Contents _____

	Preface.	Xi
	Flow Dynamics and Pumping Principles	1
	Introduction, 1 Static Pressure and Viscosity Relationships, 5 Piping System Concepts, 6 The Function of Valves, 10 Introduction to Pumps and Pumping, 21	
2	Pumps and Pumping Services	30
	Pump Classifications, 30 General Features of Centrifugal Pumps, 31 Flange and Mount Bolts, 31 Volutes and Diffusers, 31 Impeller Configurations, 35	

Wearing Rings, 36 Nozzles, - 36 Casing Construction and Orientation, 37 Stuffing Boxes, 37 Shaft Couplings, 38 Cooling Arrangements, 38 Centrifugal Pumps, 38 40 Single-Stage Overhung, Two-Stage Overhung, 41 Single-Stage (Impeller-Between Bearings), 41 In-line Pumps, 42 High-Speed Centrifugal Pumps, 42 Chemical Pumps, 42 Slurry Pumps, 42 Canned Pumps, 43 Horizontal and Vertical Multistage Pumps, 43 Regeneration Turbine Pumps, 43 Positive-Displacement Pumps, 44 Reciprocating Pumps, 44 Metering Pumps, 45 Diaphragm Pumps, 45 Rotary Pumps, 45 Basic Hydraulics and Definitions in Pumping Service, 51 Suggested Readings, 56

3 Industrial Pumps and Their Applications

Examples of Centrifugal Pumps in Service, 58
Examples of Pumps in Pollution Control Service, 67
Screw Pumps, 71
Submersible and Solids-Handling Pumps, 80
Portable Pumps for Drums and Containers, 93
Use of Sampling Pumps and Composite Samplers, 96
Miscellaneous Examples, 109
Pumps for Metering and Chemicals Handling, 114

Selection, Installation, and Sizing Criteria, 123 Installation Schematics, 132 Pump/System/Piping Design Guidelines, 135 Summary, 149 Installation Layout Considerations, 153 Chemical Compatibility, 165

4 Oscillating Displacement Pumps

Operating Principles, 181 Kinematics of Displacement, 181 Flow Rate Characteristics, 182 Efficiency, 189 Metering Error, 189 Effect of Influencing Variables on Flow Rate and Metering Error, 192 Pressure and Elasticities, 192 Volumetric Efficiency, 195 Leakage Losses in Moving Glands, 195 Reflux Losses of Valves, 195 Influences on Valve Kinematics, 196 Suction Action, Entry-Pressure Loss, Cavitation, 198 Design of Oscillating Displacement Pumps, 201 Metering Pumps, 201 Conveying Pumps, 202 Detailed Designs of Metering Pumps, 202 Drive Unit and Motor, 202 Pump Heads, 207 Pump Valves, 207 Pistons and Piston Glands, 208 Design Examples, 209 Diaphragm and Bellows Pump Heads, 210 Hydraulic Diaphragm Head with Plastic Diaphragm, 211 Diaphragm Head with Metallic Diaphragm, 212 Diaphragm Head with Mechanically Driven Plastic Diaphragm. 213

179

viii

Bellows Head with Mechanically Driven Bellows, 213
Life of Diaphragms and Rupture Control, 213
Special Types of Diaphragm Pumps, 216
Conveying Pumps, 216
Drive and Unit Motor, 216
Pump Heads, 218
Piston Glands and Valves, 221
Installation Layout for Oscillating Displacement Pumps, 222

5 System Analysis for Pumping Equipment

Characteristics of Centrifugal Pumps, 223 Net Positive Suction Head (NPSH), 228 General Pump Characteristics, 229 Head-Flow Curve, 229 Performance Curves, 232 Pump Affinity Laws, 237 Pump System Characteristics, 239 Pipe Deterioration, 241 Pipe Friction, 242 System Head Curves and Components, 246 System Operation and Control, 247 Total System Head Alteration, 251 Total Available Head Alteration, 252 Variable-Speed Pumps, 255 Functions, 255 Types, 255 Location, 255 Sensing Multiple-Branch Systems, 258 Total System Evaluation, 259 Projecting Pump Horsepower, 262 Constant Speed, 262 Variable Speed, 262 Equipment Power Comparisons and Total Energy Projection, 267

6 Mechanical Seals for Pumps

Seal Designs, 275 Single-Coil Spring Seals, 275 223

Multiple-Spring Seals, 276 Bellows Seals, 278 Sealing Points and Drive of Elastomer Bellows, 279 Metal Bellows, 279 Balanced Seals, 280 High-Pressure Seals, 282 High-Speed Seals, 282 Mechanical Seal Arrangements, 283 Double Seals, 284 Materials of Construction. 287 Secondary Seal Materials, \289 Buna N (Nitrile), 290 Neoprene, 290 Butyl, 290 Silicone Rubber, 290 Fluorosilicone, 290 Hypalon, 290 Viton, 291 Kel-F, 291 EPR/EPDM, 291 Kalrez, 291 Durafite, 292 Environmental Controls, 292 Temperature Control, 292 Contaminated Fluids Handling, 300 Stuffing-Box Throat, 301 Floating Throat Bushings, 304 Safety Features, 307 Seal Selection and Application, 308 Process Liquid Characteristics, 309 Corrosiveness, 309 Density or Specific Gravity, 309 Vapor Pressure and Boiling Point, 309 Viscosity, 310 Abrasives, 310 Physical and Chemical Changes, 311 Stuffing-Box Pressure, 311 Vacuum Conditions, 314 Stuffing-Box Temperature, 317 Equipment Design, 317 Vertically Split End-Suction Centrifugal Pumps, 318 Single-Stage Horizontally Split Case Pumps, 318

Multistage Horizontally Split Case Pumps, 319 Vertical In-line Pumps, 320 Vertical Multistage Pumps, 320 Rotary Pumps, 321 Installation and Operation, 321 Equipment Check Points, 321 Seal Check Points, 325 Seal Installation, 325 Start-up Procedures, 328 Standby Equipment, 331 Troubleshooting, 331

- A Chemical Resistance and Fluid-Handling Data
- B Tables of Engineering Data

Glossary of Engineering Terms

Summary of Pump Engine prina Data

Index