

Index

a

Absolute pressure 12, 13
 Acceptance Rules 448 ff.
 Acceptance rules for test of liquid ring machines 367 ff., 369 ff.
 Acoustic pressure spectra 234 f.
 Active corrosion protection 378 ff.
 Actual suction capacity 170, 172
 Additional SI-Units 425 f.
 Adiabatic compression 101
 Adiabatic exponent 102
 Adsorber 261 f.
 Adsorption pump 112, 120
 Aero-cyclones 300
 American NEC-Rules 412
 American thread types 447 f.
 Appendix pump 151
 Appendix pre-vacuum pump 151
 Applications of liquid ring vacuum pumps and compressors 157, 163, 231
 Applications for liquid ring machines 220, 224, 232, 234
 Applications of vacuum technology 1
 ATEX 100a 409 ff.
 Atmospheric pressure depending on altitude 483
 Automatic suction pressure control 246 ff.
 Avogadro constant 46 ff.
 Axial vacuum pump 112

b

Baffle 150, 239
 Ball check valve 319
 Barometric installation of condenser 313 f.
 Boltzmann constant 47
 Booster vacuum pump 150
 Bourdon tube 16
 Boyle-Mariotte 44, 78
 British thread types 447 f.

c

Call letters for MCR-technology 458 ff.
 Candle filter 301
 Canned motor 218 ff., 411
 Canned motor explosion protection 224 ff.
 Cavitation 100, 195 f., 379
 Cavitation protection 196 f.
 Centrifugal separator 299
 Ceramic gas jet pump 144
 Ceramic liquid ring vacuum pump 212 f.
 Ceramic roots vacuum pump 139
 Ceramic vacuum system 279
 CE-Sign 409 ff.
 CGS-Units 427
 Chamber separator 298
 Changes of state in p.v. diagram 104
 Characteristic curves of liquid ring pumps 87, 93
 Check valve 319
 Circumferential velocity 175
 Clapeyron's state equation for ideal gases 80
 Coarse vacuum, CV 9
 Co-condenser
 – dry type 312
 – wet type 311
 Color of pipes acc. to flow media 353 f.
 Combination of vacuum pumps 124 f., 130, 136, 143, 148 f.
 Compression work
 – adiabatic 101
 – isothermal 101
 – polytropic 104
 Condensate discharge 312 ff.
 Condensate recovery 253 ff.
 Condensation 100, 239
 Condensation and cavitation 100
 Condensation effect 187 ff.
 Condensation trap 151
 Condensers 7, 258 ff., 277 f., 309 ff.

Contaminants in operating liquid 187
 Contamination 303 f.
 Control valve 244, 247 f.
 Controller 246 ff.
 Conversion of different viscosities 481 f.
 Conversion of English and American units 430 ff.
 Conversion of units 428 ff.
 Conversion table – pressure 12
 Coolants refrigerants 388 f.
 Correction diagram of suction capacity 89
 Corrosion protection 380 ff.
 Corrosion 378 ff.
 Cryogenic pump 112
 Cyclon separator 291 f., 300

d

Dalton's law 49, 62, 68, 81
 Demistor (droplet separator) 261 f.
 Density of gas mixture 64 ff.
 Design of pump unit 253 ff.
 Detergents and solvents 388 f.
 Determination of suction capacity – depending on leakage 335, 337 ff.
 Diaphragm vacuum pump 112 f.
 Dimensioning of liquid ring vacuum pumps 343 ff.
 Diffusion pump 112, 119
 Diffusion ejector pump 112
 Displacement vacuum pumps 111
 Drives for liquid ring machines 216 ff.
 Dry running vacuum pumps 113
 Dynamic viscosity 38, 481 f.

e

Effective suction capacity 30 ff., 178 ff., 334, 339
 Ejector vacuum pump 112
 Elastomers 326
 Electric heating and insulation 279 f.
 Electric motors protection classes 406 f.
 Electric protection classes acc. to NEMA 417
 Electronic monitoring device 225
 English and American units 430 ff.
 Equipment groups and categories acc. to EU-Directive 94/9/EG 409 ff.
 Erosion 379
 Ergantol test 356
 Evacuation time 332 ff.
 Evaporation ion pump 112
 Examples MCR-equipment 458 ff.
 Examples of explosion protection 402 ff.
 Exhaust gas cooler 214, 242 f., 249, 255 f.

