



The University of Texas at Austin • Petroleum Extension Service

Figures vii University Foreword xi Preface xiii Acknowledgments xv Units of Measurement xvi 1. Drilling a Straight Hole 1 Hole-Angle Change 3 Total Hole-Angle Change 4 7 Rate of Hole-Angle Change Problems Associated with Doglegs and Keyseats Drill Pipe Fatigue 10 **Determining Dogleg Limits** 12 Stuck Drill Pipe, Logging Tools, and Wireline Stuck, Damaged, or Worn Casing Insufficient Cementing Circulation **Production Problems** 14 Causes of Hole Deviation 14 **Formation Factors** 14 **Mechanical Factors** 18 20 Controlling Hole Deviation Formation Evaluation 20 **Bottomhole Assemblies** 20 Reduced Bit Weight 36 36 Bottomhole Assembly Tools **Drill Collars** 36 Square Drill Collars 43 Spiral Drill Collars 44 Drill Collar Selection Drill Collar Transition Zones 47 Stabilizers 49 Rotating-Blade Stabilizers 51 Nonrotating Sleeve Stabilizer 53 Roller Reamers 54 Vibration Dampeners 55 **Deviation-Recording Instruments** 56 Methods of Running 56 Types of Instruments 60 Double Recorder 61 Multiple Recorder 62 Inclinometer 64 Instrument Troubles 65 Summary 65 2. Rig Hydraulics 67 The Circulating System 69 Pump Input Power 72

Contents

74 Hydraulic Horsepower Pressure Losses in the System 78 ngs 4923 at Austin Surface Equipment 80 Drill String 83 Bit 88 89 Annulus **Drilling Fluid Properties** 94 Bit Hydraulics 96 Nozzle Selection 98 102 Nozzle Velocity Annular Hydraulics 104 104 Annular Velocity Other Factors Affecting Removal of Cuttings Designing the Rig Hydraulics Program Summary 112 113 3. Drilling Fluids Composition of Drilling Fluids Water-Base Muds 116 Oil Muds 116 **Pneumatic Fluids** Phases of Drilling Muds 117 **Continuous Phase** 118 **Reactive Solids Phase** 118 Inert Solids Phase 124 **Chemical Properties** 125 Functions of Drilling Mud 125 RetroleumExtension Water-Base Muds 129 Treatment of Water-Base Muds 129 Types of Water-Base Muds 140 Spud Muds 140 Natural Muds 141 Phosphate-Treated Muds 142 Lignosulfonate Muds 142 Calcium-Treated Muds 143 Saltwater Muds 144 Low-Solids Fluids 146 Safety Precautions 148 Oil Muds 150 Uses of Oil Muds 150 Treatment of Oil Muds 151 Types of Oil Muds 151 **Oil-Base** Muds 151 Invert-Emulsion Muds 152 **Pneumatic Fluids** 152 Testing Drilling Mud 154 **Density** Tests 155

The University of Texas at Austin Tests for Viscosity and Gel Properties 160 Filtration and Wall-Building Tests 162 Sand Content Determination Summary 168 4. Casing 169 Types of Casing 170 Conductor Casing 172 Surface Casing 173 Intermediate Casing String Liner 177 Production Casing 180 Casing Standards 180 **Physical Properties** 180 Casing Threads and Couplings Casing String Design 184 Casing Strengths 184 Casing Size 188 Casing Accessories 189 Setting Casing 196 Preparing for the Job 196 198 Measuring the Casing Preparing the Casing 200 Preparing the Hole 201 **Running Operations** 202 Casing Landing 209 Summary 212 213 5. Cementing Mixing Cement 214 214 Water Supply Mixers 215 **Pumping Cement** 218**Pumping Units** 218219 **Primary Cementing Cement Volume Requirements** 225 Considerations After Cementing 227 Oilwell Cements and Additives 229 Secondary Cementing 232 Squeeze Cementing 233 Plug-Back Cementing 234 Summary 236 Conclusion 237 **Appendix: Figure Credits** 239 **Glossary** 247 279 Index

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.

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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 Drilling Technology 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.

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English-Units-to-SI-Units Conversion Factors

eteithereco. Drilling a Straight Hole

In this lesson:

- Hole-angle change •
- Causes of hole deviation
- Controlling hole deviation
- Bottomhole assembly tools •
- Straight-hole survey instruments

Prior to about 1930 and the development of deviation-recording instruments, crooked holes were not considered a problem for *rotary* drilling. It was believed that if a hole was started vertically, it would remain straight during drilling from top to bottom. Wells tended to be shallow, and not many were drilled below 5,000 feet (1,524 metres). Penetration was slow because weight on bit (WOB) usually did not exceed 15,000 pounds (6,675 decanewtons or daN). Drill collars, as we know them today, were not used. Instead, the bottomhole assembly (BHA) usually consisted of a fishtail bit, a crossover sub (called a collar), and drill pipe. A portion of the drill pipe was run in compression in order to supply the desired WOB.

No one suspected that wells were crooked until about 1928 during the Seminole boom in Oklahoma. During the development of the Seminole field, it was realized that some wells required considerably more casing to complete than others, even though the wells were supposed to be in the same producing horizon. The existence of crooked wellbores was finally recognized when a well drilled by one contractor intersected another wellbore. Because operators had to pay for the extra footage drilled and purchase extra casing, tubing, and rods if the well had to be pumped, deviation became a concern.

Rig Hydraulics 2 LESSON thubit

In this lesson:

- The hydraulic system
- Pressure losses in the system
- Bit hydraulics
- Annular hydraulics
- Designing the rig hydraulics program

Hydraulic, or fluid, horsepower is a significant factor in nearly all phases of rotary drilling. In drilling, particular emphasis is placed on *bydraulic borsepower (bhp)*—the amount of energy delivered to circulate fluid. At the drilling face, the energy of the drilling fluid is used as a powerful jet stream to sweep cuttings out of the way of the oncoming bit. Consequently, hhp at the bit is critical to drilling mud can do. Without an adequate supply of hhp at the bit, high penetration rates are not possible. WOB, rotary speed, and hhp are interrelated. Typically, a substantial amount of hole is drilled when a high amount of hydraulic energy passes through the bit jets, a relatively heavy weight is placed on the bit, and a high rotary speed is applied. By contrast, if the hydraulic, or circulating, system does not deliver enough power to the bit to remove the cuttings rapidly, increasing the bit weight and rotary speed will not increase the ROP.

The main requirement of the *circulating system* is to provide sufficient hhp to the bit to clean the bottom of the hole. After performing its work on bottom, the mud must also have enough power to carry drilled cuttings, including any particles that enter the mud stream from other parts of the wellbore, to the surface and maintain the walls of the hole. This is extremely important in troublesome formations, such as sloughing shales. An inefficient *hydraulics* program will result in poor penetration rates and can lead to other problems, such as stuck pipe, hole bridging, or fill-up on bottom after trips.

67

Drilling Fluids

In this lesson:

- Functions of drilling fluid
- Water-base muds and oil muds
- Pneumatic fluids
- Drilling fluid composition and properties
- Field testing drilling fluids

The ancient Chinese, who made use of the spring-pole drilling technique in the 5th century, were among the first to use water to soften rock and remove cuttings. However, the importance of drilling fluid was not clearly demonstrated until rotary drilling surpassed the hammering and percussion technique of *cable-tool drilling* in the 1900s. In fact, the continuous circulation of drilling fluid is the primary reason why the rotary drilling method became so successful.

