling line through the hoisting system's parts. Many reeving methods are available. Which one a contractor uses depends on the situation. But regardless of a crew's choice, reeved line connects the major pieces of hoisting equipment. Since reeving connects the hoisting equipment, let's trace one reeving method to get an overview of the system.

Let's assume that crewmembers are rigging up a new drilling line on a rig that is not drilling. The rig's derrick is not erected; instead, crewmembers have laid it down in a horizontal position. One end of the derrick is supported in the rig's substructure. The other end rests in a support that keeps the derrick level with the ground.

To start reeving:

- Crewmembers take one end of the rope off the supply reel.
- They are careful not to drag the rope on the ground.
- They pull the line from the reel to the top of the derrick.

Service Life

In this chapter:

- Seven main factors that affect the life of drilling line
- Sheave size and line tension
- Condition of the drawworks drum
- Impact of handling by crewmembers

A new drilling line may last less than one year or for several years. Many factors affect how long it remains in service. Crewmembers can control some of these factors. To prolong the line's life, they should properly maintain the hoisting equipment, and they should also use the drilling line properly.

Factors That Affect Service Life

Many factors influence the life of the drilling line. Some are:

- Derrick height
- Sheave size
- Line tension
- Drawworks drum type
- Deadline tie-down anchor size and location
- Handling
- Drilling job type

Derrick Height

Derrick height determines the total length of line to string up. Derrick height also determines the amount to keep on the supply reel (the reserve) for a slip-and-cutoff program. A *slip-and-cutoff program* involves unreeling (slipping) a certain length of new line off the supply reel and reeling it onto the drawworks drum. Crewmembers then cut off and discard the used part of the line. Cutting off the used line keeps it from overfilling the drawworks drum. The taller the derrick, the more reserve is needed. Short derricks tend to wear the line faster than tall ones,

Drilling Line Construction

In this chapter:

- How wire-rope makers design and construct rope
- Various types of core and strand
- Differences in wire rope design
- The impact of strand patterns
- Selecting the right wire rope
- Slipping and cutting rope

Crewmembers use many types of lines (wire ropes) on a rig. The drawworks may have, for example, not only a main drum for the drilling line, but also a sand drum (spool) for a sandline. A *sandline* is a relatively small-diameter wire rope that lowers and raises wireline tools in and out of the hole. Floorhands often hoist and move drill pipe and other tools with a small-diameter wire rope on the rig's air hoist. Offshore, crewmembers rig wire-rope slings and lifting lines to cranes, which move equipment and personnel to and from boats.

Except for the lines a rig-up crew uses to raise a rig's mast, drilling line is the largest-in-diameter line on the rig. It is large because it must be strong enough to do the main lifting work. Drilling line is wire rope that ranges in diameter from ⅞ to 2 inches (22 to 51 millimetres). Wire-rope drilling line has only three parts:

- The core
- The strands (including the center of the strand)
- The wires (fig. 11).

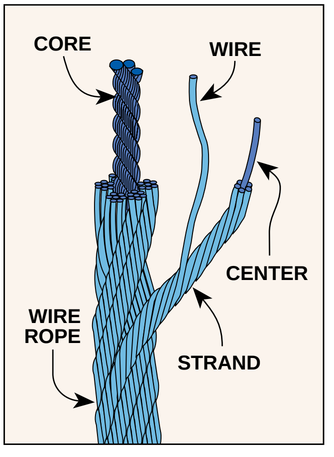

Figure 11. Wire-rope drilling line

Reeving

▼
▼
▼

In this chapter:

- Stringing line through the sheaves
- Recommended reeving arrangements
- Factors that influence reeving decisions
- Different reeving methods for different purposes

As explained earlier, stringing the line through the sheaves is called reeving. The mechanical lifting advantage increases with the number of lines strung between the crown and the traveling blocks. Contractors and crews choose from established reeving methods or work out their own methods based on experience.

When reeving takes place in the field, the toolpusher, the driller, and the derrickhand carefully plan the job. They take into account such things as:

- Position of the equipment
- Angle the fastline makes between the fast sheave in the crown block and the side of the drawworks drum (the fleet angle)
- Reeving pattern
- Placement of the deadline tie-down anchor
- Number of sheaves
- Number of lines required for the load

Reeving Pattern

The reeving pattern determines whether crewmembers reeve the line from right to left or from left to right in relation to the V-door and the supply reel. (The *V-door* is the opening in the derrick directly opposite the drawworks. Crewmembers pick up pipe from the *catwalk* and move the pipe onto the rig floor through the V-door.) A right-hand reeving pattern means that crewmembers reeve the line from the supply reel, which is to the right of the V-door, to the right-hand sheaves first, as crewmembers stand on the rig floor facing the V-door.