Explanation of frequently used abbreviations 444 ff.
 Explosion endangered areas 394 f.
 Explosion protection on canned motors 224 ff.
 Explosion protection symbols 402 ff.
 Explosion-proof electric equipment 393 ff.

f

Fast flange connections 324
 Fiber optic measuring method 228 f.
 Filling ratio 173
 Filters 300 f.
 Final pressure 151, 331
 Final vacuum pump 151
 Fine vacuum, FV 9
 Flammable gases and vapors, groups and temperature classes 399
 Flexible discharge port 165
 Flow – Volume flow 343 ff.
 – Mass flow 343 ff.
 Flow losses 28 ff.
 Flow losses in pipework 28 ff.
 Flow meter 316
 Flow types – laminar flow 25 ff.
 – molecular flow 25 ff.
 – turbulent flow 25 ff.
 – viscous flow 25 ff.
 Flow types in vacuum 8
 Flow velocity – of gases 346 ff.
 – of liquids 346 ff.
 – of vapors 346 ff.
 Fluid entrainment vacuum pump 112
 Formula symbols and their SI-units 435 ff.
 Fractionating diffusion pump 112
 Freon test gas 357

g

Gas ballast vacuum pump 124 ff., 133
 Gas binding pumps 112
 Gas binding vacuum pumps 120 f.
 Gas constant of gas mixture 65 f.
 Gas ejector 197 ff., 256 f., 259 f., 264, 272 f.
 Gas flow types in vacuum systems 239
 Gas jet vacuum pump 112, 140 ff.
 Gas laws 68
 Gas molecules – adsorbed 33
 – adsorbed in solid 33
 – desorbed 33

– diffusing on surface 33
 – in monolayer 33
 Gas ring vacuum pump 112
 Gas transfer pumps 112
 Gas-transfer vacuum pumps 112
 Gas-vapor mixtures calculation 343 ff.
 General equation of gas state 61 f.
 General gas constant R_0 45 f., 73, 75 ff.
 General state equation 44 f., 80, 98
 General universal gas constant 45 f., 65, 79 f.
 Getter pump 112, 120 f.
 Gilled pipe 307
 Graphical determination of evacuation time 333 f.
 Graphical symbols acc. to DIN 28401 451 f.
 Graphical symbols used in vacuum technology 451 ff., 456 f., 484 f.
 Greek alphabet 484
 Gay-Lussac 44, 78

h

Harmonized European Standards EN 391
 Hazardous zones 416
 Heat conductivity coefficients 304
 Heat exchangers 7, 304 ff.
 – air cooled 307
 – double tube type 306 f.
 – graphite-type 309
 – helical-type 308
 – plate-type 308
 – ribbed tube type 306 f.
 – roof-type 310
 – safety type 306
 – tubular type 305
 Heat transfer devices 301
 Heat transition 302
 Helium leak detectors 358 ff.
 Helium sniffer 358 ff.
 Helium test gas 360
 Helium test leak 367
 Hermetic drive system 218 ff.
 High vacuum 9

i

Ignition protection classes 397
 Impact plate separator 298 f.
 Impeller utilization λ (liquid ring pump) 368 f.
 Implosion 379, 387 f.
 Improvement of suction capacity 91
 Indices in physics and engineering 484 f.
 Inflow control unit 293
 Injection 294

Insulation 372 f.
 Integral leak test 362 ff.
 International electrical power supply 418 ff.
 International system of units (SI) 423 ff.
 Ion Getter pump 112, 120 f.
 Ionisation trap 151
 Ion transfer pump 112, 120
 Isothermal compression 101 ff.
 Isothermal compression performance 191 ff.
 Isothermal compression Power P_{is} 191 ff.
 Isothermal coupling efficiency 176
 Isothermal efficiency η_T (liquid ring pump) 368 f.
 Isotherm of real gas 54

j

Jet pumps 140 ff.

k

Kinematic viscosity 481 f.
 Kinetic vacuum pumps 112, 115 f.
 Knudsen flow 24 ff.

l

Laminar flow 25
 Lateral channel liquid ring pump 160
 Leakage overpressure test 354 ff.
 Leakage rates of magnetic coupling and canned motors 220, 224
 Leakages in vacuum systems 331 ff.
 Leak detection in range of vacuum and overpressure 357 f.
 Leak detection possibilities 360
 Leak rate values in practice 336 ff.
 Leak rates acc. to the vessel volume 336
 Leak test integral 363 f.
 Leak test methods 365 f.
 Leaks
 – real leaks 331
 – virtual leaks 331
 Liquid jet vacuum pump 112, 140 ff.
 Liquid ring compressors 160 ff., 163 ff.
 Liquid ring machine acceptance test 367 ff.
 Liquid ring machines
 – Characteristic curves 87, 93, 193 f.
 – Materials 210 ff.
 – Pump performance 191 ff.
 – Pump power consumption 191 ff.
 Liquid ring machines in series 243
 Liquid ring vacuum machines, designs 159 f.
 Liquid ring vacuum pump 112, 114, 129 f., 157 ff.
 – double acting construction 162

- single acting construction 162
- Liquid ring vacuum pump system with electric heating and insulation 279 f.
- Liquid ring vacuum pump with canned motor 211, 218 f., 222 f., 411
- Liquid ring vacuum pump with gas ejector 197 ff.
- Liquid ring vacuum pump with magnetic coupling 218 f., 220 f., 411
- Liquid separators 290 ff.
- Log-p-diagram acc. to Clausius-Clapeyron 58
- Loschmidt's number 47 f.