Drilling fluid is circulated through a wellbore so the cuttings that the bit produces at the bottom of the hole can be carried to the surface. Drilling fluids that are liquid are commonly referred to as drilling mud or simply, mud (fig. 65) However, not all drilling fluids are liquid. Air, gas, and gaseous mixtures, such as *foam* and *aerated drilling muds*, are used in some drilling operations. The type of drilling fluid selected for a well depends on the formations that will be drilled and the complexity of the well design. For example, when very deep and consequently hazardous wells are drilled, the drilling fluid is required to have the correct physical and chemical properties to withstand a variety of well conditions. The fluid that will offer the lowest overall drilling cost and minimize potential problems is usually selected based on local experience. The cost of maintaining the right properties, however, can be high and is often considered a major drilling expense.

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In this lesson:

- Types of casing used on land and offshore •
- Casing standards and specifications
- Casing string design, strengths, and sizes •
- Types of casing accessories
- How to prepare and set casing

Petroleur e surf Drilling for oil and gas involves boring a hole to the petroleum accumulation and installing pipe from the reservoir to the surface. The pipe, which extends from the target zone to the surface, is called casing (fig. 84). It acts as a protective lining in the wellbore. Casing is large-diameter steel pipe that is usually cemented into the hole to ensure a pressure-tight connection to the oil or gas reservoir. Running casing into the hole is very similar to running drill pipe except that the



Figure 84. Casing stacked for use in a drilling operation

Cementing

t Sitt

In this lesson:

Petrole

- Mixing and pumping cement
- Cement volume requirements
- Considerations after cementing
- Oilwell cements and additives
- Secondary cementing

Oilwell cementing is the process of mixing and placing cement slurry in the *annular space* between a string of casing and the open hole. The cement sets, bonding the pipe to the formation. A good cement job affects how much a well can produce over the course of its life. Poor cementing operations can result in a failure to isolate the subsurface zones or cause corrosion failures in production equipment. Because the effectiveness of a cementing operation can be affected by many factors—such as contaminated or incorrect amounts of water, use of improper cement, hole enlargement, and mud channels—careful planning is necessary. Cementing procedures can be classified into primary and secondary phases:

• *Primary cementing* is performed immediately after the casing is run into the hole. It serves to restrict fluid movement between formations and the surface, provide support for the casing, prevent pollution of freshwater formations, and prevent casing corrosion.

Secondary cementing includes plug-back to another producing zone, plugging a dry hole, and formation squeeze cementing. Although these secondary cementing jobs are performed as a part of *well servicing* and *workover*, they are discussed briefly at the end of this lesson.

213

Conclusion

of exas at Austin The five lessons in this segment of the Drilling Technology Series teach the background necessary for someone embarking on a career in rotary drilling. This text examines important aspects of routine drilling operations, beginning with an exploration of best practices, surface equipment, BHAs, bit and annular hydraulics, drilling fluids, casing runs, and cementing operations. Upon completing all five lessons, readers will have gained important knowledge of the major facets of drilling. To reinforce learning, an optional online assessment designed as an open-book test is available for purchase with this book. Completion of the test after reading the book provides the opportunity to receive a Completion Certificate and earn valuable Continuing Education Units (CEUs).

To further your understanding of rotary drilling, the next step is an in-depth look at special drilling operations, including controlled directional drilling, open-hole fishing, and blowout prevention. Segment III, Special Drilling Operations, provides the fundamentals of such operations for readers who are eager to receive practical procedural instruction. Also consider adding Segment I, Introduction to Rotary Drilling, to your personal library to learn about petroleum geology, the rotary drilling process, and key downhole tools, such as the bit. Segment IV, which is currently in development, explores critical aspects of offshore operations.

As a whole, the Drilling Technology Series includes a wealth of information about all phases of drilling. No other program in today's marketplace offers the same breadth of material in one location as this unique, easy-to-use collection. Although primarily designed for industry personnel or college students studying petroleum technology, it is useful for anyone who wants or needs to know more about 2etrole rotary drilling.

Index

Througout this index, *f* indicates a figure and *t* indicates a table on that page.

abnormal pressures, 127 accelerators, cement, 230 acetic acid. 219 acids, 151 activated charcoal, 231t adjustable kickoff tool (AKO), 35 aerated drilling mud, 113, 116t, 117 aging test, 167 air as a drilling fluid, 116t, 117, 127, 152 air hoist, 203f AKO. See adjustable kickoff tool (AKO). alkalinity, 125, 136, 142, 154 alkalis, 145, 148, 151 American Petroleum Institute (API) casing standards of, 180-181, 212, 229 cement standards of, 230 dogleg severity tables by, 8 anhydrite, 134t, 135, 138, 143 annular space cement channeling in, 193 cementing, 213, 227-228 drilling fluid circulation in, 126f hydraulics program in, 104 as part of the circulation system, 69f, 70 pressure loss around, 89-90, 90t-93t, 93, 95f removing cuttings from, 68 annular velocity, 30, 68, 104, 105 107t, 108 annular volume, 108 annulus. See annular space. API. See American Petroleum Institute (API). artificial lift equipment, 170 asbestos fibers, 129, 130, 139, 144 asphalt, 151 attapulgite, 122, 144, 152 austin chalk, 16f automatic fill-up shoe, 190, 191, 205 axial compression, 187 axial load, 21, 21*f*, 22

back-pressure, 50, 102, 126 back-pressure valve, 191, 227 baffle collar, 191 baffle plate, 57*f*, 58, 59*f*, 192*f* baking soda. See *sodium bicarbonate*. balling up, 18

atAustin barite, 124, 129, 130, 131, 132f, 136, 230, 231t barium carbonate, 137t barium hydroxide, 145 barium sulfate. See barite. bark extract. 129 barrels per minute (bbl/min), 74, 76, 108 batch mixer, 216, 217f beds. See salt beds. bell nipple, 224 bent housing, 35, 35f bentonite adding to phosphate treated mud, 142 as cement additive, 230, 231t, 232 to control water loss, 135 invert-emulsion muds and, 152 for natural muds, 141 for pH control, 136 polymer muds and, 147 reaction with water, 118, 118f in saltwater mud, 144 for spud mud, 140 as water-based mud treatment, 129, 130 Wyoming, 122, 123f BHA. See bottomhole assembly (BHA). bhhp. See bit hydraulic horsepower (bhhp). BHP. See bottomhole pressure (BHP). billet, 180 bit balling, 130 bit hydraulic horsepower (bhhp), 68, 96-97, 101 bit jets, 67 bit nozzles. See nozzles. bit pin, 57f, 58 bit records, 20 bit weight (B_w), 38, 39 bits common sizes of, 188f cooling with drilling fluid, 125 deviation of, 2 drilling fluid circulation in, 126f dull, 18f hydraulics program and, 96-98, 99t, 100-102 as part of the circulation system, 69f pressure loss around, 88–89, 95f unstable BHA and, 19 blanking off a nozzle, 101-102 blowout preventer (BOP), 172, 174 blowouts controlling formation pressure and, 127 doglegs and, 14

