ROTARY DRILLING

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The Blocks and Drilling Line



Third Edition, Rev. UNIT I • LESSON 5



texas at Austin **ROTARY DRILLING SERIES**

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- Lesson 5: The Blocks and Drilling Line
- Lesson 6: The Drawworks and the Compound
- Drilling Fluids, Mud Pumps, and Conditioning Equipment Lesson 7:
- Lesson 8: **Diesel Engines and Electric Power**
- The Auxiliaries Lesson q:
- Lesson 10: Safety on the Rig

Unit II: Normal Drilling Operations

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

Unit III: Nonroutine Operations

- Controlled Directional Drilling Lesson 1:
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Offshore Technology Unit V:

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- Spread Mooring Systems Lesson 2:
- Buoyancy, Stability, and Trim Lesson 3:
- 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 o: Life Offshore

2etti

Lesson 10: Marine Riser Systems and Subsea Blowout Preventers

Figures vii **Contents** ersity of texas at Austin Tables viii Foreword ix Acknowledgments xi Units of Measurement xii 1 Introduction Derricks versus Masts 1 Hoisting System Components 2 Top Drives 3 Blocks 4 Drilling Line 4 Deadline Tie-Down Anchor 4 Lifting and Lowering 5 Drilling Line, Crown Block, and Traveling Block To Summarize 6 Installing the Line 7 Pulling Line from the Supply Reel 8 Reeving the Crown Block 8 Reeving the Traveling Block 8 Reeving between the Crown Block and the Traveling Block Taking in Line on the Drawworks 9 Securing the Deadline 9 Using the Hoisting System 9 0 System Overview 10 To Summarize 14 Service Life 15 Factors that Affect Service Life 15 Derrick Height 15Sheave Size Line Tension Ī6 Drawworks Drum 17 Deadline Tie-Down Anchor 18 Handling 18 Drilling Job Type 18 To Summarize 18 Drilling Line Construction 19 Wire-Rope Steel 20 2ett 20 Preforming Design 21 Cores 21 Strands 21 Construction 21 Single Layer 22

```
Filler Wire
                                                                  22
                                                                              otexasathustin
                                                    Seale
                                                             22
                                                    Warrington
                                                                  22
                                                                     22
                                                    Combination
                                                    Wire-Rope Lay
                                                                       24
                                                 Ordering Wire Rope
                                                                       25
                                                 Selection
                                                             25
                                                    Diameter
                                                                25
                                                    Length
                                                                27
                                                        Slip-and-Cut Programs
                                                        Slipping
                                                                  29
                                                                  29
                                                        Cutting
                                                        Cost Versus Line Length
                                                 To Summarize
                                                                  31
                                             Reeving
                                                        33
                                                 Reeving Pattern
                                                                  33
                                                 Number of Lines
                                                                     36
                                                 Other Factors
                                                                36
                                                                37
                                                 Fleet Angle
                                                 Reeving Using Old Line
                                                 Reeving Using a Catline
                                                 To Summarize
                                             Drum Spooling
                                                 Types of Spooling
                                                                     44
                                                    Helical Grooving Pattern
                                                                               44
                                                    One-Step Grooving Pattern
                                                                                 45
                                                     Two-Step, or Counterbalance, Spooling
                                                                                           46
                                                     Two-Step Spooling With Soft Crossover
                                                                                           47
PetroleumExtensi
                                                 To Summarize
                                                                  48
                                             Measuring Service Life
                                                                     49
                                                                  50
                                                 Slip and Cutoff
                                                                50
                                                    Slipping
                                                    Planning Slip and Cutoff
                                                                               53
                                                    Cutting
                                                                54
                                                    Procedure for Slip and Cutoff
                                                                                    57
                                                    Using Charts
                                                                     58
                                                 Visual Inspection
                                                                     61
                                                                  62
                                                 To Summarize
                                             Care of Wire Rope
                                                                  63
                                                 Care at the Supply Reel
                                                                          63
                                                 Minimizing Stress
                                                                     65
                                                 Minimizing Scrubbing
                                                                          66
                                                 Care at the Drum
                                                                     66
                                                 Lubrication
                                                                68
                                                    Factory Lubrication
                                                                          68
```

