

Index

a

- absolute humidity 17
 - deficit 18
 - to dry air 17
 - to moist air 17
- absorption 228
 - bond energy of water 27
 - and desorption of water 339
 - process of water absorption, and release by a solid 31
 - spectral absorption of NIR radiation 418
 - thermal energy 5
 - uncontrolled absorption of water 92
- acid dew point 202, 203
 - determination 203
 - monitoring 202
 - sensor based on conductivity measurement 203, 204
 - sensor measurements in flue gas 204
 - variation 203
- acoustic sensors 166, 263, 314
- adhesion water 33, 53
- aerosols 7, 52, 58, 130, 131, 190, 264, 297, 298, 300, 382
 - droplet size of 130
 - scattering intensity 130
- aerospace industry, requirements for measurement equipment 438
 - atmospheric conditions on Mars surface 438
 - combined measurement sensor 445
 - humidity indicators 447
 - humidity sensors 445
 - sensors for atmospheric measurements 446
 - soil measurements 446
 - combined probe
 - for extra terrestrial atmospheric humidity measurements 450–454

- for extra terrestrial soil moisture measurements 447–449
- general climatic conditions 438
- MiniHUM experiment 450
 - instrument, technical specifications 451
 - sensor assembly 453
 - sensor chip 452
 - sensors, measuring ranges 451
 - scientific objectives 450
 - setup 452
- phase diagram of carbon dioxide 439
- technical requirements, of measurement equipment 439
 - integration into the overall system 439
 - requirements for operation 440
 - technical specifications, sensors for spaceflight applications 440, 441
 - enhanced high-frequency probe 442, 443
 - neutron probe 441, 442
 - optical sensors 442
 - sensors, for ERH measurements 443–445
- aerospace, measurement methods 432
 - ground-based measurement methods 433–436
 - planetary surfaces, measurements on 432, 433
 - remote sensing 432
 - testing and calibration, of aerospace technology in laboratory 436–438
- air-conditioning 237
 - systems, for permissible climate fluctuations 341
- aircraft components, mechanical and climatic stress 302
 - air flow 30, 42, 237, 252, 283, 284, 354, 377, 383, 391, 414, 416
- air humidity 36, 190, 210, 236, 299
 - inside the pipe 282
 - optimally conditioned 412

- relative 407, 408, 413
 - sensor 241, 262
 - air temperature 11, 204, 209, 213–215, 284, 377, 380
 - air velocity 42, 43, 282
 - alternating current (AC) 62, 370
 - altitude 213
 - humidity measurement 216, 217
 - aluminum oxide sensors 73–75, 275, 302, 420, 444, 445
 - ambient humidity 81, 97, 113, 155, 229, 248, 288, 339, 340, 389, 473
 - concave curving of paper 340
 - water absorption of paper at 340
 - analogy models 53–55
 - apartments and workplaces
 - humidity measurement 377–379
 - artificial snowing schemes 208
 - artificial wetting, of fruits 190
 - Assmann psychrometer 15, 78, 79, 205, 208
 - atomic force microscopy (AFM) 156
 - automated moisture measurement, in pipe segments 291
 - automatic sample extraction system 282
 - automotive and aircraft construction industries
 - automotive components made from 295–297
 - measurement in oil and fuel systems 294, 295
 - moisture measurement 294
 - sorption isotherms, raw material 296
 - typical production line of manufacturing 296
 - aviation weather service 207
- b**
- bakery products 248
 - baking temperature 249
 - Beaufort scale, of wind speed estimation 211
 - bimetal hygrometer 98
 - black body 214
 - element temperature 215
 - temperature gradient 214, 215
 - radiation 117
 - sensitive sensor element 214
 - black ice 212, 213
 - Boltzmann constant 173, 469
 - building materials, technical specifications 62
 - buildings and brickwork, measurement on 366–368
 - calcium carbide method 368, 369
- electromagnetic methods 370–372
 - equilibrium relative humidity 372, 373
 - infrared (IR) reflectometry 376
 - technical specifications 376
 - neutron measurement 370
 - nuclear magnetic resonance 376
 - radar measurement 376
 - thermal properties, measurement of 374
 - infrared thermography 374
 - measurement of thermal conductivity 375
 - temperature measurement using optical fibers 375, 376
 - thermogravimetry 370
 - Bureau International des Poids et Mesures (BIPM) 173
- c**
- calcium carbide
 - measurement principle 106
 - measurement setup 106, 108
 - for moisture measurement in concrete 367
 - pressure chamber, of measurement setup 106
 - technical implementation 106–108
 - calcium hydride
 - detection and measurement of low water content present in plastics
 - setup 309
 - humidity measurement device, setup of 108, 109
 - measurement principle 108
 - technical implementation 109
 - calibration 17, 69, 76, 97, 169, 178, 185, 216, 235, 300, 344, 411, 436, 443, 452
 - case studies 179, 180
 - certified gases 180
 - capacitance 37, 49, 61, 73, 80, 81, 89, 155
 - capacitive polymer sensors 74, 81, 82, 83, 85, 237, 250, 314, 335
 - dew point mirror
 - Heinze, measurement devices 89, 90
 - instruments 87
 - lithium chloride dew point measurement device 90–92
 - physical principle 86
 - sensitive surface, contamination of 87–89
 - surface acoustic waves (SAW) 90
 - technical implementation 86, 87
 - physical principle 80, 81
 - specialties 84, 85
 - technical implementation 81–84
 - capillaries, influence of 226
 - capillary diffusion 402

