

# Contents



Figures and Tables	vi
Foreword	xi
Acknowledgments	xiii
Units of Measurement	xiv
Introduction	i
Drilling Fluids and Equipment	i
Drilling Fluids	i
Equipment for Circulating Drilling Mud	2
Other Equipment	4
Circulating Air and Gas	7
History	8
Circulating Systems	ii
Functions of the Circulating System	ii
Cleaning the Bottom of the Hole	12
Transporting Cuttings to the Surface	13
Cooling the Bit and Lubricating the Drill Stem	14
Supporting the Walls of the Well	15
Powering Downhole Equipment	19
Getting Information about the Formation Rock and Fluids	21
To Summarize	21
Mud Circulating Systems	22
Equipment	22
Hydraulics of Mud Circulation	35
To Summarize	37
Air Circulating Systems	38
Mist Drilling	39
Equipment	40
Layout and Drilling Procedures	41
Volume, Pressure, and Velocity	43
Compressors	44
To Summarize	44
Drilling Muds	45
Composition of Drilling Muds	45
Solids in Mud	46
Water-Base Muds	47
Oil Muds	57
Synthetic Muds	60
To Summarize	61
Testing of Drilling Mud	62
Preparing Mud Samples	62
Density Test	63

Viscosity and Gel-Strength Tests	64
Filtration and Wall-Building Tests	67
Measuring Sand Content	68
Solids, Water, and Oil Content	69
Determining pH	70
Other Tests	70
To Summarize	70
Treatment of Drilling Mud	71
Breakover	71
Weighting Up	72
Calculating Increased Volume	79
Using Tables	80
Calculating Hydrostatic Pressure	82
Water-back	83
Factors Affecting Mud Performance and Cost	84
To Summarize	85
Safe Handling of Muds and Additives	86
Storage and Handling of Mud Materials	86
Handling Chemicals	90
Handling Oil Muds	93
To Summarize	94
Pumps on the Rig	95
Reciprocating Pumps	96
Configuration of a Triplex Mud Pump	99
Configuration of a Duplex Mud Pump	108
Pumping Output of Reciprocating Pumps	110
Suction	112
Pressure Surges	113
Comparison of Triplex and Duplex Pumps	118
To Summarize	119
Operating Reciprocating Pumps Efficiently	120
Maintenance of Triplex Pumps	125
Maintenance of Duplex Pumps	134
To Summarize	136
Centrifugal Pumps	137
Advantages of Centrifugal Pumps	139
Fluid Regulation	139
Operating Centrifugal Pumps Efficiently	140
Pump Sizing and Selection	141
Maintenance of Centrifugal Pumps	142
To Summarize	144
Other Circulating Equipment	145
Shale Shakers	146
How It Works	146

Mud Properties	148
Screens	148
Fine-Mesh Screens	149
Sand Trap	151
Plugging	151
Maintenance	152
To Summarize	152
Solids Control	153
Desanders and Desilters	154
Mud Cleaners	160
Mud Centrifuges	165
To Summarize	171
Mud Gas Separators and Degassers	172
Mud-Gas Separators	173
Vacuum Degassers	175
Centrifugal Degasser	177
Eductor Design	178
To Summarize	178
Other Equipment	179
Mud Mixers and Agitators	179
Jet Hoppers	179
Mud Agitators	181
Mud Monitoring Instruments	182
To Summarize	192
Glossary	193
Review Questions	229
Answers to Review Questions	235

# Figures



1. Drawn without the derrick, this diagram shows the relationship of the many components of the circulating system. 2
2. Modern mud pumps 3
3. Cuttings carried by the mud are removed by two shale shakers on this location. 5
4. Additional circulating equipment includes a degasser, desilter, and desander, which are located over the mud pits downstream from the shaker. 6
5. Cuttings are blasted out the blowout line. Should gas be encountered, the flare will ignite it so that the gas will burn away harmlessly. 7
6. Early mud pump 8
7. Watercourses in a roller cone bit 9
8. Circulating drilling fluid lifts cuttings. 12
9. The drilling mud's hydrostatic pressure pushes on the sides and bottom of the hole, and forces the liquid part of the drilling mud into the formation. 15
10. Solid particles in the drilling mud plaster the wall of the hole and form an impermeable wall cake. 17
11. Blowout preventer stack on a land rig. At the top of the stack is the annular preventer. Two ram preventers are nipped up below the annular. 18
12. (a) Drilling assembly using a downhole motor and a bent sub. (b) Turbo-drill 20
13. This schematic diagram shows the circulating path of drilling mud. 22
14. Trip sheet with spaces to show displacement of drill stem components, number of stands pulled, and calculated versus actual amounts of fill-up mud. 25
15. High-pressure mud manifold 26
16. Suction line from mud suction tank to mud pump 27
17. The mud pump sends mud up the standpipe and into the rotary hose. 28
18. Rotary hose attached to the swivel gooseneck 29
19. Standpipe height for a 55-foot (17-metre) hose 30
20. Construction of rotary hose 31
21. The kelly passes through the kelly bushing, which fits into the master bushing of the rotary table. 32
22. This mud return line is carrying drilling mud from the wellhead, on the right, to a mud-gas separator. 33
23. Pressure losses in a circulating mud system 35
24. Chemical tank and pump for circulating with foam 39
25. Arrangement of equipment for air circulation 41