Field Lubrication 68 iversity of texas at Austin To Summarize 70 Visual Inspection 71 To Summarize 73 Blocks and Hook 75 Load Capacity 78 Sheaves 78 Sheave Construction 78 Groove Radius 79 Tread Diameter 80 Crown Block 82 Traveling Block 84 Traveling Block Design 86 Hook 86 Combination Hook-Block 88 To Summarize 90 91 Elevators **Bottleneck Elevators** 92 Collar-Lift or Square Shoulder Elevators 93 Elevator Design, Size, and Latches 93 94 To Summarize Care of Blocks, Hook, and Elevators 95 95 Lubrication of Blocks and Hook Sheaves 96 Visual Inspection of Blocks and Drilling une 97 Visual Inspection of Hook Assembly 98 Hydraulic Snubber Oil Level 99 Elevator Lubrication and Inspection Elevator-Link Check To Summarize Conclusion 103 Appendix A: Calculating Ton-Miles (Megajoules) of Drilling Line Service 105 Appendix B: Slip-and-Cutoff Programs 115 Appendix C: Troubleshooting Drilling Line Problems 118 Glossary 119 **Review Questions** 131 143 Index Answers to Review Questions 153

en as at Austin Units of Measurement

hroughout the world, two systems of measurement dominate: L the English system and the metric system Orday, 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) PetroleumExtensi 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.

Quantity or Property	English Units En	Multiply glish Units By	To Obtain These SI Units
Length,	inches (in.)	25.4	millimetres (mm)
depth,		2.54	centimetres (cm)
or height	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 s	ize 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)
	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	\bigcirc 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)
	gallons per minute (gpm)	0.00379	cubic metres per minute (m ³ /min)
Pump output and flow rate	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)	$6.895 \\ 0.006895$	kilopascals (kPa) megapascals (MPa)
Temperature	degrees Fahrenheit (°F)	$\frac{^{\circ}\mathrm{F}-32}{1.8}$	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) pounds per cubic foot (lb/ft ³)	119.82 16.0	kilograms per cubic metre (kg/m ³) 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)
	32nds of an inch	0.8	millimetres (mm)
Filter cake thickness			Irilowatta (IrW)
Filter cake thickness Power	horsepower (hp)	0.75	KHOWALLS (KVV)
Filter cake thickness Power	horsepower (hp) square inches (in. ²)	0.75 6.45	square centimetres (cm ²)
Filter cake thickness Power	horsepower (hp) square inches (in. ²) square feet (ft ²)	0.75 6.45 0.0929	square centimetres (cm ²) square metres (m ²)
Filter cake thickness Power Area	horsepower (hp) square inches (in. ²) square feet (ft ²) square yards (yd ²)	0.75 6.45 0.0929 0.8361	square centimetres (cm ²) square metres (m ²) square metres (m ²)
Filter cake thickness Power Area	horsepower (hp) square inches (in. ²) square feet (ft ²) square yards (yd ²) square miles (mi ²)	0.75 6.45 0.0929 0.8361 2.59	square centimetres (cm ²) square metres (m ²) square metres (m ²) square kilometres (km ²)
Filter cake thickness Power Area	horsepower (hp) square inches (in. ²) square feet (ft ²) square yards (yd ²) square miles (mi ²) acre (ac)	0.75 6.45 0.0929 0.8361 2.59 0.40	square centimetres (cm ²) square metres (m ²) square metres (m ²) square kilometres (km ²) hectare (ha)
Filter cake thickness Power Area Drilling line wear	horsepower (hp) square inches (in. ²) square feet (ft ²) square yards (yd ²) square miles (mi ²) acre (ac) ton-miles (tn•mi)	0.75 6.45 0.0929 0.8361 2.59 0.40 14.317	square centimetres (cm ²) square metres (m ²) square metres (m ²) square kilometres (km ²) hectare (ha) megajoules (MI)
Filter cake thickness Power Area Drilling line wear	horsepower (hp) square inches (in. ²) square feet (ft ²) square yards (yd ²) square miles (mi ²) acre (ac) ton-miles (tn•mi)	0.75 6.45 0.0929 0.8361 2.59 0.40 14.317 1.459	square centimetres (cm ²) square metres (m ²) square metres (m ²) square kilometres (km ²) hectare (ha) megajoules (MJ) tonne-kilometres (t•km)