from insufficient WOC time, 227 production casing and, 179 surface casing and, 174, 186 BOP. See blowout preventer (BOP). bore, 38. See also inside diameter (ID); wellbores. bottom wiper plug, 222-223, 222f, 223f bottomhole assembly (BHA) cleaning, 89, 97 collapsed casing and, 185 deviation-recording instruments for, 56-65 downhole motor assembly for, 34–36, 34f, 35f drill collar size and, 19 history of, 1 packed-hole assembly and, 27–32, 28f, 31f packed-pendulum assembly and, 20-26, 21f, 23f, 32, 33f preventing crooked hole assembly through, 20 roller reamers and, 54 spiral drill collars and, 44, 44f square drill collar and, 43, 43fstabilizers and, 49-53 stiff, 54 vibration dampeners and, 55, 55f bottomhole assembly (BHA) tools drill collars, 36, 36f, 37f, 38-40, 41t-42t spiral drill collars, 44f transition zones, 47-49 bottomhole pressure (BHP), 167 bottomhole pump, 185 boxes (drill collar), 38 brackish-water mud, 144 bradenhead squeeze cementing, 2 brakes/braking, 196, 205 bridges, 201 bridging materials, 232 brine, 118, 122, 146, 17 bucket-and-slings, 202 buckling in the hole, 45 buckling stress, 187, 209 buoyancy, 38-39, 42t, 128 Burnet county dolomite, 16f burst pressure, 184, 186 burst strength, 186 bypass plug, 192f cable-tool drilling, 113 calcite, 16f calcium carbonate, 151 calcium chloride muds, 116t, 137t, 143, 151, 230, 231t calcium clay mud, 118 calcium hydroxide muds, 137t, 143. See also slaked lime. calcium in drilling muds, 116t, 125, 143, 145, 154

calcium lignosulfonate, 137t calcium sulfate muds, 137t, 138, 143. See also gypsum muds. calcium-ion concentrations, 142 caliper log/survey, 226 cambro-ordovician calcite/dolomite marbles, 16f carbon dioxide (CO₂) cartridges, 162 Carboxymethyl cellulose (CMC), 129, 135, 144, 231t Care and Use of Casing and Tubing (API, May 1999), 205 casing centralizers. See centralizers casing crews. See crews, work. casing elevator, 196, 197f casing hanger, 209, 209f casing pack, 150 casing shoe, 133, 190f. See also guide shoe. casing slips, 170, 197f, 198. See also spider. casing stabber, 196, 203-205 casing accessories for, 189-195 availability of, 189 caving/cave-ins and, 170, 173 expansion of, 227–228 failure of, 187, 212 grooved due to doglegs and keyseats, 10 handling, 200, 202, 202f for offshore drilling, 170 overview of, 169-170, 169f size of, 188-189, 188f standards, 180-181, 212, 229 strength of, 184–187 tension and, 209, 211 variety of purposes of, 212 casing string. See also conductor casing; intermediate casing; production casing; surface casing. design, 184-189 evidence of crooked holes through, 1 liners, 177–178, 177*f* with reciprocating scratchers, 194, 195f rotating and reciprocating, 208 running through a dogleg, 14 strength of, 184-187 testing after cementing, 227 threads and couplings, 182–183, 182f typical arrangement of, 170–171, 171f variety of purposes of, 212 casing string, setting fluid circulation, 206-209 landing, 209-211 measuring, 198 overview of, 196 preparing for, 196, 198, 200-201 preparing the hole, 201

running operations, 202-208 stabbing, 203-205 tally sheet, 199f casing tongs, 196, 197f casinghead, 173, 209, 209f cathead, 196 catline, 202 catwalk, 200, 202 caustic soda (sodium hydroxide), 125, 137*t*, 138, 145, 148, 149f caving/cave-ins. See also sloughing. casing and, 170, 173 causing hole irregularities, 90 high water loss and, 135 salt contamination and, 139 use of drilling mud to prevent, 125, 127 cedar park limestone, 16f cement. See also slurry. additives to, 230, 231t API standards in, 230 as a contaminant, 135, 138, 143 contaminating drilling mud, 134t hydration of, 229 importance of correct displacement of, 224 mixers for, 215–216, 215f, 216f, 217f mixing, 214 setting time for, 214, 229 volume requirements of, 225–226 cement bond log, 228 cement channeling, 193 cement clinker, 230 cementing considerations after, 227-229 doglegs and, 14 failure of, 10, 232 float collar and, 191 guide shoes and, 190 importance of, 236 multistage tools for, 192-193, 192f oilwells, 229-232 overview of, 213 pressure-testing, 229 primary, 213, 219-224, 222f, 236 to relieve compression load, 211 remedial, 228 secondary, 213, 232-235, 236 torsional stress and, 187 cementing head, 221, 221*f*, 222*f* cementing pumps, 218, 218f, 219f, 221-224 centipoise (*cp*), 109, 122 centralizers, 193-194, 193f, 195f, 207, 208, 222f centrifuge, 141, 141f check valve, 191

as at Austin chemical barrel, 148, 149f chemically treated muds classifications of, 116t to control deflocculation, 120, 134t to control yield point, 119 to enhance clay performance, 122, 125 phosphate-treated, 142 for water loss, 135 chlorides, 139, 154, 214 chlorinated phenol, 129 chrome lignosulfonate, 137t circulation rate (Q), 80, 82, 98, 102 circulation system automatic fill-up shoe and bridging materials for, 232 before cementing, 208 components of, 69f, 70 doglegs and, 14 drilling fluids and, 126f, 127 fluids while setting casing and, 206-209 hydraulic horsepower and, 67 mud weight and, 131 overview of, 69-71 stabilizers and, 50 stopped, 56, 120, 120f, 127 viscosity and gel strength and, 134 when preparing the hole, 201 clay chemically treating, 122, 125 commercial, 124, 129 low solids, 147 native, 122, 123f natural, 114, 115f nature of, 122 premium, 129, 130, 144 salt-resistant, 139 salt/saltwater, 122, 123t, 129, 144, 145 sodium, 118 for spud mud, 140 weight of, 123f, 133 clay hydration, 150 clay solids, 118 clay yield, 122, 123f clinton flake, 232 closing plug, 192f CMC. See Carboxymethyl cellulose (CMC). collapse pressure, 184, 185 collar. See drill collars. colloidal fraction, 117, 117*f*, 118 compressibility, 80 compression, running in, 38 compression load, 211 compressive strength, 16, 16*f*, 17*f*, 229