- capillary force 228, 244
 capillary water 26, 49, 183, 184, 290, 308, 310, 396, 401
 capping filters, properties 85
 carbide method (CM method) 106, 107, 368
 – moisture measurement using 368
 cardboard 340, 341
 – external moistening 347
 – water content, influenced by 347
 CCC. *see* condensation, controlled capacitance (CCC)
 cellulose 95, 149, 322, 337, 339, 382
 ceramic-resistive humidity sensor 99
 chemical drying 321
 chemisorption 227
 climate conditions 189, 200, 253, 254, 256, 347, 357, 377, 378
 – in agricultural buildings 190
 – controlled and modified atmosphere 255, 256
 – controlling humidity during transport 256, 257
 – maturation of cheese and meat 254, 255
 – monitoring 258
 – on planet 438
 climate control equipment, in agriculture 190
 climate modeling 207
 closed chambers and small rooms, climate control in 381
 – air humidifying 381
 – condensation dehumidifier 383
 – dehumidifying of air 382, 383
 – evaporator 382
 – sprayer 382
 – steam humidifier 382
 coated metal oxide sensors 305
 combustion material 202
 compensation 64, 75, 76, 176, 286, 315
 – empirical, bulk density 317
 – during measurement 279
 – temperature 316
 condensate
 – collection 258
 – formation in cargo container 257
 condensation 23, 204
 – controlled capacitance (CCC) 89
 – inside switch stations, suppression of 305
 – on sensor 204
 conductivity 49, 91, 204, 304, 342. *See also* electrical conductivity; thermal conductivity
 constants, and parameters 171, 470
 contactless measurement 239
 contact measurement 51
 continuous measurement, of paper and fabric webs 346
 continuous water content measurement, in glycerin using a high-frequency sensor 334
 cooling 195
 – sample, reverse effect 228
 – of sensitive surface 204
 – traps 306
 corrosion 35, 153, 202, 256, 303, 379, 420
 cost, of measurement setup 168
 coulometric devices 103, 444
 coulometric measurements 101, 102, 104, 271, 272, 454
 coulometric sensors 270, 305
 – self-monitoring 270
 – sources of error 270
 coulometric trace humidity sensor 101
 cross-sensitivities 279
 – determination
 – influence of bulk density 317, 318
 – temperature compensation 316, 317
 cryoscopy, definitions 35
 cryostatic measurement 225
 cryostatic water activity measurement devices 235
 – technical specifications 235
 cyclic cooled mirror (CCM) 89
- d**
- data analysis 73, 87, 122, 170, 290
 dehumidifying of air 382, 383
 – absorption dehumidifier 383
 – adsorption dehumidifier 383
 – condensation dehumidifier 383
 desiccants 148, 306
 desiccator, definitions 34
 device-specific parameters 237
 dewetting 230
 dewing on individual components, prevention 305
 dew point measurement, in acids 203
 dew point mirrors 87, 270, 342
 – Heinze 90
 – setup 86
 – typical technical specifications 88
 dew point sensors 91, 222, 223, 314
 diameter of molecules, role in ERH measurement 332, 333
 dielectric measurement methods 278, 282
 diffraction 127, 130, 131, 133, 155
 diffusion 34, 241, 268, 290, 397
 direct concentration measurement, of SO₃ and H₂SO₄ in facility 203