- m**
- Magnetic coupling type valve 318
- Magnetic coupling 218 ff., 411
- Magnetic filter 297
- MAK-values 392
- Mass composition 59 ff.
- Mass flow 343 ff.
- Mass transfer 7
- Materials of liquid ring machines 210 ff.
- Mathematical symbols 485
- mbar-Torr, conversion table, 470 ff.
- McLeod 19
- McLeod compression manometer 20
- MCR (measuring, control, regulation) circle 460
- MCR call letters 456 ff.
- MCR equipment, examples 458 ff.
- MCR, examples 458 ff.
- MCR, Sequence of letters in a MCR 460
- Mean free path 24
- Mechanical kinetic vacuum pump 112, 116
- Mechanical shaft seals 214 ff.
- Melting temperature 56
- Metallic bellow valve 318
- Mercury 389 f.
- Mixtures of ideal gases 59 ff.
- Molar composition 60
- Molar mass of gas mixture 64 f.
- Molar volume 44 ff.
- Molecular flow 25 f.
- Molecular sieves 261 ff.
- Molecular vacuum pump 112, 117
- Motive fluid 152
- Multi-cell vacuum pump 112, 114, 127 f.

- n**
- Names and definitions in vacuum technology 105 ff.
- Names and definitions of vacuum pumps and accessories 150 ff.
- Names and definitions of vacuum systems 281 ff.
- Natural logarithm 332
- Needle valve 317
- Nekal test 356
- Norms and guidelines in vacuum technology 441 ff.

- o**
- Oil sealed vacuum pumps 113, 125, 128, 131 f.
- Operating liquid 177 ff., 254
- Operating liquid supply 202 ff.
- Oscillation displacement vacuum pump 112 f., 115
- Outflow control unit 293
- Overpressure 12 f.
- Overpressure leak detection 365 f.
- Overview of vacuum pumps 112

- p**
- Partial pressures 60 ff., 343 ff.
- Particle density 48 f.
- Passive corrosion protection 378 ff.
- Phase transitions and descriptions 55 ff.
- ph-ranges, acid/alkaline fluids 483
- Physical and technical units 434 ff.
- Physical basic principles of ideal gases 44 ff.
- Physical data of liquids and gases 464 ff.
- Pickling solutions 383 f.
- Piston vacuum pump 112 f.
- Plate valve 165 ff.
- Polytropic exponent 104
- Port plate versions 168 f.
- Positive displacement vacuum pumps 111 f.
- Pressure coefficient K (liquid ring pump) 368 f.
- Pressure conversion table 12, 470 ff.
- Pressure curves for saturated vapors 56
- Pressure gradient ψ 175
- Pressure meters 14 ff.
- Pressure units 12
- Pre-vacuum pressure 153
- Pre-vacuum pump 153
- Pump capacity factor 173 f.
- Pump characteristic curves 193 f.
- Pump combinations 149
- Pump performance and power consumption 87, 93, 191 ff.
- Pumps 7
- Pumps and accessories, graphical symbols 451 ff.

Pumps, graphical symbols 451 ff.
p,V-diagram 54

q

Quantity of substance 423

Quart

- quart (GB) 431

- quart (US) 431

r

Radial vacuum pump 112, 116

Real gas factor Z 74 f.

Real gas 53

Real gas factors for hydrogen and air 74

Real leaks 331

Real vapor 53

Reciprocating displacement vacuum pump
112 f.

Reciprocating piston vacuum pump 112 f.

Recovery of polluted solvents 260 f.

Recovery of solvents 257, 261

Recuperators 301

Regenerators 301

Regulations (acceptance rules) 448 ff.

Relative humidity 369 f.

Relative molar mass M 45, 77

Reynolds number 25 f.

Ring liquid cooler 255 ff.

Roots pump 133 ff., 256

Roots vacuum pump 112, 115

Roots vacuum pump with canned motor 138

Rotary displacement vacuum pump 111 ff.

Rotary plunger vacuum pump 112, 115, 131

s

Safety heat exchanger 306

Safety standards for rotating machines 232 f.

Safety valves 320 f.

Saturation temperature 56

Sealing materials 325 f.

Sealing of liquid ring machines 214 ff.,
218 ff.

Sealing surface 323

Self-cleaning diffusion pump 112, 119

Semi-barometric installation 314

Separators 7, 241 ff.

Shut-off valves

- graphical symbols 453 f.

- schematic diagram 317

Sieve with magnetic filter 297

Similarity law of liquid ring gas pumps

189 ff.