conductor casing, 170, 171f, 172, 212. See also casing string. conductor pipe, 171 cone, boundary of, 3, 3f connections. See also couplings. failures in, 47 handling-tight, 182-183, 201, 204 power-tight, 182-183 pressure-tight, 169 stabbing and, 203, 204 continuous phase, 117, 117f, 118 controlled-solids muds, 146-147 conventional muds, 141 core barrel overshot, 57f, 58 coring, 150 corrosion acetic acid to inhibit, 219 conductor casing protection from, 172 drill pipe fatigue and, 10, 11f oil muds to reduce, 150 pneumatic fluid use and, 153 countercurrents, 83 couplings, 182-183, 182f, 184, 200-202. See also connections. crews, work, 128, 154-155, 196 critical velocity, 104 crooked hole. See deviation, hole. crooked-hole country, 14, 32 crooked-hole tendencies, 24, 27, 30, 31 crosscurrents, 94 current, 64, 127 cutters, 54, 54f, 70 cuttings annular hydraulics and, 104 factors affecting removal of 109 importance of drilling fluids to, 125, 168 mud gel strength and, 120, 120f oversized drill collars restricting passage of, 45 pneumatic fluids transport of, 153 pressure and, 89 removal of, 126-127, 141, 141f stabilizers and, 50 cyclic stresses, 10 deflection, 32 deflocculating agents, 130, 147 defoamers, 144 degasser, 69f, 70, 71f, 133 density, drilling fluid buoyancy and, 128 hydrostatic pressure and, 127 impact on pressure loss, 94, 124 increasing, 124, 129

as at Austin low, 152 testing, 155-157, 158t-159t to transport cuttings, 126, 147 density, slurry, 191, 220, 230, 231t derrick, 128 derrick floor, 202 derrickhand, 119, 148f, 196, 204, 205f desander to keep weight down, 133 in natural muds, 141 role of, 69f, 70, 71f, 124, 146 design factors, 184 design strength, 229 desilter to keep weight down, 133 in natural muds, 141 role of, 69f, 70, 71f, 124, 146 deviation, hole. See also hole curvature; straight hole, drilling. causes of, 14–19, 18f comparison to straight hole, 2f correcting, 20 depth of, 2fhistory of, 1 problems caused by, 1-2 specifying maximum, 56 tendencies of, 24, 27, 30, 31f weight on bit and, 18, 36 deviation angle. See *hole-angle change*. deviation prevention bottomhole assemblies and, 20 choosing placement of equipment based on, 24 by controlling weight on bit, 35 downhole motor assembly, 34–36, 34f, 35f formation evaluation, 20 ideal placement of stabilizers for, 24 importance of, 65 packed-hole assembly for, 27-32, 28f, 33f pendulum assemblies for, 20-26, 21f, 23f deviation survey, 56 deviation-recording instruments, 56-58, 60-64, 60f, 65 diaphragm, 223, 223f diatomaceous Earth, 231t diesel oil, 116, 142, 151, 231t differential pressure, 89 differential shoe, 191 differential sticking, 44, 44f, 150, 193 dip angle, 15, 20 direct-indicating viscometer, 160, 161f directional drilling, 24, 56, 125 directional survey, 8

discharge line, 69f dispersants, 136, 137*t*, 232 dispersed phase, 152 displacement fluid in multistage cementing, 192f in primary cementing, 222f, 223, 224 volume of, 206-207, 206f, 207f dogleg severity (DLS), 8, 12–13, 12f, 13f doglegs causing sticking, 13 drill collar stiffness and, 28 formation of, 2, 9f hole-angle change, 4 packed-hole assemblies and, 27 problems associated with, 10-14 rate of hole-angle change and, 7f reducing bit weight and, 36 square drill collars and, 43 dolomite, 16f, 53, 124 dome salt, 139, 144 dope. See threads. double recorder, 61-62, 61f downdip, 15, 15f downhole hanger, 211 downhole motor assembly, 34–36, 34f, 35f drag, 83, 121 drift angle. See *deviation*, *hole*. drift diameter, 181 drill collars annular velocity around, 105t-107t becoming stuck in the wellbore, 13 choosing correct size of, 24, 25*t*, 26 choosing diameter of, 29, 29t determining number of, 40 failures due to doglegs and keyseats, 10 filter cake and, 121 history of, 1 hole clearance and, 1 oversized, 45, 46t overview of, 36, 36f, 37f, 38-40 in the packed-hole assembly, 30, 31f, 32 as part of the circulation system, 69f pressure loss around, 79f, 87, 87t-88t size of causing deviations, 18–19 special features for, 46, 47f spiral, 44, 44*f* square, 27, 28, 43, 43f stabilizers for, 22 stiffness of, 28, 29, 47 transition zones and, 27, 30, 31t, 32, 47-49, 55 weight of, 37f, 38-40, 41t drill pipe annular velocity around, 105t-107t

at Austin becoming stuck in the wellbore, 13, 139 bending, 18 in the circulation system, 69f, 126f damaged, 200 displacement volume of, 225 dogleg severity (DLS) and, 12 for drill collar transition, 48 failures due to doglegs and keyseats, 10 fatigue in, 8, 10, 11f, 12, 38 grade/mixed, 200 handling, 200 history of, 1 importance of drilling fluids t plastic-lined, 84 preparing for casing run, 196 pressure loss around, 95f racking for, 172f, 189, 196, 200 in tension and in compression, 185 types of for transitions, 48-49, 48f, 49f weight of drill collar and, 38 drill pipe float, 57f, 58 drill stem, 18, 56, 79f, 125 drill stem test (DST), 229 drill string becoming stuck in the wellbore, 13 in the bottomhole assembly, 20 in the circulation system, 70 in a downhole motor assembly, 34 drill pipe fatigue and, 10, 11f natural bending of, 2 pressure loss and, 83-84, 83f, 85t-86t, 86-87 transition zones and, 47 weight of drill collar and, 38 weight on bit and, 18, 18f drilling crew. See crews, work. drilling fluids. See also oil muds; water-base muds. circulation of, 126f, 127 classifications of, 116t composition of, 114-117 drill collars and, 44 drill pipe fatigue and, 10 function of, 113, 125-128 in the hydraulics program, 68, 70f importance of, 168 intermediate casing protecting, 176 losing pressure through, 94, 95f mud pump as source of power for, 69 pneumatic fluids, 152-153 in a primary cementing job, 222f drilling line, 196 drilling mud. See also mud. additives to, 130 chemical properties of, 125 circulation of, 67, 70, 114f

considering properties of, 30 as a displacement fluid, 224 phases of, 117-124, 117f, 120f properties of, 94 speed of, 84 suspension, 124 types of, 113 weight of, 94 Drilling Mud Report Form, 154 drilling mud, testing density, 155-157, 158t-159t filtration and wall-building, 162–166, 163f, 165f overview of, 154-155 sand content, 166-167 viscosity and gel properties, 160-162 drive shaft, 34 dry cement, 229 dry hole, 234 DST. See drill stem test (DST). dump bailer, 235 duplex pump, 74 dynamic loads, 205

eddies, 83f, 90, 94 edwards limestone, 16f efficiency (E), 73, 77 efficiency rating, 80 electrochemical forces in mud, 119 electromagnetic inspection, 187 elevators, 46, 170, 196, 197f, 210 emulsification, 129, 130, 142, 152 emulsified oil, 135 emulsifying agent, 151 emulsion stability test, 16 endurance limits, 12 entrained gas, 134 equilibrium conditions, 24 equivalent mud weights (EMW), 175f erosion, 45, 50, 128 exploration wells, 139

false depths, 2 farigue, drill pipe, 8, 10, 11*f*, 12, 38 faulting, 15, 20 feet per minute (ft/min), 104 filter cake buildup of, 201, 226 consequence of inadequate, 127 considering when choosing casing size, 188 control of filtration and, 135 controlling size of, 121, 121*f* differential sticking and, 44, 44*f*