English-Units-to-SI-Units Conversion Factors

In this chapter:

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- •

- ence between a derrick and a mast ...e drawworks and crown block How a top-drive system works The central function of the blocks and drilling the Lifting loads and stresses r hoisting, subsurface concern Crewmembers run ar vs. They also -etres) cr ifting, 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).

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.

- · Fishing tools
- Testing tools
- Casing
- Drill bits
- Drill pipe

Derricks Versus Masts

oftexasathustin Installing the Line

In this chapter:

- Drilling line and its parts: fastline and deadline •
- Reeving the drilling line, crown block, and traveling block Securing the deadline to the anchor •

D eeving means to *string up*, or thread, the drilling line through K 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. Petroleum

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.

oftexasat Austin **Service Life**

Sill

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

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.

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 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,

Factors That Affect Service Life

Derrick Height

university of texas at Austin **Drilling Line** Construction

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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

rewmembers 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 7% to 2 inches (22 to 51 mil-Imetres). 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 * Auction *

In this chapter:

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

A s 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

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 righthand 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.

Reeving Pattern

versity of texas at Austin **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

C pooling a new line onto the drawworks drum or respooling after **J** 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

D rilling 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 weat to unworn parts of the line, thus increasing the line's life.

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.)

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

t to the set of the se 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

he objective of any slip-and-cutoff program is to get as many **L** 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

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).

Care at the **Supply Reel**

versity of texas at Austin Visual Inspection

In this chapter:

- What to look for when inspecting the line ٠
- Examining the dead crown block ٠
- Checking the deadline tie-down anchor •
- Inspecting for line diameter changes
- Suspending operations to check the line

rilling 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 •

(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.

Check for:

- · Worn grooves
- Corrugated grooves
- · Surface irregularities

g line situ **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

B oth 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 blockand-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 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).

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

Elevators

In this chapter:

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

ke wt ubi $E^{\rm levators}$ 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

otexasatAustin The blocks and drilling line handle a huge amount of work in L 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 egin .ey. Asa .sisa high pr universion the universion the universion 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

Index

air hoist
catline replaced by, 83
line tension and, 17, 40, 43, 66
small-diameter wire rope on, 19
American Petroleum Institute (API), 25, 78
anchor. See *deadline tie-down anchor*.
angle-control sections, 45
API RP 9B, *Recommended Practice on Application*, *Care*, and Use of Wire Rope for Oil Field Service, 49
API Spec 9A, Specification for Wire Rope, 25
automatic positioner, 86

bail(s)

elevators and, 2-3, 91 hook and, 86 link locking arms and, 87 traveling block and, 84 bail pins, 96, 98 bearing capacity, 86 birdcaged wire, 65 block(s). See also crown block; traveling block. function of, 4, 6 load capacity of, 78 lubrication of, 95-96 maintenance of, 101 raising/lowering, 65 types of, 90 visual inspection of, 97 block-and-tackle system, 75 block-size-and-load capacity, 78 bottleneck elevators about, 92

etas at Austin center-latch, 93-94 inspection of, 100 side-door type, 93 braking system, 5, 9, 18, 75, 96 breaking out pipe, 86 calipers elevator links and, 101 wire rope and, 26 care of wire rope about, 63, 70 at supply reel, 63-64 at the drum, 66-67 lubrication of, 68-69 scrubbing, minimization of, 66 stress minimization and, 65 catline, 83 catwalk, 33, 36 center-latch elevator 18-degree, 92 collar-lift-type, 93 hinge-pin, 94 charts basis of information, 58 cut goals for rigs with no performance records, 115–117 drum laps before first cutoff, 59, 61 ton-miles (megajoules) before first cutoff, 58 ton-miles (megajoules) relative to safety factor, 60-61 closing machine, 20 collar-lift elevators, 93, 100 combination hook-block, 88-89