26. Blowout preventers for air drilling 42
27. Bentonite reacting with water 49
28. Destabilization of shale specimen by hydration of a healed fracture 51
29. Two percent oil emulsion mud magnified 900 times 52
30. Protective skin of surfactant molecules around a hydrophilic solid 58
31. Mud balance 63
32. Marsh funnel 64
33. Direct-indicating viscometer 65
34. Schematic diagram of the direct indicating viscometer 65
35. High-pressure/high-temperature filter press 67
36. Screen set 68
37. Mud still 69
38. Sacks of material in a mud house 87
39. Two P-tanks on a land rig 89
40. Equipment for chemical treatment of mud 90
41. First aid for chemical burns of the skin 92
42. First aid for chemical burns of the eye 92
43. In a reciprocating pump, a piston moves back and forth in a liner. 96
- 44a. Operation of piston and valves of a triplex pump 97
- 44b. Operation of one piston and valves of a duplex pump 97
45. Power and fluid ends of a triplex pump 99
- 46a. Power bands (V-belts) from the rig's compound drive this triplex pump. 100
- 46b. Electric motors turn a chain drive under the steel guard. 101
47. Essential parts of the power and fluid ends of a mud pump 101
48. Pony rod wipers 102
49. Part of a triplex pump's fluid end, showing valve pots 103
50. Pump piston 104
51. Liner, rod, and piston for a triplex pump 105
52. Motor-driven pump for cooling piston rods and a supercharging pump 105
53. Piston rod 106
54. Liner packing 106
55. Valves and valve seats 107
56. Duplex, double-acting pump 108

57. Fluid end of a duplex pump	109
58. Piston rod packing	109
59. The bumpy line to the left indicates surges in pump delivery.	113
60. Cavitation occurs where fluid passes through sharp ells under high pressure.	114
61. At top, the piston moves to right faster than mud can travel, leaving a gap between the mud and the piston.	115
62. Suction and discharge dampeners	116
63a. Bladder-type discharge dampener	117
63b. Spherical, nonbladder-type discharge dampener	117
64. Suction line from suction tank to pump	120
65. Pressure-relief valve on pump discharge line	122
66. Settling chamber on pump's power end	126
67. Measuring liner wear for a single-acting pump	128
68. Piston service life related to piston liner demand	131
69. Hydraulic valve seat puller	132
70. Typical rod wear pattern of a double-acting pump	134
71. Cutaway of a centrifugal pump	137
72. Operation of a centrifugal pump	138
73. Suction and discharge piping for a centrifugal pump	140
74. Troubleshooting guide for centrifugal pumps	143
75. Shale shaker	146
76. Pyramid screen	150
77. Solids size and removal equipment	153
78. Plastic hydrocyclones	155
79. Operating principles of a cone-shaped centrifuge	155
80. Applications of a cone-shaped centrifugal separator	156
81. Cones in a desilter	158
82. Mud cleaner	160
83. Mud cleaner separation process	161
84. Closed system (unweighted mud)	164
85. Decanting centrifuge	165
86. Operation of a decanting centrifuge	166
87. Operating parts of a concentric cylinder centrifuge	167
88. System to salvage barite from weighted mud	168
89. System to remove solids from unweighted mud	170
90. Mud-gas separator	172
91. Vacuum degasser	173
92. Operation of a mud-gas separator	174

- 93. Operation of one type of vacuum degasser 176
- 94. Centrifugal degasser 177
- 95. Vacuum degasser using an eductor 178
- 96. Centrifugal pump and jet hopper for mud mixing 179
- 97. Mud agitator 181
- 98. Jet siphon for moving mud or cuttings 182
- 99. Arrangement of a pit level indicating instrument 183
- 100. A pump speed indicator can be attached to the mud pump in several ways. 185
- 101. Pump speed indicator, calibrated to show strokes per minute 186
- 102. Mud pump pressure gauge 187
- 103. A return-flow sensing system 188
- 104. Air-actuated mud density recording device 190
- 105. Electrical mud density and temperature recording device 191

- 1. Pressure Losses with Mud Pump at Pumping Rate of 400 gal/min at 2,000 psi 36
- 2. Approximate Rate of Circulation (ft<sup>3</sup>/min) in 8¾-inch hole (m<sup>3</sup>/min in 222-mm hole) with 4½-inch (114-mm) Drill Pipe with Volumes to Produce Lifting Power Equivalent to a Velocity of 3,000 ft/min (915 m/min) 43
- 3. Basic Mud Chemicals 48
- 4. Mud-Weight Adjustment with Barite or Water 80
- 5. Mud Weight-up Chart 81
- 6. Nominal Pumping Rates of Triplex Single-Acting Pumps at 130 spm 110
- 7. Comparative Weights of Pump Liners 118
- 8. Locating Sources of Pump Troubles 123
- 9. Allowable Liner Wear 129
- 10. Impeller sizing 141
- 11. Screens for Various Particle Sizes 148

## Tables