SatAustin excessive due to water loss, 232 formation of, 121 importance of, 128 testing for, 162, 164-165 when spudding in a well, 140 filter paper, 124 filter press, 162, 163f filtrate, 44 filtration control agents, 130 filtration rate. See also fluid loss. analysis of, 154 of cement contaminated mud, 138 control of, 135 importance of, 121 lignosulfonate muds and, 142 phosphate-treated mud, 142 polymer muds, 146 in saltwater mud, 144 testing, 154, 162-166 water as drilling fluid and, 146 when calculating cement volume requirements, 226 fish, 45, 46t fishing (drill pipe recovery), 12, 145 flammability, 153, 164 float collar in cementing, 192f, 222f, 223-224, 223f fluid circulation and, 206 overview of, 190, 191, 191f float device, 190 float shoe, 190, 206 float valve, 227 flocculating agents, 133, 135, 139, 142, 146 flocculation, 120 flow path, 78 flow rate calculating, 76, 108 of drilling mud, 84, 94, 96 at the nozzle, 101, 102 pump style and, 74 soft formations and, 104 fluid displacement. See displacement fluid. fluid loss, 121, 121f, 232. See also filtration rate. fluid pressure, 44, 68, 88, 89, 124, 174 fluids oversized drill collars restricting passage of, 45 during setting casing, 206–209, 206f stabilizers and, 50 foam, 113, 116t, 117, 152 foaming, saltwater muds and, 144 formation breakdown, 133, 192, 194, 207, 224 formation damage, 127, 208 formation dip, 15, 24, 25*t* formation evaluation, 128

formation fluids, 124, 130-131, 141, 153, 228 formation gas, 153 formation pressure, 44, 44f, 127, 141, 174. See also pressure. formation reaction, 21, 21t, 22 formations. See also beds; hard formations; soft formations. alternating layers in, 15, 16 annular hydraulics and, 104 causing hole deviation, 14-15 choosing placement of equipment based on, 26 evaluating, 20 fracture gradient, 174, 175f hard banding for use in, 47f importance of drilling fluids to, 125 oil muds for, 150 permeable, 44, 44*f*, 135 properties of, 15 purpose of surface casing and, 173 reaction to a pendulum assembly, 21, 21f, 22 roller reamers for, 54 stabilizers for, 52, 53 truncated, 5f wall support of, 30 zones in, 31f, 32 fracture gradient, 174, 175f fracturing, 15, 20 freshwater, 118, 118f, 173. See also water. freshwater muds, 116t, 118, 125, 129, 140 friction, 45, 78, 94, 220 frictional resistance, 83, 84 Fuller's Earth. See attapulgite. funnel viscosity test, 162 galling, 204 gallons per minute (gpm) calculating, 76, 77 pressure loss and, 81 pump output, 75frunning pumps in parallel, 74 when figuring bit nozzle size, 98, 99t gas cutting, 133 gas sands, 172 gel strength from calcium sulfate contamination, 138 of calcium-treated muds, 143 of cement contaminated mud, 138 chemical treatments for, 136 controlling in water-based muds, 134, 134t of oil-dispersible clays, 152 overview of, 120, 120f phosphate-treated mud, 142 salt contamination and, 139

i Austin in saltwater mud, 144 strength of, 127 testing, 154, 160-162 gilsonite, 232 glen rose limestone, 16f go-devil assembly, 57-58, 57f, 61f, 62, 65 Grade E drill pipe, 12, 12f, 13f, 170 graded string, 200 granite, 16f guide shoe, 189–190, 189f, 190f, 192f, 222f also casing shoe. gum, 135 gun barrel approach, 27 gypsum muds, 116t, 134t, 1 143. See also calcium sulfate muds. gyroscope, 62 hairspring, 64 handling-tight couplings, 182-183, 201, 204 hanging load, 209 hard banding, 46, 47f hard formations. See also formations. alternating layers in, 15, 16 flow rates and, 104 high velocity jets and, 89 roller reamers for, 54 stabilizers for, 49, 52 hardfacing, 51, 52 heavy-walled drill pipe, 48, 48f heavyweight drill pipe, 49, 49f hectorite, 152 holdback rope, 203 hole. See wellbores. hole clearance, 19, 29 hole curvature, 12-13, 12f, 56. See also deviation, hole. hole diameter to calculate cement volume requirements, 225 caving and, 90 common sizes of, 188f, 189 drill collar and, 30, 43

pump input power and, 72, 73*f*, 77 hole enlargement calcium-treated mud and, 143 calculating cement volume requirements of, 225, 226 in salt formations, 145 soft formations and, 30 spud mud and, 140 stimulated by drilling fluid, 127 hole-angle change choosing size for deviation prevention, 25*t*, 26 importance of controlling, 65 overview of, 3–4, 3*f* packed-hole assemblies and, 27–28

rate of, 7-8 square drill collars and, 43 total, 4, 5f, 7 hopper, 139, 148, 148f, 216, 216f horizontal deviation, 6t, 7 horizontal distance, 4 horizontal drift, 2, 4, 6t horsepower (hp), 72 HP. See hydrostatic pressure (HP). humic acid, 214 hydraulic horsepower (hpp) calculating, 76–77 importance of drilling fluids to, 125 importance of in a hydraulics program, 112 output of by pump, 68 overview of, 67, 74-78, 96 pressure and, 77 pressure loss and, 78-79 pump input power and, 72 hydraulics program annular hydraulics and, 104 annular velocity and, 104, 105t-107t, 108 bits and, 96–98, 99t, 100–102 circulating system and, 69-71, 70f designing, 110, 111f hydraulic horsepower and, 74-78 nozzle velocity and, 102, 103t overview of, 67-69, 112 pressure loss from drill fluid properties, pressure loss in the annulus, 89-90, 90t-93 pressure loss in the bit, 88–89 pressure loss in the drill collar bore, 88t pressure loss in the drill string, 83-87 pressure loss in the surface equipment, 80-82 pressure losses in the system, 78-79 pump input power, 72 removal of cuttings, 109 hydrogen sulfide, 155 hydrostatic pressure (HP) casing and, 185, 187 cementing and, 230 cuttings and, 104 drilling fluid overcoming, 126 pneumatic fluid use and, 117, 153 See inside diameter (ID). impact loading, 200 impermeable layers, 5finclination drill collars and, 22 formation dip and, 15 hole-angle change and, 4, 6t pendulum assembly and, 21f

AUSTIN recording instruments and, 60 inclinometer, 64, 64f inert solids phase, 117, 117f, 124 inhibited muds, 143 inner casing, 209f input power, 96 inside diameter (ID), 38, 40, 84, 181. See also bore. integral-blade stabilizer, 52, 53f intermediate casing. See also casing string. cementing, 226 common sizes of, 188f limitations of, 170 overview of, 171f, 176, 209 uses of, 186 International Association of Drilling Contractors (IADC), 68 invert-emulsion mud, 116t, 151, 152, 167 iron oxide (hematite), 230, 231t jerk line, 196 jet mixer, 216, 216f jet nozzles. See nozzles. joint back-off, 204 joints, 172, 172f, 200 junked hole, 12, 234 kaolite, 232 kelly overview of, 69f, 70, 70f pressure loss around, 79f, 80, 82 types of, 80t keyseats causing sticking, 13 formation of, 8, 9f hole-angle change, 4 problems associated with, 10-14 kick, 153 kilograms per litre (kg/L), 155 laminar (slow) flow, 83f, 84, 89-90, 104 landing casing, 209-211 landing collar, 177f lateral movement, 16, 17f, 19, 24 law/legislation. See regulations. LCM. See lost circulation materials (LCM). lease lines, 4 lignites, 136, 137t, 142 lignosulfonate, 129, 136, 138, 144–145, 230, 231t lignosulfonate muds, 116t, 136, 142-143 lime, 140, 145, 154 lime muds, 116t, 137t, 138. See also calcium bydroxide muds.

