

Figures	V
Foreword	IX
Acknowledgments	XI
Units of Measurement	XII
Introduction	1
ROP, Longevity, and Gauge	4
Formations and Bit Design	5
Choosing a Bit	7
To Summarize	8
Roller Cone Bits	9
History	12
Types of Roller Cone Bits	13
Tungsten Carbide Bits	13
Roller Cone Bit Manufacture and Design	15
Cones	16
Cone Alignment	17
Interfit	19
Journal Angle	19
To Summarize	20
Cutters	21
Steel-Tooth	21
Tungsten Carbide Inserts	22
Bit Gauge	22
To Summarize	24
Drilling Fluid and Hydraulics	25
Reactive and Nonreactive Materials	26
Air and Gas Drilling Fluids	26
To Summarize	27
Watercourses and Jet Nozzles	28
Jet Nozzles	28
Hydraulic Horsepower	30
To Summarize	30
Bearings	31
Roller and Ball Bearing Bits	32
Journal Bearing Bits	34
Bearing Lubrication	37
To Summarize	39
Wear	40
Cone Wear	40
To Summarize	43
Cutter Wear	44
To Summarize	48
Bearing Wear	48
Other Types of Wear	49
Normal Wear Example	49
To Summarize	50
Diamond Bits	51
The Properties of Diamonds	52
Natural Diamond Bits	54

Contents



Natural Diamond Bit Manufacture and Design	55
Profile	56
Cutters	58
Hydraulics	60
To Summarize	62
Synthetic Diamond Bits	63
PDC Bits	63
PDC Bit Manufacture and Design	64
Profiles	65
Cutters	66
Hydraulics	68
TSP Bits	69
To Summarize	70
Hybrid Bits	71
To Summarize	72
Diamond Bit Wear	73
To Summarize	76
Special-Purpose Bits	77
Roller Cone Bits	77
Fixed-Head Bits	78
To Summarize	80
Bit Performance	81
Formation Properties	81
How Bits Drill	83
To Summarize	84
Bit Selection	85
Roller Cone Bits	85
Diamond Bits	87
To Summarize	88
Weight on Bit, Rotary Speed, and Penetration Rate	89
Roller Cone Bits	90
Diamond Bits	91
To Summarize	92
Bit Classification	93
Roller Cone Bits	93
Diamond Bits	95
To Summarize	98
Dull Bit Grading	99
To Summarize	102
Costs	103
To Summarize	104
Field Operating Procedures	105
Drilling with a Roller Cone Bit	105
Drilling with a Diamond Bit	106
To Summarize	108
Conclusion	109
Glossary	111
Review Questions	127
Answers to Review Questions	135

1. A bit drills the hole. 1
2. Circulating drilling fluid lifts cuttings. 2
3. Bit cutters can be steel teeth (a), metal buttons (b), diamonds (c), or special compacts (d). 3
4. Undergauge hole 4
5. Many layers of rock occur in the earth. 5
6. Several wells are required to produce a large reservoir. 7
7. A roller cone, or rock, bit 9
8. Each cone rotates on its own axis. 10
9. The row of cutters on one cone intermesh in the space between the cutters of the cone next to it. 11
10. Cones rotate on bearings. 11
11. A drag bit 12
12. Watercourses 12
13. Steel teeth are milled out of the cone. 13
14. Tungsten carbide buttons are inserted into the cone. 13
15. A bit cone has a machined opening into which the bearings fit. 16
16. On-center (a) and off-center (b) cone alignment 17
17. A chisel penetrates rock to remove it. 18
18. A shovel gouges out dirt. 18
19. Journal angle 19
20. Chisel-shaped, cone-shaped, and hemispherical inserts 22
21. Gauge cutters determine the hole's diameter, or gauge. 22
22. Flat tungsten carbide inserts on the gauge row 23
23. Drilling fluid circulation 25
24. One of the three jet nozzles on this bit 28
25. Extended nozzle 29
26. A center jet nozzle 29
27. Roller and ball bearings 32
28. A plain, or journal, bearing in the nose of the cone 33
29. A journal bearing 34
30. Ball bearings hold the cone on the bearing assembly. 35
31. A retaining ring holds the cone on the bearing assembly. 35
32. Mud cools and lubricates unsealed bearings. 37
33. Grease from a built-in reservoir lubricates sealed bearings. 37
34. Skidding, or dragging, flatten the bit's teeth 40
35. Cone erosion 41
36. Cracked cone 42
37. Off-center wear 42
38. Center coring 43

Figures



39.	Broken inserts	44
40.	Broken teeth	45
41.	Chipped cutters	45
42.	Flat-crested wear	46
43.	Self-sharpening wear	46
44.	Tracking wear	47
45.	Heat checking	47
46.	Gauge rounding	47
47.	Bit damaged by junk	49
48.	Washout	49
49.	Normally worn bit	49
50.	A diamond bit has three main parts.	55
51.	Single-cone profile	57
52.	Double-cone profile	57
53.	Parabolic profile	57
54.	Concave profile	57
55.	Grid plot	58
56.	Circle plot	59
57.	Ridge plot	59
58.	Radial flow watercourses	60
59.	Feeder-collector, or cross-pad, watercourses	61
60.	A polycrystalline diamond compact (PDC)	63
61.	Short parabolic profile	65
62.	Shallow-cone profile	65
63.	Parabolic profile	65
64.	PDC cutters range in size from $\frac{3}{8}$ inch to 2 inches (9 to 50 millimetres).	66
65.	Two PDC cutter shapes are the cylinder and the stud.	66
66.	Back rake angle	67
67.	Side rake angle	67
68.	PDC cutters in the body of the bit	68
69.	Jet nozzles on a PDC bit	68
70.	TSPs are triangular or round in shape.	69
71.	Diamond-impregnated pad, or stud, on bit gauge surface	71
72.	A diamond-impregnated backup stud behind a PDC cutter	72
73.	Bottomhole pattern caused by bit whirl and normal rotation	73
74.	A spiral-shaped hole	74
75.	PDC cutter wear and failures	75
76.	A jet deflection bit	77
77.	An antiwhirl bit	78

- 78. An eccentric bit 79
- 79. A core bit 79
- 80. A sidetracking bit 79
- 81. Drilling action of a roller cone bit 83
- 82. Drilling action of a natural diamond bit 83
- 83. Drilling action of a PDC bit 83
- 84. Drilling action of a TSP bit 83
- 85. Ring gauge held so that two cones touch the ring 101
- 86. Roller cone vs PDC bits 104

- 1. IADC classification for steel tooth and insert bits 94
- 2. IADC classification for PDC bits 96
- 3. IADC classification for TSP and natural diamonds 97
- 4. IADC dull grading chart 100

Tables