Drum Spooling

In this chapter:

- Spooling a new drilling line
- Types of spooling and grooves
- Spooling schemes and crossover points
- Two-step, or counterbalance, spooling

Spooling a new line onto the drawworks drum or respooling after a cutoff is the driller's job. The driller has two objectives:

- To make the wraps tight
- To meet the manufacturer's guidelines on the recommended number of dead wraps

As mentioned earlier, dead wraps are wraps of nonworking drilling line that always remain on the drum, even when the traveling block is fully lowered.

The driller should always spool the number of dead wraps recommended by the manufacturer. Dead wraps prevent loads from being placed on the drilling line where the line is attached to the drum, which is a weak point. The wraps should be tight enough to prevent slack. Slack causes sudden jerks and shock loads on the line when the driller stops or releases the drawworks drum. The loads and jerking action can damage and stress the line and sheaves.

To wrap the line tightly, the driller reels the line onto the drum under tension. Usually, crewmembers attach an air hoist line to the drilling line and use it to pull tension on the drilling line as the driller makes the dead wraps. The number of wraps to take depends on the design of the drum.

Measuring Service Life

In this chapter:

- More about slipping and cutting
- Shifting critical points of wear
- Planning slip-and-cutoff programs
- How to perform slip and cutoff
- Monitoring service life

Drilling line is expensive, so extending its service life ranks high on the list of a contractor's priorities. Measuring and recording service life is a vital part of getting the most use of the line. Crewmembers measure and record the amount of line use so they can slip and cut the line in a systematic way. By slipping the line past the points in the hoisting system where it gets worn more, they can distribute the wear to unworn parts of the line, thus increasing the line's life.

Hoisting line that moves 1 ton over 1 mile = 1 ton-mile of service.

The driller records line use in ton-miles (megajoules). When the hoisting line has moved 1 ton over a distance of 1 mile (1,000 newtons over a distance of 1,000 metres), the line will have rendered 1 ton-mile (1 megajoule) of service. Drillers and toolpushers calculate the ton-miles (megajoules) of work performed by the drilling line using formulas provided by the wire-rope manufacturer, the drilling contractor, or API RP 9B, *Recommended Practice on Application, Care, and Use of Wire Rope for Oil Field Service*. Drillers record these measurements to keep track of wear. (See Appendix A for examples of how to calculate ton-miles and megajoules of wear.)

Care of Wire Rope

In this chapter:

- Proper care of the drilling line
- Limiting stress on the line
- Care at the supply reel and drum
- Proper lubrication to extend service life

The objective of any slip-and-cutoff program is to get as many ton-miles (megajoules) of service possible from the line while maintaining safe working conditions. Care and handling practices also place a priority on safety, because injury is a real consideration any time rig hands work with a heavily loaded drilling line. Proper care of the drilling line focuses on:

- The supply reel
- Minimizing stress and scrubbing
- Care at the drum
- Good lubrication

Care at the Supply Reel

Always move supply reels carefully, taking care not to crush the wire rope. Use a crowbar on the reel flange only, not on the wire itself (fig. 31). When lifting a reel with a hoist, put the sling through the center hole of the reel instead of around the rope, to protect against crushing. Do not roll the supply reel over uneven surfaces where the line can pick up dirt or sand. If necessary, cover the reel to protect the rope against mud, corrosive water, and windborne abrasives. When reeving, use line-support devices when necessary to prevent contact with the ground (fig. 32).

Visual Inspection

In this chapter:

- What to look for when inspecting the line
- Examining the dead crown block
- Checking the deadline tie-down anchor
- Inspecting for line diameter changes
- Suspending operations to check the line

Drilling line needs periodic inspection. Beginning at the drawworks drum end, crewmembers should check for broken wires, crushing, and signs of cutting. While near the drum, they should check it for:

- Worn grooves that have become sharp and that shave away small bits of steel from the line
- Corrugated grooves that are rippled across the surface and dig into and damage the tightly wrapped line
- Any surface irregularities that could also damage the line

Check for:
- Worn grooves
- Corrugated grooves
- Surface irregularities

(See Appendix C for additional pointers on troubleshooting problems with the drilling line.)

Crewmembers should also inspect the fastline and the remainder of the working drilling line for breaks and wear at critical points. Worn or weak places sometimes show up as broken or worn wires, corroded sections, kinks, or line distortion. Crewmembers remove these places from the line by slipping and cutting it.

