Index

Buffer continued Abrasion measurement, 25 pressure system, 180 Abrasive media, 189 Buffer fluid, 174, 176, 177, 179, 181, 186, Acetylene, 200 Aerospace industry, 9 Buffer pressure, 172, 177 Agitator seals, 165, 172-182 Buffer pressure installation with ancillary highly loaded, 181 gear, 181 initial costs and maintenance costs, Buna S, 22 Burgmann Co., 36, 92 short-length, 174 Agitator test rig, 38 Carbides, 149, 207 Agitators, bottom-driven, 181 metal, properties, 110-111 Alignment of seal faces, 11 Alloys, 107 Carbon deposits, 85 Aluminium oxide, 102, 109 Carbonate deposits, 200 Ammonium sulphate, 197 Carbons, 130, 148, 149, 185 metal-impregnated, 107, 133, 182 Annular circulation grooves, 92 synthetic, properties of, 105-107 Area ratio, 16, 17 Cartridge unit, 213, 251 Auxiliary packing box, 171 Cast chromium, 101 Axial forces, 44 Caustic soda, 197, 198 on floating seal member, 12 Axial temperature gradient, 51, 153 Centrifugal pressure, 70, 76, 77 Ceramics, 84, 101, 110, 197 Channel formation, 115, 123 Balancing sleeve, 17 Channelling, 61 Bearig area, 125, 197 Chemical industry, 3, 6, 134 Bearing ring, 25 Bellows, 6, 188, 190 Chrome plating, 87 Chromium, 101 Bellows, metal, 188 Circulation grooves, 88, 90 Blistering, 212 Circulator device, 256 Blocking risk, 193 Boiler feed pumps, 137 Closing force, 13 Bore tolerance, 27 Cold injecting, 198, 200 Boric acid action, 236 Composite materials, 152 Compression seatings, 27-29 Boundary lubrication. See Lubrication Compressor seals, testing, 40 Brakes, 166 Buffer Conical spring, 2, 200 Contact pressure, 63-69, 76, 136, 153 circulation, 179 influence on wear, 117 fluid, 177 Convection, 150 gas, 190 pressure, 178 Cooling chamber, 172

286 II	NDEX
Cooling flange, 177 Cooling fluid, 177	Face seals, auxiliary regulator circuit,
Copper coating, 124	balanced, 16-17, 68, 162, 164
Copper deposit, 124	high pressure, 7
Corrosion, galvanic, 124	calculation of dimensions, 29-34
Corrosive wear, 133	classification, 15-21
Couette flow, 160	by layout, 15
Counterface (seal seat), 25	by load balancing, 16
Counterface cooling, 152, 221	of working conditions, 4
Counterface material, effect on wear, 120	closing load, derived from spring or
Cracking, 187, 191	magnet, 12
Crankshaft sealing, 5	controlled clearance, 18
Cryogenic friction, 148	corrosion-resistant, 7
Crystalline solutions, 194	definition, 1
Cyclone dirt separator, 232, 233	design and operation, 10-14
D 1 11 1 2 200	double, 20, 171, 174, 176, 187, 197, 198
Dead end lubrication, 221	extreme high pressure, 182-184
Deformation, mechanical, 182–184	factors affecting performance, 14
thermal, 182–184	fields of application, 1–9
Desorption, phenomena, 105	first, 2
Diatomite, 191	floating form, 16
Diester fluid, 121	for abrasive media, 189–202
Direction of flow, 70	for liquid gas, 189
Distortion, 44, 67, 81, 164 and leakage, 57–60	for liquid oxygen, 189
calculation, 48, 50, 52, 53, 54, 56	fundamentals, 10–34
mechanical, 43–51, 142	grooved land, 166
plastic, 72	high pressure, 29, 125, 182
superposition of, 54	with internal flushing, 202 high speed, 93, 184–187
thermal, 51–53, 142, 150, 165, 189	with floating member stationary, 9
Double O-ring, 173	high temperature, 187
Double suction pump device, 188	hybrid hydrodynamic-hydrostatic, 19
Dow Chemical Co., 174	hydrodynamic, 163, 166, 180
Drive from below, 181	with circulation grooves, 18, 176,
Dry friction, 148	177, 184
	with internal flushing, 198
Elastomeric materials and their pro-	hydrostatic, 18, 166
perties, 21, 25, 188, 189	low temperature, 188-189
Elastomeric rings, 21	magnetic, 12
Elastomeric sleeve, 10	operating life, 133–137
Elastomers, 22	possible arrangements of, 15
Electrographite, 101, 105	requirements, 3, 10
Electrolytic corrosion, 196	reversible, 171
Emergency operating characteristics, 148	seats. See Seats
EP rubber, 22	simple form of, 2, 10, 11
Erosion pits, 192–193	sleeve-type, 14
Ethylene-propylene, 239	sophisticated types, 18
Explosions, 165	special designs, 172–202
External arrangement, 15 External pressure, 32	tandem arrangement, 171, 192, 200
Extruding, 24	thermodynamic, 86
Zarading, 27	with circulation grooves, 88–93, 137
Face friction, 138	unbalanced, 16, 166 with and without hydrodynamic
Face materials, 96	with and without hydrodynamic grooves, 140
	5100763, 170