THE BLOCKS AND DRILLING LINE

combination strand, 22-23 conversion factors, English-units-to-SI-units, xiii core of wire rope, 21 counterbalance spooling, 46 critical points of wear. See also visual inspection of line. causes of, 70 moving wear points and, 53 nonmoving, 52 slipping/shifting of, 29, 50 wear areas, 51 crossover drum diameter and, 17 short full-pitch, 45 crossover points drawworks design and, 17 one-step spooling and, 45 two-step spooling and, 46-47 wear areas and, 27, 44, 51, 59, 66 crossover sections, 45 crown block drilling line to, 2 fastline and, 10-11 lifting capacity, 6 mounted on beams, 75ª reeving and, 8-9 sheaves in, 75-76 See also charts; slip-and-cutoff cutting slipped line programs preformed wire, friction tape for, 54 seizing using metal band, 56 seizing using wire, 54-55 vire rope cutters for, 57 dead crown block sheave, 72 deadline deadline tie-down anchor and, 9, 13 location of, 36 securing, 9

as at Austin deadline sheave as extra sheave, 82 nonmoving critical point on, 52 deadline tie-down anchor deadline and, 9, 13 fastline to, 12 function of, 4-5 mounting of, 18 visual inspection of, 72 dead wraps manufacturer's guidelines, 39, 43, 48 nonmoving critical points and, 52 second dead layer, 44 spooling line onto drum, 52 decanewtons (dN), 105 deep well amount of pipe and, 36 fastline and, 12 sheaves on block and, 78 derrick(s) height of, 15-16 in hoisting system, 2 masts versus, 1 reeving pattern and, 34 design of drilling line. See also *strand(s)*. cores, 21 lay of wire rope, 24 patterns of construction, 21-23 diameter, wire-rope, 25-27, 32, 72 downhole assembly, suspension of, 6 drawworks brake, 5, 9, 18, 75 design of, 17 fleet angle and, 37 function of, 2 taking in line on, 9 drawworks drum crossover, 17 fastline from, 10 nonmoving critical point on, 52

overfilling, avoidance of, 15 reeving pattern and, 34 slipped line on, 29 drill collars, 92 driller, 4 drilling job type, 18 ton-miles (megajoules) calculation, 113 drilling line. See also critical points of wear; design of drilling line; drilling line construction; fastline; service life; visual inspection of line. components of, 14 equation for length to cut, 117 function of, 6 handling of, 18 length of, 30 parts of, 19 reeving of, 4 rope diameters, 16-17, 19, 72 stresses on, 6, 16, 65 supply reel and, 28 traveling block and, 75-76 troubleshooting, 118 visual inspection of, 61, 97 wear, 15-16, 29 drilling line construction. See also design of drilling line; ordering wire rope parts of wire-rope lines, 19 preforming, 2 wire-rope steel drilling line service, slip and cut programs, 28 drilling practices, line stress minimization and, 65 drill stem, 3, 6, 75, 96, 105 drill stem weight, 4 drill string, 84 drum. See drawworks drum; grooved drums. drum laps before first cutoff, 59, 61 drum spooling. See also dead wraps. about, 43-44, 48 helical grooving pattern, 44–45

new line onto drum, 66 one-step grooving pattern, 45 two-step spooling, 46–47

AUSTIN Ť 18-degree elevators. See bottleneck elevators. elevator(s). See also *bottleneck elevators*. about, 91, 94 S collar-lift, 93, 100 hinge-pin, 94 latches for, 3, 93-94 lubrication and inspection, maintenance of, 102 square-shoulder, elevator latches, elevator-link check, 101 elevator links. See *bail(s)*. English-units-to-SI-units conversion factors, xiii equation, length of drilling line to cut, 117 extra improved plow steel (EIP), 25