limestone, 15, 16f, 53, 124 liner packer and hanger, 177f liner string, 171 liners, 74, 75f, 177–178, 177f liquid content, testing, 154 liquid latex, 232 liquid phase, 118, 128 long string. See oil string. lost circulation materials (LCM), 101, 130 lost returns, 104 low clay solids muds, 147 lowering casing, 203-205 low-solids muds, 146–147 low-yield clay, 122, 123f Lubinski, Arthur, 8, 12 lubricants, 94, 116, 128, 130 lye, 148 magnesium, 145 magnetic compass, 62 magnetic deviation, 46 magnetic-particle inspection, 187 make hole, 18 make-up torque, 196, 205 makeup water, 140, 144, 145 making up, 52, 57, 183, 196, 198, 203-205 mandrels, 53 Marsh funnel, 119, 134, 154, 160-162, 160/ mast, 128 maximum shut-in pressure, 186 measurement while drilling (MWD), 35, 50 mechanical power, 96 mesh, 166 methylene blue test, 155 mineral oil, 116 minimum yield strength, 181 mist as a drilling fluid, 116t, 117, 152 mixed string, 200 moment of inertia (I), 29, 29t montmorillonite, 122 mud. See also drilling mud. buoyancy of, 38 filtrate, 44f removal of, 220 return of, 207, 207f viscous, 109 mud balance, 155, 155f, 156, 220, 220f mud buoyancy factors (Fmb), 39, 42t mud cake. See filter cake. mud column, calculating pressure of, 155 mud density, 94, 124, 128, 155, 157 mud engineer, 154-155

...., 80, rarallel, 74 report, 154 mud solids. See *filter cake*. mud tanks, 69*f*, 94, 95*f*, 126*f*. See also *tank*, *chemical*. mud weight adding water and, 133*t* buoyancy and, 42*t* controlling, 130, 141 conversion units for correcting for mud line, 78 doglegs and, 12 low-solids muds, 14 testing, 154 water-base muds and, 130-131, 132t, 133 mud-up operation, 129 multiple recorder, 62, 63f multistage cementing tools, 192-193, 192f MWD. See measurement while drilling (MWD). native clay, 122, 123f natural clay, 114, 115f natural gas, 116t, 117, 127, 152, 153 natural muds, 141 neat cement, 229 Nicholson, Robert W., 12 nondispersed muds, 147 nonmagnetic drill collars (NMDC), 46, 47f, 62 non-rotating stabilizer, 50f, 53, 53f nozzle velocity, 102, 103tnozzles combinations of, 100-101 hydraulics program and, 68, 98, 99t, 100-102 measuring, 98f pressure and, 88 pressure loss around, 79f, 95f, 99t role in the circulation system, 70 size of and jet velocity, 103t nut shells, 226 OD. See outside diameter (OD). offset ledge, 16, 17*f* offshore drilling calcium-treated mud and, 143 casing failures and, 187 casing for, 170 cementing units for, 219f

mixing water for, 145 setting conductor casing in, 172 spudding in a well, 140 oil dispersible clay, 152 oil muds. See also drilling fluids. classifications of, 116t overview of, 116 phases of, 117-124 testing for sand content, 167 treatment of, 151 types of, 151-152 uses of, 150 oil string, 177, 179, 188f. See also production casing. oil-based mud, 94, 116t, 151 oil-emulsion mud, 94 oilwells, cementing, 229-232 on bottom, 22 open hole, 177, 225 opening plug, 192f outside diameter (OD) casing size and, 188 choosing, 45 of conductor casing, 172 drill collar and, 19, 38, 40, 41t input power and, 77 pressure loss and, 84, 85t-86t standards and, 181 overshot, 45, 46t PAC. See polyanionic cellulose (PAC). packed-hole assembly, 27-32, 28f, 31f packed-pendulum assembly, 32, 34 packer fluid, 150, 151 packer squeeze cementing packers, 14 paraformaldehyde, 129 pendulum assembly, 20-26, 21f, 23f, 64f pendulum collar, 32 pendulum effect, 60, 60f, 62 penetration rate. See rate of penetration (ROP). perlite, 231t permeability, 121, 121f, 135 permeable formation, 44, 44f, 135 personal protective equipment, 148f **pH** control of water-based muds, 136, 137*t* pH of drilling mud, 125, 154 phosphate mud, 116t, 137t, 142 phosphates, 214 pick-up line, 196 piercing mill, 180f pile driver, 172 pins (drill collar), 38

atAustin pins, bit, 57f, 58 pipe. See drill pipe. pipe tally, 198, 199f piston, 208 pit level, 131 pits, 134, 207, 207f plastic viscosity (PV), 119, 134, 152, 160 plug container. See cementing head. plug-back cementing, 232, 234–235, 234f plugs cement contamination and, 138 in the cementing head, 222, 22 mechanical, 235, 235f stage cementing, 192, 1 pneumatic fluids, 116t, 117, 152–153 point of tangency, 21f. polyacrylates, 135 polyanionic cellulose (PAC), 129, 135, 139 polymer muds, 146–147 polyphosphates, 129, 136 porosity, 121 porous intervals, doglegs in, 13 • Portland cement, 230 pounds per cubic foot (lb/ft^3) , 155 pounds per gallon (ppg), 155 pounds per square inch (psi), 74, 76, 77, 155 power tongs/wrench, 196 power-tight couplings, 182-183 pozzolans, 226, 231t ppg. See pounds per gallon (ppg). precambrian calcite/dolomite marbles, 16f pregelatinized starch, 135, 144 premium connections, 183 pressure. See also formation pressure. burst, 184, 186 casing couplings and, 183 cementing and, 226, 227 collapse, 184, 185 controlling with casing, 170 drilling fluids and, 125, 127 fracture gradient and, 174 hydraulic horsepower (hpp) and, 77 intermediate casing and, 176 measuring, 74 setting casing and, 206 surface casing and, 173, 174 surges in, 207, 208 pressure at the bit (Pb), 96, 98, 100 pressure control, 128 pressure gradient, 155 pressure loss around the annulus, 89-90, 90t-93t, 93