INDEX

Face seals continued	Gap, centrifugal force in, 70
with double PTFE coated Viton O-	mechanical distortion, 43
rings, 8	Gap distortion, 44
with interchangeable sealing ring, 5	factor, 74
with radial grooves, 127	geometry, 42, 48
with radial recesses, 139	pressure, 63
with spring-loaded sealing lip, 23	Gap factor, 77, 80
with stationary floating chamber, 6	Gap geometry, 54, 69
working range of, 168	Gap height, 62, 64, 65, 81, 124
Failure, 126, 168	Gap pressure, 73
Fatigue, 188	Gap temperature, 153
Fatigue strength, 32	Gap width, 73–74, 84
Feed thread, 181	Gas constants, 189
Feed water, 204	Gas cushion, 178
Fibrous suspensions, 198	Gases, liquefied, 189
Filter screen, 232	Graphite, 105, 107, 130, 149
Flatness measurement, 42	properties of, 105–107
Floating intermediate ring, 184	Groove ratio, 88, 92
Floating member, rotating, 15	5,55,514,16,55,72
static sealing of, 21–25	Hard alloy, 107
stationary, 6, 9, 15	Hard nickel, 107
Floating ring, 10	Hardened carbon, 105, 107
Flow factor, 83	Hastellog A, 101
Flow regulator, 128	Hastellog B, 101
Fluid barrier, 176	Hastellog C, 101
Fluorosilicone rubber, 22	Heat conduction, 136
Flushing, 201	Heat conduction coefficient, 86, 94
Force equation, 13, 64, 65	Heat crazing, 128–133
Form factor, 129	assessment of material, 128
Fracture, 168	assessment of seal design, 130
Friction, 112	Heat dissipation, 161, 194
and lubrication, 139–150	Heat dissipation factor, 137, 155
dry, 147–149	Heat loss, 52
interface, 138–150	Heat sink, 53
relationship with leakage and wear,	Heat source, 53
162–163	Heat stress cracks, 95, 128
Friction coefficients, 84, 93, 116, 136,	Heat stress crack resistance factor, 128
137, 138, 140, 162–163	Heat transfer 144, 154
for dry friction, 148	Heat transfer coefficient, 53, 154-156,
for oil and water, 142, 147	161
for various area ratios and rubbing	Heat transfer factor, 51, 132
speeds, 146	Hertz theory, 71
for various groove lengths and sealed	Hexane, 187
pressures, 142	High performance feed thread, 207
under vacuum conditions, 149	High pressure heat exchanger, 229, 230
with boundary lubrication, 142	High pressure test rig, 36
Friction force, 66	High speed test rig, 38
Friction losses, 58, 59	Hooke's law, 129
Friction moment, 138, 156, 160	Household machinery, 4
interface, 147	Housing, rotating, 160
Friction test rigs, 25	Hydraulic load force, 13
Frictional heat, 150, 155, 174	Hydraulic load ratio, 164
Full film lubrication, 139	Hydraulic loading, 16
**	· On a

Hydrodynamic circulation grooves, 87, 90
Hydrodynamic effects, 84, 118
Hydrodynamic pressure, 140
Hydro-retarders, 166
Hydrostatic relief, 80