Similarity law of liquid ring pumps 368 f.

Sliding vane vacuum pump 112, 114, 124 ff.

Solenoid 2/2 way valve 319

Solid getter pump 112, 121

Solid separator 272 ff.

Solubility of gases in water 183

Sorption 239

Sorption of vacuum vessels 33

Sorption trap 152

Sound power level 235

Sound pressure level 234

Special gas constant 77 f.

Specific heat capacity and κ -values of gases

103

Specific volume 45

Spring type safety valve 320

Sputtering ion pump 112, 121

Standard air cyclone 300

Standard temperature 52 f.

Standards, national and international

441 ff.

Stationary end pressure 34

Steam jet liquid ring vacuum systems 275 f.

Stuffing box shaft seal 167, 215

Sublimation (evaporation) pump 112, 120

Sublimation temperature 56

Suction chamber 152

Suction capacity 191 ff., 332

Suction capacity depending on vacuum vessel
volume 338 f.

Suction capacity of the fore pump 147 ff.

Suction capacity range of vacuum pumps
123

Suction power 335 ff.

Suction power units 336

Suction pressure control 244, 246 ff.

Suction pressure ranges of vacuum pumps
123

Summery of physical and technical units
434 ff.

Supply factor λ_1 173

Supply of operating liquid 202 ff.

Surface condensation 7

Surface condenser 310 f.

Surface irrigation cooler 254

Symbols acc. to DIN 1304 484

Symbols acc. to DIN 28401 451 f.

Symbols of explosion-prone areas 401, 404 f.

System comparison of magnetic couplings
and canned motors 219

t

TA-Luft (Technical regulations for air pollution
control) 263

- Technical Bureau of CENELEC 391
 Temperature classes of dust 400
 Temperature classes of flammable gases and vapors 399
 Temperature controller 315
 Temperatures Kelvin, Celsius, Fahrenheit, Rankine 473 f.
 Testing device scheme 231 f.
 Test leak 367
 Theoretical and real suction capacity 170 ff.
 Thermal coefficients
 – Conductivity coefficient 302 ff.
 – Transition coefficient K 302 ff.
 – Transmission coefficient 302 ff.
 Thermal state equation for ideal gases 78
 Thermodynamic temperature [K] 52
 Threads, American and British 447 f.
 Three phases of evacuation 146 f.
 Titanium liquid ring vacuum pump 212
 Torr-mbar, conversion table 470 ff.
 Trap 151
 Triple point 56
 Trochoidal vacuum pump 131 ff.
 Turbo vacuum pump 112, 116
 Turbulent flow 25 f.
- u**
 Ultra high vacuum UHV 9
 Underpressure 12 f.
- v**
 Vacuum 12 ff.
 Vacuum apparatus 7
 Vacuum control valve 284
 Vacuum filter 272 ff.
 Vacuum flange connections 322, 324
 Vacuum flow types 8
 Vacuum greases 326 f.
 Vacuum in percent 12
 Vacuum leak detection 365 ff.
 Vacuum loss of vacuum vessels 342
 Vacuum measuring devices 21 ff.
 Vacuum measuring ranges 9, 11
 Vacuum measuring units 472
 Vacuum pumps 112
 Vacuum pumps acc. to DIN 28400 112
 Vacuum pumps in series 147 ff., 243, 252
 Vacuum ranges 9, 23 f.
 Vacuum sealing surfaces 323, 325
 Vacuum system
 – single stage 258
 – two stage 257
 – three stage 256
 – four stage 256
 Vacuum valves 284
 Vacuum vessels 7
 Vacuum vessel size – pumps suction capacity 339
 Valves
 – needle type 317
 – slanted seat type 318
 – solenoid type 319
 – spring safety valve 320
 – straight-way type 318
 – ventilation valve 321
 Vapor condenser 112, 143, 256, 258, 277
 Vapor jet vacuum pump 112, 141 ff.
 Velocities in pipelines 346 ff., 349
 Velocities of liquids, vapors, gases 346 ff.
 Vessel arrangements 292
 VIK-Design of electric motors 408 f.
 Virtual leaks 331
 Viscosities, conversion table 481 f.
 Viscous flow 25 f.
 Volume flow 343 ff.
 Volumetric composition 60 ff.
 Vortex separator 251, 290 f.
- w**
 Water jet pump 246
 Water vapor temperature table 474 ff.
 Wear and tear 378 ff.
 Working range of vacuum pumps 122 f.
 Woullff bottle 246 f.
- x**
 Xenon 470
 X-rays 425
 X-units 428
 Xylol
 – m-xylol 467
 – p-xylol 467
 – o-xylol 467
- y**
 Yard 430
 Y-rays 425
- z**
 Zoning of explosion-prone areas, Zones 0, 1, 2, 10, 11, 20, 21, 22 393, 409 ff., 416