Blocks and Hook

In this chapter:

- The importance of proper lubrication
- Measuring sheave wear
- Care of the wire rope and sheave grooves
- Routine inspection of the blocks and drilling line
- Hook assembly wear
- Care of the elevator moving parts and joints

Both the crown block and the traveling block have large pulleys called sheaves. Crewmembers reeve (thread) the drilling line through the sheaves in the traveling block and over the sheaves in the crown block (fig. 36). The blocks and drilling line form a large block-and-tackle system. A block and tackle provide a lot of lifting power when several lines are reeved between the blocks. Put another way, a single line run several times between the rig's crown and traveling blocks provides the lifting effect of several lines.

The block-and-tackle system with a reeved drilling line provides powerful lifting capacity.

The rig builder mounts the crown block on beams at the top of the derrick (fig. 37), but drilling line suspends the traveling block from the crown block (fig. 38). The traveling block is free to move up and down in the derrick. When the driller engages the drawworks drum to reel in the drilling line, the traveling block moves up. When the driller releases the brake on the drawworks drum, the drilling line spools off the drum and the traveling block and anything attached to it moves down.

Manufacturers attach a large hook to the bottom of the traveling block. On a rig without a top drive, the swivel and drill stem hang from the traveling block's hook when the bit is on bottom and drilling (see fig. 2). When tripping the drill stem in or out of the hole, elevators on the hook suspend the pipe (see fig. 3).

Elevators

▼
▼
▼

In this chapter:

- Elevator types and designs
- Boring and machining to match drill pipe shapes
- Elevator latch types and features

Elevators are special clamps that rotary helpers use when running tubulars (drill pipe, drill collars, casing, and tubing) in and out of the hole. Elevators latch onto and grip pipe so that the traveling block and hook can raise or lower the pipe out of or into the hole. Crewmembers attach the elevators to the hook by *elevator links*, or bails (fig. 51).

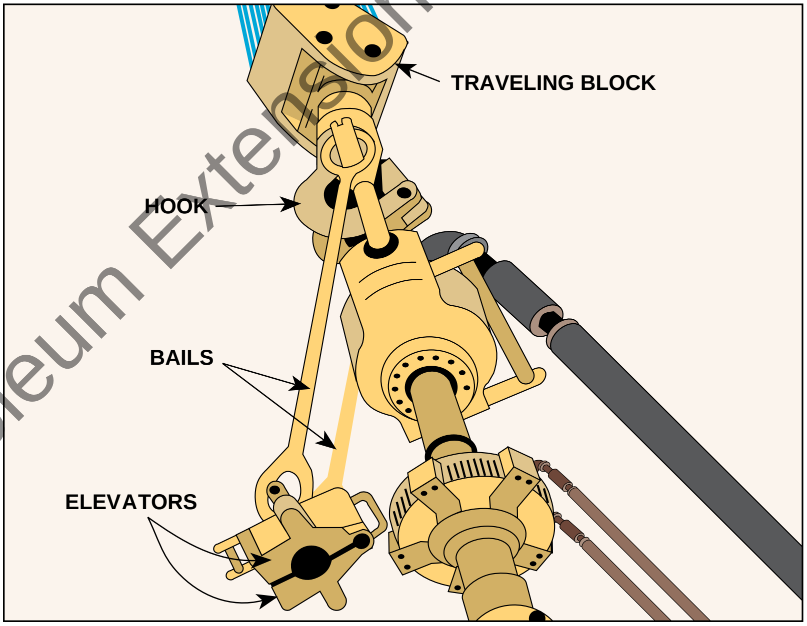

Figure 51. Attachments to the traveling block

Conclusion

The blocks and drilling line handle a huge amount of work in tons (tonnes) lifted and ton-miles (megajoules) of force expended. This equipment must perform well under harsh weather conditions and under the heavy stresses of drilling. When the blocks are in good condition and operating smoothly, the drilling line offers longer service, and the rig contractor spends less money. As a result, proper care of both the drilling line and the blocks is a high priority for contractors and their crews.

Index

To obtain additional training materials, contact:

PETEX
THE UNIVERSITY OF TEXAS AT AUSTIN
PETROLEUM EXTENSION SERVICE
J.J. Pickle Research Campus
10100 Burnet Road, Bldg. 2
Austin, TX 78758

Telephone: 512-471-5940
or 800-687-4132
FAX: 512-471-9410
or 800-687-7839
E-mail: petex@www.utexas.edu
or visit our Web site: www.utexas.edu/ce/petex

To obtain information about training courses, contact:

PETEX
LEARNING AND ASSESSMENT CENTER
THE UNIVERSITY OF TEXAS
4702 N. Sam Houston Parkway West, Suite 800
Houston, TX 77086

Telephone: 281-397-2440
or 800-687-7052
FAX: 281-397-2441
E-mail: plach@www.utexas.edu
or visit our Web site: www.utexas.edu/ce/petex

ISBN 0-88698-170-0
9 780886 981709

2.105301
0-88698-170-0