Ice formation, 189
Impregnating, 106
Individual spring, 11
Interface, 21
with concentric grooves, 62
Interface contact pressure. See Contact pressure
Interface film pressure, force due to, 13
Interface friction, 138–150
Interface friction moment, 147
Interface profile, 165
Interface temperature, 120, 150, 153
Internal arrangement, 15
Internal pressure, 32
Invar, 101
Iron, 217

Jacket cooling, 175, 221

Koppers Co., 39

Labyrinth, 24, 199 Laminar flow, 158, 160-161 Lead bronze, 86 Leakage, 41-95, 144 and distortion, 57-60 calculation, 41 causes, 41, 93 literature, 41 relationship with wear and friction, 162-163 secondary path, 93-95 standardised comparative values, 42 Leakage equation, 77 Leakage flow, 126 Leakage losses, 21, 41, 58, 78, 92, 126 with boundary lubrication, 69-80 with full film lubrication, 83 with mixed film lubrication, 80-83 Leakage measurement, 35 Leakage outlet, 176 Life expectancy, 133-137 Light band, 43 Liquid buffer, 176 exchange flow, 69, 71 turbulence, 158

Liquid exchange flow, 72 theory of, 69 Load capacity, 125 Load ratio, 14, 16 Lubricant, vaporisation, 140, 147, 150, 167, 168 Lubrication, and friction, 139-150 at very low temperatures, 114 boundary, 69, 115, 117, 118, 142-147 leakage losses with, 69-80 nature of, 143 tests on, 143-144 hydrodynamic (or full film), 83, 114, 139, 144 leakage losses with, 83 improvement of, 83 by geometrical design, 85 by special materials, 84 influence on wear, 114-117 mixed film, 140 leakage losses with, 80-83 vacuum, 114

Magnetic face seal, 12 Magnetic filter, 203, 231 Material properties, 98 Materials, low temperature, tough, 189 Mechanical distortion. See Distortion Metal bellows, 188 Metal carbides, 102, 107, 110 properties, 110-111 Metal ceramics, 110, 120 Metal-impregnated carbons, 107 Metal oxides, 102, 109, 149 as sliding face materials, 109 Metal sliding materials, 107 Metals, 148, 149 Mixed film lubrication, 140 Monochromatic light, 42 Mono-ethanol amine, 134 Motor industry, 4

O-rings, 10, 23, 24, 25, 27, 65, 134, 169, 172, 184, 192, 194, 200 compression, 24, 26 groove, 24 hardness, 24
Oil condenser, 192
Oil industry, 134
Operating costs, 174
Operational reliability, 162
Optical flat, 43
Optical interference testing, 43
Outflow section, 76