- direct measurement
 - of leaf wetting 196
 - of road icing, device for 216
- disk/rotary sprayer 382
- dispersity 34
- DOAS devices 217
- dripping water, bond energy 26
- droplet formation 129
- dry air
 - components of 11
 - parameters 469
- dry environment, storage of samples 325
- desiccants 325
 - activated alumina 327
 - molecular sieves 327, 328
 - silica gel 325–327
 - membrane dryers 328, 329
- dryer types, and common fields of application 322
- dry gas 18, 304, 405
 - chemically neutral 327
 - flow 148, 301, 402
 - fluctuation in the humidity 406
- drying
 - controlling technology 41
 - definitions 34, 35
 - grain 188
 - principle, selection 322
 - processes, monitoring and control 322, 323
 - of solid materials 318
 - characteristic, of curves 319
 - goals 318
 - principles 318–322
- dry ovens 149
- dry thermometer 77
- dynamic water activity measurement 224, 225
 - components of device 225
 - cryostatic measurement 225, 226
 - influence of surface water on 231
 - parameters 225
 - sorption isotherm 226
- e**
- electrical conductivity, of road surface 215
- electrical properties, measurement 58–62
 - direct coupling of signal 59
 - equivalent circuit diagram 61
 - high-frequency method
 - measurement principle 64, 65
 - technical implementation 66–69
 - low-frequency method
 - measurement principle 62
 - technical implementation 62–64
- measurement principle 60–62
- microwave method
 - measurement principle 70
 - technical implementation 70–72
- radar method
 - measurement principle 72
- specialties 73
 - technical implementation 72, 73
- resistance 61, 342
 - substrate coupling 59, 60
- electrical resistance, measurement 342
- electrode shapes, for measuring in containers 192
- electromagnetic moisture measurements 167
- electromagnetic radiation 278
- electromagnetic waves
 - classification of 51
 - transmission and absorption of 116
- electronic Assmann psychrometers 208
- electronic components
 - monitoring humidity 303
 - trace humidity measurement in 302–304
- electronic recording devices, for climate measurements 208
- electron microscopy 156
- emulsion, definitions 34
- energy conversion, water, significance of 6, 7
- engine heat 213
- enhancement factor 21
- equilibrium humidity 258
 - measurement 258
- equilibrium relative humidity
 - sensor for continuously running webs 348
 - equilibrium relative humidity (ERH) 187, 222, 310, 331, 332, 338
 - diameter of molecules 333
 - fluids 333
 - influencing, paper properties 339
 - measurement 51
 - measurement by injecting conditioned air 354
 - measurement in paper stacks using a penetration sensor 342
 - moving and resting filaments 353
 - for nonmoving goods 341
 - probes adapted, for measurement at different positions 341
 - paper/textiles under laboratory conditions 345
 - fixation 345
 - measuring chamber 345
 - sensors 301

-- specialized sensors, for measurements on moving webs 348
 -- for continuously running webs 348
 - technical specifications of devices
 -- for moisture measurement in paper 342
 - technical specifications of ERH instruments 345
 ERH sensor *see* equilibrium relative humidity, sensors
 evaporation 15, 23, 34, 149, 150, 373, 382, 392, 426
 evapotranspiration 23, 24

f

Fabry-Pérot interferometer 127
 fast-moving gases during injection and ignition processes 297–299
 - calibration of measurement setup 299–301
 fertilizer 191
 fiberglass 147
 fiber hygrometer
 - exposure of 96
 - operation range of 97
 fiber optics humidity measurement system 127
 film sensors 36
 filter, sensor 43
 flue gas 202, 205
 - flow 203
 - psychrometric measurement in 205
 food industry
 - monitoring and control of production stages 242, 243
 - typical dryer types 322
 - water activity as a parameter in 219
 food processing 232
 - evaluation of measurement methods 233
 - moisture measurement in meat and sausage products 232, 233
 - production control 235
 -- influence of ambient climate 236, 237
 -- inspection of incoming goods 235, 236
 -- typical humidity and temperature values 237
 - product monitoring 233–235
 food products 106, 164, 235
 - climate box for the energy-efficient storage of 253
 - growth conditions of microorganisms 220
 - storage conditions for 251
 Fourier transformation (FFT) 122
 Fraunhofer diffraction 131
 freeze-drying 321

freezing, of soil 183
 freezing point, measurement 215, 216
 freezing point temperature 216
 freezing/solidification 23
 freshness 196, 197
 - influence of water activity/enzymatic activity 198
 - measurement device 199
 - methods of food freshness evaluation 198
 Fresnel hologram 132
 frost point 13
 frost-proof tensiometers, technical specifications 139
 fruits, water potential measurement 199
 FTIR spectroscopy 121, 122
 fungicide 191