around the kelly, 79f at the bit, 88-89 bit nozzles and, 99t calculating bit hydraulic horsepower for, 97 in the drill string, 83-84, 83f, 85t-86t hydraulic program and, 68 overview of, 78-79 in surface equipment, 80-82 through the drill collar bore, 87, 87t-88t through the drilling fluid, 94, 95f pressure surges, 128 pressure-tight couplings, 169, 183 primary cementing, 213, 219-224, 222f, 236. See also *cementing*. prime mover, 69, 72, 95f, 96 producing zones, 1, 2, 2f, 4, 7, 176, 194 production casing, 170, 171f, 179. See also casing string; oil string. production liner, 177 protection casing. See intermediate casing. psi. See pounds per square inch (psi). pull-up strain, 209 pump in the circulation system, 126f input power, 72-74, 73f, 77 output, 74, 75f, 97, 108 pressure, 34, 223–224 pressure gauge, 74, 75f running parallel, 73-74 speed of, 94 pumping units, cement, 218, 218f, 21 pumprate, 98 pup joints, 180 PV. See plastic viscosity (PV quartzite, 16f quebracho, 136, 137t, 13 quick-opening valve, 196, 206 Range 3 length, 180 rate of penetration (ROP) hydraulic horsepower and, 67 oversized drill collars and, 45 pneumatic fluids and, 153 rotary drilling and, 1 slowing of, 2 spiraling and, 19 square drill collars and, 43 weight on bit and, 18 RCM. See recirculating cement mixer (RCM). reactive solids phase, 117, 117f, 118–124 reamers, 24, 43, 50f, 54, 54f

ras at Austin reaming, 32 recirculating cement mixer (RCM), 215, 215f Recommended Practice for Field Testing Oil-based Drilling Fluids, 4th Edition (2005), 154 Recommended Practice for Field Testing Water-based Drilling Fluids, 4th Edition (2009), 154 recording disc, 60, 60f, 61f, 62 reeling mill, 181f regulations on cementing, 226 on float valves, 227 hole-angle change and, 4 surface casing, 173 on WOC time, 227, 22 regulator, 164 relative density. See specific gravity. remedial cementing, 228 remedial work, 189 replaceable-blade stabilizer, 52, 53f reserve pit, 131, 131*f* reservoirs drainage patterns of, 4 impermeable layers and, 5f piping into, 169 protecting, 179 targeting, 4 resistance, 21, 78 resistivity, 155 retarder, cement, 230 return line, 69f revolutions per minute (RPM), 34 rig crew for, 196 easing strain on, 190 hydraulics program for, 110, 111f preparing, 196 size of, 189 skidding, 20 rig floor, 4 rod strings, 12 roller cone bit, 16 roller reamers. See reamers. ROP. See rate of penetration (ROP). rope slings, 200 rotary drilling, 1 rotary hose in the circulation system, 69f, 70, 70f, 126f pressure loss around, 79f, 80, 82 types of, 80t rotary speed, 36, 67 rotating blade stabilizer, 50f, 51–52, 51f, 53f rotational viscometer, 134

rotor-stator, 34 RPM. See *revolutions per minute (RPM)*. run casing order, 196 run pipe, 207 running in, 14, 56–58, 57*f*, 59*f*, 177*f*

safety

casing strengths and, 184 drilling fluids and, 128, 168 through familiarity with processes, 212 with water-based muds, 148-149 safety clamp, 198 safety factor (F_s), 38, 39 safety margins, 184, 186, 226 salt as a cement additive, 230, 231t as a contaminant, 125, 134t, 135, 139, 143 dissolving, 150 salt beds, 125, 139, 144. See also formations. salt clay, 123f, 129 salt content, 131, 142 salt water, 118, 118f, 144f, 146, 224 saltwater clay, 122, 145 saltwater mud, 116t, 125, 140, 144-145 sand accumulations of, 133 allowing to settle out, 134 in drilling mud, 124 filtration and, 135 testing for content of, 154, 166 sandline, 57, 57f, 58 sandstone, 15 saturated salt mud, 116t, 144 scale division, 157 scratchers, 187, 194, 195f, 207, 208 screen set for sand content testing, 166, 166f sea water, 140, 214, 230) See also *water*. seamless casing, 180 seawater mud, 116t, 118, 144-145 secondary cementing, 213, 232-235, 236 seismic surveys, 20 Seminole boom, 1 set casing, 201 set shoe and valve, 177f setting depth, 170, 173, 174, 177, 198 setting time, cement, 214, 229 settling pit, 146 shale allowing to settle out, 134 control of filtration and, 135 hole deviation and, 15 nature of, 122

at Austin oil muds for, 150 weight of, 133 shale shaker, 69f, 94, 124, 141, 146 shallow wells, 142 shock absorber, 55, 57, 61f shock loading, 200 shoe, 14 short string. See conductor casing. 125 shoulder, 183, 198 shrunk-on sleeve stabilizer, 52, 53f shut down, 223, 227 shut-in pressure, 186 shutoff plug, 192f silica flour, 231t silt, cement set time and, 214 six-point reamer, 54, skids, 200 slack off weight, 209–210, 211 slaked lime, 143. See also calcium hydroxide muds. sleeves, 52, 53*f* slip elevator, 196, 198 slip velocity, 109, 126 • slips, 46, 47f sloughing. See also caving/cave-ins. calcium-treated mud and, 143 causing stuck pipe, 13 change in mud properties causing, 139 high water loss and, 135 pneumatic fluid use and, 153 slurry. See also *cementing*. additives to, 230, 231t chemically treating to reduce friction, 220 density of, 191, 220 figuring volume requirement of, 225–226 formation of, 214, 215 ratio of, 226 volume of, 220 soap, 151 soda ash, 137t, 138, 140 sodium acid pyrophosphate, 137t, 138 sodium bicarbonate, 137t, 138 sodium carbonate. See soda ash. sodium chloride. See salt. sodium chromate, 148 sodium clay, 118 sodium dichromate, 148 sodium hexametaphosphate, 137t sodium hydroxide. See caustic soda (sodium hydroxide). sodium tetraphosphate, 137t soft formations. See also formations. alternating layers in, 15, 16

annular hydraulics and, 104 doglegs in, 8 drill collars for, 18, 30, 43 pendulum assembly for, 24 solids, composition of, 154 spear-point assembly, 57f, 58, 59f, 61f, 62 specific gravity, 124, 155 Specification for Cements and Materials for Well Cementing (API, December 2010), 230 Specification for Oil-Well Drilling-Fluid Materials, 18th Edition (2010), 154 Specifications for Casing and Tubing (API), 180 spider, 198. See also *casing slips*. Spindletop well, 114, 115f spinning rope, 196 spiral blades, 51, 51f spiral drill collars, 44, 44f spiral heavy-walled drill pipe, 48, 48f spiral hole, 19, 19f spud mud, 116t, 140 spudding in a well, 140 square drill collar, 27, 28, 43, 43f squeeze cementing, 185, 232, 233, 233f stab, 196 stabbing board, 204, 205f stabbing casing, 203-205 stability meter, 167 stabilizers choosing ideal placement of, 25t clearance to wall of hole, 29 ideal placement of, 24 non-rotating, 50f, 53, 53f overview of, 49–50, 50f 8,28f,30,31f,32 in the packed-hole assembly, in a pendulum assembly. 23f reamers, 50f rotating blade, 50f, 51+52, 51t, 53f rubber finger, 59f stage cementing. See multistage cementing tools. standpipe in the circulation system, 69f, 70, 70f pressure gauge, 74 pressure loss around, 79f, 80, 82 types of, 80t tarch, 129, 135, 144, 145 state of equilibrium, 22 stiff bottomhole assembly, 54 straight hole, drilling. See also deviation, hole. bottomhole assembly tools for, 36-49 causes of deviation in, 14-19 controlling hole deviation in, 20-36 depth of, 2f