INDEX

Oxygen, liquid, 189 Parallel gap, 42 Pentane, 203 Petroleum industry, 3, 6 Pfaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetraflurorethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Pore loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radiation load, 234 Refili pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 influence on wear, 118	Over-heating, 167 Oxides, metal, as sliding face materials,	Running in, 125 Running-in period, 124
Parallel gap, 42 Pentane, 203 Petroleum industry, 3, 6 Pfaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Safety factors, 30–34, 130 Safety precautions against twisting, 168 Salt solutions, 194 Sand, 191 Scoremarks, 126 Screen housing, 199 Sea water, 197 Seal, agitator, 20, 172 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, testing, 40 crarkshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressursed water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 207 seal, upition, 201 scal, upition, 201 scal, upition, 201 scal, palled, 218 scompressor, testing, 40 corpressor, 183 compressor, testing, 40 corpressor, 183 compressor, 183	109	
Pentane, 203 Petroleum industry, 3, 6 Pefaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Safety precautions against twisting, 168 Salt solutions, 194 Sand, 191 Scoremarks, 126 Screen housing, 199 Sea water, 197 Seal, agitator, 20, 172 balanced mechanical, 17 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, 184 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, 18	Oxygen, liquid, 189	The second of th
Petroleum industry, 3, 6 Pfaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetrafilouroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio. 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Salt solutions, 194 Sand, 191 Sccreen housing, 199 Sea water, 197 Seal, pushing, 1-9 Seal, pushing, 1-9 Seal, pushing, 1-9 Seal, pushing, 1-9 Seal, pushing, 1-2 cartridge, 218, 256 compressor, testing, 40 crankshaft, 4 compressor, testing, 40 crankshaft, 4 crapting, 179 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 18, 89 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 24 saft solutions, 194 Sand, 191 Scoremarks, 126 Screen housing, 199 Sea water, 197 Seal, pushing, 1-2 cartridge, 218, 256 compressor, testing, 40 crankshaft, 4 crankshaft, 4 crapting, 179 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating face, 16 floating ring, 237 function of, 1 pushing, 1-7 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, pushing, 1-7 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, pushing, 1-7 bellowstype,	Parallel gap, 42	
Pfaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio. 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184	Pentane, 203	Safety precautions against twisting, 168
Pfaudler Werke, 38 Plastics, 116, 148, 149 wear resistance, 97-105 Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84-85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164-171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184		
wear resistance, 97–105 Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure pifferential regulator, 174 Pressure performance diagram, 218 Pressure pifferential regulator, 174 Pressure performance diagram, 218 Pressure pifferential regulator, 174 Pressure performance diagram, 218 Pressure pifferential regulator, 174 Pressure pifferential regulator, 174 Pressure performance diagram, 218 Pressure pifferential regulator, 174 Pressure pifferential regulator, 174 Pressure performance diagram, 218 Pressure pifferential regulator, 174 Pressure differential regulator, 174 Pressure pifferential regulator, 174 Pressure differential regulator,		Sand, 191
Polymerisation deposits, 191, 203 Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184	Plastics, 116, 148, 149	Scoremarks, 126
Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 PIFFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio. 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Seal, agitator, 20, 172 balanced mechanical, 17 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 200 rot, 132 seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals hoating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 19 low temperature, 187 hydrodynamic slid		Screen housing, 199
Polytetrafluoroethylene (PTFE), 22, 23 Porosity, 94, 106 Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Seal, agitator, 20, 172 balanced mechanical, 17 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 17 bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical mechanical, 19 low temperature, 187 hydrodynamic sliding ring, 12 mechanical, 52 safety, 237 sleeve, 14 slotted ring, 28 stesiliding ring, 19 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Polymerisation deposits, 191, 203	Sea water, 197
Porous materials, 84–85, 96, 105, 142 Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic shoding ring, 12 mechanical. See Face seals metal bellows type, 4, 6, 14 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, 1		Seal, agitator, 20, 172
Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial waar, 113, 127 Rediability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic wechanical, 18 hydrostatic wechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Porosity, 94, 106	balanced mechanical, 17
Power consumption, 139, 147 Power industries, 6 Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial waar, 113, 127 Rediability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 boiler feed pump, 205 Seal, bushing, 1–2 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic wechanical, 18 hydrostatic wechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Porous materials, 84-85, 96, 105, 142	bellows type, 4, 6, 14
Power loss due to liquid turbulence, 159 Pre-cooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 cartridge, 218, 256 compressor, 183 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		boiler feed pump, 205
Prescooling section, 214 Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals magnetics, 16 floating face, 18 floating face, 16 floating face, 23 extreme pressure, 21, 181 face. See Face seals floation face, 16 floating face, See Face seals hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic hydr	Power industries, 6	Seal, bushing, 1–2
Pressure differential regulator, 174 Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 compressor, testing, 40 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Power loss due to liquid turbulence, 159	cartridge, 218, 256
Pressure performance diagram, 218 Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 crankshaft, 4 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating	Pre-cooling section, 214	compressor, 183
Pressure pulses, 166, 168, 170 Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating speeds, 4, 77, 184 Rubbing speeds, 4, 77, 184 double, 26, 197, 237 extreme pressure, 21, 181 face. See Face seals floating face, 16 floating fine, 12 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic heydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals floating face, 16 floating face, 16 floating face, 16 floating fine, 18 foct. See Face seals floating face, 16 floating fine, 19 substance, 10 floating fine, 19 substance, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic heydromechanical mechanical, 18 hydrostatic hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 19 rotation of, 1 generator, 2,23 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sloing, 18 hydrostatic hedromechanica	Pressure differential regulator, 174	compressor, testing, 40
Process industries, 6 PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation load, 234 Refill pump, 179 Refliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating speeds, 4, 77, 184 Rubbing speeds, 4, 77, 184 extreme pressure, 21, 181 face. See Face seals floating face, 16	Pressure performance diagram, 218	crankshaft, 4
PTFE, 25, 27, 116, 169, 188 Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating speeds, 4, 77, 184 face. See Face seals floating face, 16 floating fice, 16 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrodynamic sliding, 19, 84, 86 ring, 183 pta (metal beloa type, 184, 86 ring, 183 pta (metal beloa type, 184 see seals magnetic sliding ring, 12 mechanical. See Face seals magnetic sliding ring, 12 mechanical. See Face seals magnetic sliding ring, 12 mechanical. See Face seals magnetic sliding rio, 18 pta (methanical mechanical, 18 hydrostatic mechanical ring, 18	Pressure pulses, 166, 168, 170	double, 26, 197, 237