g

gas constants 22
 gases generation, with defined humidity 398
 - complete humidification of a gas flow 399, 400
 - gas humidification by permeation 400, 401
 - humidification and drying of gas flows 398, 399
 - humidification by capillary diffusion 401, 402
 - humidification by continuous injection 402
 - humidity generators 402–407
 - saturated and unsaturated solutions 407, 408
 -- closed volume to generate a constant relative humidity value 410
 -- relative humidity above H_2SO_4 solutions 411
 -- relative humidity above saturated salt solutions 409
 -- relative humidity of lithium chloride solutions 410
 -- relative humidity of mixtures of water and H_2SO_4 411
 -- saturated solutions 407, 408
 -- temperature dependence of the humidity correction term 410
 -- unsaturated salt solutions 408
 gases, water vapor pressure, measurement
 - metal oxide sensors
 -- physical principle 73, 74
 -- principal application 75
 -- technical implementation 74, 75
 - psychrometer 76
 -- mathematical description 80
 -- physical principle 77

- technical implementation 77–80
 - quartz microbalance
 - physical principle 75
 - principal application 76
 - technical implementation 75, 76
 - gas flow 270
 - aggressive components 270, 271
 - detection of leakages in cooling systems 273, 274
 - boiler installations 274, 275
 - gas and oil pipelines 275
 - gas turbines 274, 275
 - measurement at high pressure 276
 - measurement in corrosive/highly contaminated environments 272, 273
 - self-monitoring/sensor checks for inline trace humidity measurement 270, 271
 - output signal during self-monitoring 271
 - setup 120
 - gas humidity measurement 25, 57
 - methods 47, 57
 - gas humidity measurement sensors
 - classification of 48
 - principles of 52
 - technical implementation 62
 - gas humidity methods
 - for moisture measurement 58
 - gas humidity/moisture, in solids 30–33
 - absorption 31
 - adhesion water 33
 - adsorption 31
 - cryostatic method 30
 - crystal water – chemically bound water 33
 - energy balance 32, 33
 - equilibrium relative humidity 30
 - sample extraction 31, 32
 - sorption/desorption 30, 31
 - sorption isotherm 31
 - water activity 30
 - water balance 32
 - gas laws 228
 - gas temperature 9, 13, 22, 78, 203, 401, 465
 - definitions 12
 - enhancement factors 22
 - fluctuations 71
 - glass fiber 151
 - Good Laboratory Practices 179
 - gradation, influence of 27, 69, 184, 226
 - grain
 - drying 188
 - ERH value 189
 - moisture 188
 - storage 188
 - groundwater 183, 184, 426
 - level 138
 - groundwater–soil–atmosphere system 183
 - growth conditions, of microorganisms in food products 220
 - gypsum block devices 187
 - typical technical specifications 140
 - vs. tensiometers 140
 - gypsum block sensors 140
- h***
- halogen lamps 148
 - hammer-shaped sensor 280
 - installation 280
 - hardware costs 168
 - hardware selection, measurement
 - cost calculation 168, 169
 - equipment, comparison of 168
 - material-specific parameters
 - laboratory measurements 169, 170
 - real production conditions 170, 171
 - Haude factor 23, 24
 - empirical 24
 - heating 39, 83, 135, 147, 148, 193, 202, 216, 251, 274, 308, 377, 393, 420, 437
 - heating, ventilation, and air-conditioning (HVAC) 190
 - Heinze dew point measurement 90
 - Henry's law 332, 335
 - HF moisture measurement 68
 - high-altitude humidity measurement, from ground 217
 - high-frequency sensor 201, 334, 384
 - continuous water content measurement in glycerin 334
 - homogenization 35, 244, 293, 402
 - humidity 7, 210, 304
 - humidity generators 402, 403
 - coulometric humidity generator 406, 407
 - gas mixing humidity generator 405, 406
 - two-pressure humidity generator 403, 404
 - two-temperature 404, 405
 - humidity indicators 358
 - applications 114
 - indicator paper 114
 - irreversible indicators 358
 - technical realization 112
 - irreversible indicators 113, 114
 - reversible indicators 113
 - humidity measurement 9–25, 208, 216, 261
 - acoustic methods 134
 - airplane equipment 216