factory-lubricated rope, 68 fastline. See also drilling line; visual inspection of line. fleet angle and, 37 from drawworks drum, 10 through crown block sheaves, 11 through crown block to traveling block, 12 to traveling block, 12 fastline sheave, 82 fastline whip, 67 field lubrication, 68-69 filler wire strand, 22-23 fleet angle reeving pattern and, 36–37 scrubbing and, 66 floorhands, 19, 54, 57, 86, 100 friction tape, 54 groove radius, 79-81 grooved drums

about, 44

THE BLOCKS AND DRILLING LINE

```
designs for, 48
    helical-spiral wrap, 44-45
    one-step, 45
    soft crossover, 47
    spooling and, 17
    two-step, 46
hangline, 57
hard banding, 100
helical grooving pattern, 44-45
hinge-pin elevator, 94
hoisting system. See also air hoist.
    key components, 1-3, 6
    lifting capacity, 6
    smooth operation of, 65
    system overview, 10-14
    tasks performed, 1
    using the, 9
hook
    components, 90
    lubrication of, 95-96
    maintenance of, 101
    positioner and, 86
    safety latch of, 87
    swivel, kelly assembly and
hook assembly, visual inspection of, 98
hook-block, 88-89
hook load, 4
hook positioner, 86
                -85, 96, 101
housings, 8, 84
hydraulic snubber oil level, 99
hydraulic wire rope cutters, 57
IADC Drilling Manual, 105
independent wire-rope center (IWRC), 25
inspection. See maintenance; visual inspection of line.
kelly assembly, 2-3, 86
```

atAustin lay of wire ropes, types of, 24, 31 letting out line, 5 lifting and lowering, 5 lifting sub, 92 linear caliper, wire rope and, 26 line guides, 67 line service. See *slip-and-cutoff programs*. lines, types of, 19 line-support devices, 63, 65 line tension, 16-17 line wear. See critical points of wear. link-block bolts, 100 link ears, 98 links. See bail(s) load capacity. lowering and lifting, 5 lubrication blocks and hook, 95–96 elevator, 99-100 elevator-links, 101

of wire rope, 68-69

maintenance. See also care of wire rope; lubrication. about, 101-102 blocks and drilling line, visual inspection of, 61, 97 elevator inspection, 99-100 elevator-link check, 101 hook assembly, visual inspection of, 98 hydraulic snubber oil level, 99 of sheaves, 96-97 making hole, 2 masts, 1, 19 measurement, units of, xii-xiii measuring service life, 49. See also ton-miles (megajoules). mechanical wire rope cutters, 57 megajoules. See ton-miles (megajoules). monkeyboard, 34, 36

lang lay, 24

one-step grooving pattern, 45 ordering wire rope diameter, 25–27 length, 27 slip and cut programs, 28–29 standards for wire rope, 25

pickup points, 51 pipe-handling equipment, 77 plow steel, 20 positioner, 86–87 preformed (PRF) rope cutting, friction tape and, 54 manufacturing, 21 ordering, 25

reconditioning elevators, 100 sheave groove and, 79-81 sion-the reeling in line, 5 reeving catline, using a, 41 considerations, 33, 42 crown block and, 8-9 drilling line and, 4 factors, other, 36 fleet angle, 37 function of, 14 lines, number of, line support devices and, 63, 65 new rope and, 39 old line, using, 38-40 pattern, 33-35 sheave size and, 16 start of, 7–8 string-up steps, 14 traveling block and, 8-9 rig floor, 13, 36 right regular lay (RRL), 25 roller bearings, 78, 86