Pump industries, 6 Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radialon, 236 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Right floating ring, 237 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Process industries, 6	
Pumps, auxiliary boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Right metal, 192, 198 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	PTFE, 25, 27, 116, 169, 188	
boiler feed, 137 quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial waer, 113, 127 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 function of, 1 generator, 8, 223 hard metal, 192, 198 high speed, 186 high seped, 186 high seped, 186 high speed, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 hard metal, 192, 198 high speed, 186 high speed, 186 high speed, 186 high speed, 186 high speed, 18 high speed, 186 high speed, 18 high speed, 186 high speed, 186 high speed, 186 high speed, 18 high speed, 186 high speed, 186 high speed, 186 high speed, 18 high speed, 186 high speed, 186 high speed, 186 high speed, 18 high speed, 186 high speed, 18 high speed, 186 high speed, 18 high	Pump industries, 6	
quenching oil, 200 submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial war, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 generator, 8, 223 hard metal, 192, 198 high speed, 186 high temperature, 187 hydrostatic hydromechanical, 18 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals mechanical. See Face seals magnetic sliding ring, 12 mechanical see, 188 nagnetic sliding ring, 12 mechanical. See Face seals rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Pumps, auxiliary	
submersible, 191 swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 high speed, 186 high temperature, 187 hydrostatic mechanical, 18 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal belows ring, 183, 188 hydrostatic mechanical, 18 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal belows magnetic sliding ring, 12 mechanical siding ring, 12 mechanical seet, 18 hydrostatic mechanical, 18 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 19 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, see mechanical, 19 low temperature, 188 magnetic sliding ring, 19 selsonical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 19 sel	boiler feed, 137	
swimming pool, 191 waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 high speed, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 186 high temperature, 187 hydrodynamic sliding, 19, 84, 86 ring, 187 hydrodynamic sliding, 19, 84, 86 ring, 183 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical. See Face seals metal bellows type, 188, 189 prissurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
waste, 200 PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 hydrostatice, 187 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrostatic mechanical, 18 hydrostatic mechanical, 19 hydrostatic mechanical, 19 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 19 hydrostatic mechanical, 19 hydrostatic mechanical, 18 hydrostatic mechanical, 18 hydrostatic mechanical, 19 hydrostatic hydrost	submersible, 191	
PV values, 132 Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radialon, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 hydrodynamic sliding, 19, 84, 86 ring, 183, 188 hydrodynamic sliding, 19, 194 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 slotted ring, 84 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubbing speeds, 4, 77, 184 Reynolds Speeds, 4, 77, 184 Reynolds Number, 155 Ring speeds, 4, 77, 184 Reynolds Reynolds Reynolds Reventage of the removed pump, 192 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Rydrostatic mechanical, 18 hydrostatic hydromechanical mechanical, 18 hydrostatic hydromechanical mechanical, 18 hydrostatic hydromechanical mechanical, 18 hydrostatic hydromechanical mechanical, 18 hydrostatic hydrostati		
Quenching, 200 Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubbing speeds, 4, 77, 184 Redial forces, 49 Rodiaticn-hydromechanical mechanical, 18 hydrostatic hydromechanical mechanical, 19 low temperature, 18 mechanical, 19 nechanical, 19 nechanical, 19 nechanical, 19 mechanical, 19 nechanical, 19 nechanical, 18 hydrostatic-hydromechanical mechanical, 18 hydrostatic-hydromechanical nechanical, 19 nechanical, 20 nechanical, 20 nechanical refields principal processes as metal bellows type, 188,	PV values, 132	
Quencing oil pump, 200, 201 Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 hydrostatic-hydromechanical mechanical, 19 hodrostatic-hydromechanical mechanical, 19 hydrostatic-hydromechanical mechanical, 19 hydrostatic-hydromechanical mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 low temperature, 188 magnetic sliding ring, 12 mechanical, 19 mechanical, 20 mechanical,	Quanching 200	
Radial forces, 49 Radial grooves, 87, 88 Radial temperature gradients, 52 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Radiatior froces, 49 Rodianting index temperature, 188 Radiation ring, 12 Rechancial. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 Rotating shaft, 158 submerged pump, 192 swimming bath pump, 191 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184		The state of the s
Radial grooves, 87, 88 Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Radiation ring, 12 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Queneing on pump, 200, 201	
Radial temperature gradients, 52 Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 mechanical. See Face seals metal bellows type, 188, 189 pressurised water reactor, 237 primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Radial forces, 49	
Radial wear, 113, 127 Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubbing speeds, 4, 77, 184 Radiation, 236 Resurce water reactor, 237 Resurce water reactor, 237 Remary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1	Radial grooves, 87, 88	
Radiation, 236 Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Radiation, 236 Primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Radiation dose, 238 Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Radiation dose, 238 Primary, 200 rotor, 197 rubber V-ring, 2 safety, 237 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Radiation load, 234 Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Rotor, 197 Rubber rotor, 197 Rubber V-ring, 2 safety, 237 sleeve, 14 s		A .
Refill pump, 179 Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Reliability, 164–171 Safety, 237 Seleve, 14 Sleeve, 14 Steel sliding ring, 193 Submerged pump, 192 Swimming bath pump, 191 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Triple TV-ring, 2 Safety, 237 Sleeve, 14 Steeve, 14 Subter sleeve, 14 Submerged pump, 192 Swimming bath pump, 191 Swimmi		
Reliability, 164–171 Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Reynolds Number, 237 Reve, 14 Slotted ring, 84 Steel sliding ring, 193 Submerged pump, 192 Swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Reynolds Number, 155 Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 sleeve, 14 slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Ring clamping element, 173 Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Rotating slotted ring, 84 steel sliding ring, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Rotating housing, 160 Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 Rotating housing, 193 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Rotating shaft, 158 Roughness ratio, 61 Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 submerged pump, 192 swimming bath pump, 191 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Roughness ratio, 61 swimming bath pump, 191 Rubber mountings, 27 thermohydrodynamic face, 90 Rubber sleeve, 11, 12 thickness, 17 Rubbing speeds, 4, 77, 184 types of, 1		
Rubber mountings, 27 Rubber sleeve, 11, 12 Rubbing speeds, 4, 77, 184 thermohydrodynamic face, 90 thickness, 17 types of, 1		
Rubber sleeve, 11, 12 thickness, 17 Rubbing speeds, 4, 77, 184 types of, 1		
Rubbing speeds, 4, 77, 184 types of, 1		
0 1		