as at Austin deviation-recording instruments, 56 hole-angle change and, 3–9, 5*f* instrument problems in, 65 methods of, 56–59 overview of, 1-2, 65 problems with doglegs and keyseats, 10-14 stabilizers, 49-54 types of instruments for, 60–64 vibration dampeners, 55, 55f stratigraphic trap, 4, 5f stringers, 138, 200 strokes per minute (spm), 74 stuck pipe centralizers and, 193 circulation and, 56, 67 from doglegs and keyseats, 13 filter cake and, 128 liners and, 178 mud weight and, 141 oil muds for, 150 saltwater flows and, 139 subsurface geological maps, 20 sucker rods, 14 suction line, 69f suction pit, 166 sulfomethylated tannin compound, 129 surface casing. See also *casing string*. in the casing string arrangement, 170, 171f cementing, 226 common sizes of, 188f fast drilling below, 141 overview of, 173-174 purpose of, 171, 186 surface equipment, pressure loss through, 80-82, 80t, 81t surface pipe, 140, 208 surface pressure, 94, 100, 186 surfactant, 219 swabbing effect, 128, 134 swivel in the circulation system, 69f, 70, 70f, 126f pressure loss around, 79f, 80, 82 types of, 80t synthetic-based muds (SBMs), 116 A Tabular Method for Determining the Change of the Overall Angle and Dogleg Severity (API), 8 tack-welded, 191 tank, chemical, 148. See also mud tanks. TD. See total depths (TDs). temperature bottomhole, 142, 150, 165, 165f, 167

cement and, 228, 229 landing casing and, 210 salt solubility and, 145 survey, 228, 228f tensile load, 10, 11f tensile strength, 181, 184, 209, 229 tensile stress, 10 tension casing and, 209, 211 couplings in, 183, 210 in a dogleg and keyseat, 9f, 10 of a drill pipe, 8, 36 drill string, 38 tetrasodium pyrophosphate, 137t thinners, 130, 135, 144, 151 thread protector, 196, 200, 203 threaded-sleeve stabilizer, 52 threads casing, 182-183 compound for, 191, 201, 203-204 makeup of, 198 protecting, 196, 200-201, 202 three-point reamer, 54, 54f tie-back strings, 178, 178f tolerances, 183 tong dies, 196 tong marks, 185, 186 tongs, 52, 170, 196, 197f tool joints, 8, 10, 11f, 18, 83 toolpusher, 148 top wiper plug, 222-223, 222f, 223f torque, 191, 194, 204, 205 torsion, 187 total depths (TDs), 2, 2f, 20 total hole-angle change tour, 154, 196 transition zone, 38 tricone bits, 101 trip, drill collars during, 43 trip gas, 133 triplex pump, 74 tripping, doglegs and, 14 true vertical depth (TVD), 4, 6t tubing, 14, 209f tungsten carbide, 43, 52 turbines, 34 turbulent (fast) flow, 83f, 84, 89-90, 104, 220 TVD. See true *vertical depth (TVD)*. two-cone bits, 101

ultrasonic inspection, 187 unconsolidated formations, 24

at Austin undergauge hole, 19, 19f units of feet per second (ft/s), 102 unproven areas, 56 updip, 15, 15*f* upper string, 177 velocity annular, 104, 105*t*-107*t*, 108 bit nozzles and, 98, 102, 103t S critical, 104 of fluids, 45, 68, 88-89, 94, 126 slip, 109, 126 variable, 95f vertical deviation, 6t, vibration dampeners, 31f, 32, 55, 55f viscometer, 160, 161f viscosity from calcium sulfate contamination, 138 of calcium-treated muds, 143 of cement contaminated mud, 138 chemical treatments for, 136 controlling in water-based muds, 134, 134t cuttings and, 109 hydration of clay increasing, 119 of lignosulfonate muds, 142 phosphate-treated mud, 142 polymer muds, 146-147 pressure loss and, 94 salt contamination and, 139 in saltwater mud, 144 testing, 154, 160–162 waters and, 146 when spudding in a well, 140 volume, 108, 225-226 waiting on cement (WOC), 227, 229 wall building, 154, 162-166 wall cake. See *filter cake*. wall sticking. See differential sticking. wall support, 30, 128 wall thickness, casing, 181 wall thickness, drill collar, 45 wall-stuck pipe. See stuck pipe. washed-out formations, 24 washouts, 90, 172, 226 washover, 45, 46t washover pipe, 45, 46t water. See also freshwater; sea water. adding for mud weight, 133, 133t casing and, 170 as a displacement fluid, 224 as a drilling fluid, 114, 115f, 118, 146

impurities in, 214

loss of from calcium sulfate contamination, 138 loss of from salt contamination, 139 loss of in permeable formations, 135 for mixing cement, 214, 220, 229 natural muds and, 141 pH of, 136 precautions with caustic soda and, 148 as a preflush, 219 surface casing and, 173 water content tests, 167 water zones, 229 water-back operation, 129 water-base muds. See also drilling fluids. additives, 130 classifications of, 116t contamination of, 138-139 control of filtration, 135 controlling viscosity and gel strength, 134 controlling weight of, 130–131, 132*t*, 133 overview of, 116 pH control, 136, 137t phases of, 117–124 safety precautions with, 148-149 testing for sand content, 167 treatment of, 129-130 types of, 140-147 wireline logging and, 127 water-phase reactions, 150 wear pad, 48 weight of drill collars in air (DC_{wa}), 39 weight on bit (WOB) for deviation prevention, 24, 2 drill collar size and, 29 factors reducing, 2 history of, 1 hydraulic horsepower and, 6 overview of, 18-19 packed-pendulum assembly and, 32 reducing, 36 square drill collars and, 43 weight-up operation, 129 welded pipe, 180 welded-blade stabilizer, 52, 53f well logging. See drill stem test (DST). well servicing, 213 settol

ras at Austin wellbores. See also bore. buoyancy factors and, 39 casing and, 169 causes of deviation in, 14-19 classifications of, 24, 25t clearance between stabilizers and wall of, 29 crooked, 1 dogleg in, 7fdrilling fluids and, 126 hole clearance and, 19 preparing, 201 wall support, 30 wellhead, 178, 186 wellhead assembly, 209, 209, 211 wiper plug, 191 wireline logging, 127 wireline operation, 64 wirelines, 10, 13, 235, WOB. See weight on bit (WOB). WOC. See waiting on cement (WOC). working pressure, 186 workover, 213 Wyoming bentonite, 122, 123f yield point controlling, 134, 134t in invert-emulsion muds, 152 overview of, 119 plastic viscosity and, 119 polymer muds, 146-147 testing, 160 vield strength, 181 zones crooked-hole, 20 drill collar, 27, 30, 31f, 32, 55 fluid migration between, 227, 228 in formations, 31t, 32 high-pressure, 176, 230 low-pressure, 230 producing, 2, 2f, 4, 7, 176, 194 target, 169 transition, 38, 47-49 for vibration dampener, 55 water, 173

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