at Austin rope. See wire rope. rope diameters large-diameter, 80 nominal diameter, 27 sheave diameter and, 16-17 rotary crews, 99-100 rotary table, 3, 86 round trip, ton-miles (megajoules) calculation, 106, 110-112 running casing, ton-miles (megajoules) calculation, 114 safety factor, ton-miles (megajoules relative to), 60–61 sandline, 19, scrubbing, minimization of, 66 Seale (S) pattern, 25 Seale strand, 22–23 seizing using metal band, 56 using wire, 54-55 service life. See also drilling line; measuring service life. about, 49 derrick height and, 15-16 drawworks drum and, 17 drilling job type, 18 factors influencing, 15 handling and, 18 line tension and, 16-17 sheave size and, 16 sheave groove radius gauge, 80 sheaves. See also dead crown block sheave; deadline sheave; fastline sheave. block-and-tackle system and, 75 construction of, 78-79 crown block and, 8 design factors, 90 groove radius, 79-81 maintenance of, 96-97, 101

reconditioning of, 80 size of, 16-17 tread diameter, 78-80 side-door elevator latch, 18-degree type, 93 single-layer strand, 22-23 slip-and-cutoff programs. See also charts; cutting slipped line; ton-miles (megajoules). cost versus line length, 30 derrick height and, 15 equation, length of drilling line to cut, 117 factors based on, 50, 62, 117 ordering wire rope, 28-29 planning, 53-54, 62 procedure for slip and cutoff, 57, 62 visual inspection of line, 61 wear of rope and, 32 wire rope cutters for, 57 snatch blocks, 38, 66 snubber, hydraulic oil level, 99 shock absorption and, 86 soft crossover section, 47 spin-up of pipe, 86 spiral pattern of wire ropes, 24 spooling. See drum spooling square-shoulder elevators steel, wire-rope, 2 strand(s) about, center of 19 combination, 22 filler wire, 22 helical shape of, 20 patterns of construction, 21-23 single-layer, 22 stranding machine, 68 string-up, traveling block and, 8 supply reel extra drilling line on, 28

at Austin line from anchor to, 13 moving, 63-64 pulling line from, 8 slip and cut off of line, 14 suspension of operations, 72 swivel, 2-3 swivel lock assembly, 87 swivel-swinging grip, 38 Systeme International (SI) d'Unites xii-xiii, 105 tie-down anchor. See deadline tie-down anchor. ton-miles (megajoules before first cutoff, 58 calculating, 105 charts, rope manufacturers, 115-117 equation, length of drilling line to cut, 117 for drilling, example, 113 for round trip, example, 106–112 for running casing, 114 line use recorded in, 49 of work, uniformly spread, 103, 115 safety factor and, 60-61 tool joint bottleneck elevators and, 92, 100 collar-lift elevators and, 93 hard banding and, 100 hydraulic snubbers and, 99 toolpushers, 25, 33, 49, 58, 60-61 top-drive system, 3, 77, 84 traveling block attachments to, 91 design of, 86 ears of, 2-3housing of, 8, 84-85 lifting capacity, 6 raising/lowering, 9 reeving and, 8-9 sheaves of, 84 suspension of, 75-76

tread diameter, 78-80 troubleshooting drilling line problems, 118 turnback points. See crossover points. two-step spooling about, 46 with soft crossover section, 47

Union Wire Rope, 105 units of measurement, xii-xiii unreeling line, 15

V-door

location of, 36 reeving and, 33-34 visual inspection of line blocks and, 97 PetroleumExtensionthe fastline/drilling line, 71

non-moving parts and, 72 steps, summary of, 73 troubleshooting, 118

atAustin Warrington strand, 22–23 wear points. See critical points of wear. wickered wire. See birdcaged wire. wire rope. See also *care of wire rope*; *ordering wire rope*; *preformed (PRF) rope*; *rope diameters*. abrasion of, 72 birdcaged (wickered), 65 core of, 21 criteria for selection of, 31 lay of, 24 steel for, types of, 31 supply reel and, 63-64 wire-rope closing machine, 20 wire-rope drilling line. See drilling line.

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