Seal accessories, 226	Sliding materials continued
Seal arrangement, 15	physical and mechanical properties of,
Seal dimension calculation, 29	97
Seal elements, static, 25	Sliding rings, oval-shaped, 86
Seal face couple, 84	Sliding speed, effect on wear, 118
Seal faces, alignment of, 11	Sliding surfaces, roughness of, 124
materials, 96-111	Sliding surfaces, rising of, 16, 164
profile, 42	Sodium cooling, 235
separation of, 164–167	Solid particles, 123, 187, 191
wear of, 11, 112, 124	Solids, separation of, 217
width, 58	Solutions, 200
Seal gap, stabilised, 248	Spring, 10, 193
distortion, 43	Spring force, 12, 14
opening, 16, 164	Spring pressure, 12, 16, 193
temperature, 153	Spring protection device, 192, 198
Seal interface. See Interface	State of wear, 35
Seal seat (counterface), 25	State of wear, 33 Static charge, 197
Sealed pressure, 139, 162–163, 174	Static charge, 197 Stator slip, 168–170
Sealing head, 21, 25	
with tapering section, 75	Strass concentrations 32
	Stress concentrations, 33
Sealing lip (spring loaded), 24 Sealing liquids, 72, 85	Stress concentration coefficient, 25
influence on wear, 121	Stress cracks, 94, 112, 128
	Stroboscopic tests, 184
Sealing pressures, 4	Stuffing box, 174
Sealing rings, 21, 177 calculation of dimensions, 29–34	auxiliary, 171
and the second s	Support ring, 23
composite, 151	Supporting jacket, 248
design calculations, 152–153	Surface quality, 42, 70, 125
erosion, 194	Surface roughness, 60–63, 69, 75–76, 164
homogeneous, 151	influence on wear, 121
hydrodynamic, with radial grooves, 87	Suspensions, 200
material selection, 152	Swimming pool pumps, 191
rubber, 23	Synthetic carbons, properties of, 99,
sectional alterations, 31	105–107
stresses in, 31	Synthetic resin compression material,
tensile stress in, 31	97, 98
wear, 123	Synthetic resin impregnations, 106
Sealing sleeves, 23	Synthetic urea solution, 198
Seatings, compression, 27–29	T- 1- 1- 102
construction and mounting, 25–27	Tandem arrangement, 170, 192
shrinkage, 27–29	Tantalum, 217
Section springing, 12	Taylor vortices, 186
Service life, 133, 162, 248	Temperature difference, highest per-
Shaft rotating, 158	missible, 129, 132
Shore hardness, 24	Temperature effects, 150–156
Shrink fit seats, 27	Temperature gradient, 51, 153
Shrinkage seatings, 27–29	in sealing gap, 152
Silicone oil, 120	Temperature gradients, axial, 51, 153
Silicone rubber, 22, 236	radial, 52, 153
Sliding face, eccentrically running, 85	Temperature range, 132
Sliding materials, 97	Test rigs, 35–40
assessment of, 133	agitator, 38
compatibility, 111	friction, 35

INDEX

Test rigs continued	Vibrations, 126, 168
high pressure, 36, 38	axial, 126
high speed, 39	effect on wear, 126
wear, 35	
	radial, 126
Thermal conductivity, 51, 59	Viscosity, 142
temperature dependence of, 154, 155	influence of, 72
variation with temperature, 133	Viton, 22
Thermal conductivity coefficients, 132	
Thermal distortion. See Distortion	
Thermal expansion, 11	Wacker-Chemie, 177
Thermal expansion coefficient, 25, 51, 53	Washing machine and drier, 6
Thermal expansion equation, 129	Waste pump, 200
Thermal resistance factor, 129	Water pumps, 3
Thermal stress cracks, 95, 128, 133, 136,	Waviness, 75
164, 167	Wear, 96-137, 139, 144, 148, 149, 150,
see also, Heat crazing	164, 189, 191
Thermal stress resistance factor, 129, 131	abrasive, 112, 123, 124, 126
Thermodynamic effect, 85	adhesive, 112, 113, 126
Thermo-hydrodynamic effect, 84	corrosive, 113, 133
Thermo-siphon buffer pressure device,	effect of counterface material, 120
177–179	effect of sliding speed, 118
Thermosiphon effect, 228	effect on life expectancy, 133-137
equipment, 170, 179	erosive, 127, 194
Titanium carbides, 103, 111	influence of contact pressure, 117
Torsion test rig, 36	influence of fluid lubricating proper-
Track roller seal, 194	ties, 121
Tritium, 105	influence of lubrication, 114
TTV ring, 156, 185	influence of solids, in suspension, 123
Tungsten carbide, 110, 111, 124, 126,	influence of surface roughness, 124
	influence of temperature, 120
184, 192, 196 Turbulance 6, 25, 02, 186	influence of vibration, 126
Turbulence, 6, 25, 93, 186	of seal faces, 11
power loss due to, 159	
Turbulence losses, 156–161, 212	radial, 113
Turbulence tests, 159	relationship with leakage and friction,
Twisting moments, 44	162–163
XI - 1 10 65 66	running-in, 122, 123
U-seals, 10, 65, 66	surface, 113
USUS (independent safety and sabotage	Wear resistance, 83, 112–127
pump, 260	Wear test rigs, 35
	Wedge gap, 44
V-ring, 3	ring, 23
Vacuum conditions, 149	Welds, 118, 132, 148
Vacuum friction, 149	Wobbling action, 176
Vaporisation of lubricant, 140, 147, 150,	
165, 167, 168	Zero leakage 42