- with dew point devices 86
 - different principles of 52
 - equipment for range of 100–200°C 261, 262
 - capacitive polymer sensors 262
 - dew point mirror devices 262
 - measurement in exhaust air using acoustic methods 263
 - extreme conditions 261
 - extremely high temperatures 263, 264
 - contactless measurement 264, 265
 - zirconium oxide sensors 265, 266
 - fiber optics 152
 - in gases 71
 - gas temperature
 - definitions 12–14
 - dew point 14
 - gas water vapor pressure 10–12
 - at high altitude 216
 - airplane equipment 216, 217
 - IR humidity measurement *see* infrared 265
 - measurement at high temperatures 261, 262
 - in packaging 257–259
 - psychrometric equation 14–16
 - dry bulb temperature 15
 - water vapor partial pressure and water vapor saturation pressure 14
 - wet bulb temperature 15
 - saturated water vapor pressure 11
 - saturation deficit 11, 12
 - sensor installation and sampling 266–269
 - compact setup of measurement system 269
 - construction of extraction system 268
 - contaminations of setup 269
 - drying duration of different materials 267
 - gas extraction system 268
 - humidity measurement in pipes 266
 - sensor equipment, adapted to setup 269
 - technical specifications, instruments 265
 - thermodynamic equilibrium states 9
 - water vapor pressure 11
 - humidity parameter
 - electrical/humidity, analogies 54
 - electrical parameter 54
 - humidity sensors 48, 279, 304
 - hydration of samples 230
 - hydrogen compounds
 - melting and boiling temperatures of 4
 - hydrology 137
 - hydrophilic products 228
 - hydropower plants 7
 - hygrometer 95, 96
 - hygroscopic behavior 247
 - hygroscopic fibers 97, 98
 - hygroscopic layer 304
 - hygroscopic materials, transport of 357, 358
 - hygroscopic properties 227
 - hygroscopic shell material, optical fiber coated 129
 - hygroscopy, definitions 35
 - hygroscopy, of paper and cardboard 337
 - hygrostat, switching hysteresis 43
 - hysteresis effects 228
- i*
- icy conditions 213, 215
 - impact jet psychrometer 205
 - technical specifications 205
 - incinerator 202, 203
 - indoor climate, monitoring 337
 - industrial applications, typical terms 180
 - typical regimes of industrial humidity measurement 181
 - infrared hygrometers 118
 - infrared light-emitting diode (IR-LED) 119
 - infrared measurement system 119
 - infrared radiation 148
 - infrared spectral range 116
 - double-beam method without chopper 119, 120
 - Fourier transform infrared spectroscopy (FTIR spectroscopy) 121, 122
 - liquids, measurement 123
 - opaque materials, measurement 123, 124
 - optical chopper 119
 - physical principle 116, 117
 - single-beam method 118, 119
 - technical implementation 117
 - tunable diode laser spectroscope (TDL) 120, 121
 - infrared wavelength ranges 117
 - inhomogeneous distribution of water in wood 152
 - injection molding system
 - with quasi-continuous, automated moisture measurement 311
 - inline measurement equipment 249
 - inline measurement in nonaqueous fluids 330
 - sensor modifications 330–334
 - inline measurement of powders and granules 310, 311
 - in high moisture range 311–316

- dielectric measurements at high frequency 314, 315
- equilibrium relative humidity 313, 314
- measurement with neutrons 316
- microwave moisture measurement 315, 316
- optical measurement 312, 313
- selection of a measurement method 311, 312
- thermogravimetric measurement 313
- with low moisture content 310, 311
- equilibrium relative humidity (ERH) 310
- quasi-continuous measurement 310, 311
- inline moisture measurement of paper 349
- inline trace humidity measurement 270
- systems with self-monitoring 270
- instant coffee 248
- irreversible morphological changes 248
- storage and packaging 247
- insulating materials 304
- moisture measurement 153
- International System of Units (SI) 21, 173
- ionic self-assembly monolayer (ISAM) 155
- IR measurements, in solids 124

- k**
- Karl Fischer titration 109, 110, 111, 197, 232, 246, 258, 305, 310, 311, 330, 395, 396, 436
- quasi-continuous measurement 310
- kinetic energy 141
- kiwi fruits 256

- l**
- laboratory measurement stations 387
- climate chambers 388–390
- comparison of priorities in moisture measurement 388
- gas mixing systems 390, 391
- for humidity and moisture measurement 387
- tasks 387
- trace moisture in solid materials 395
- combined methods 396
- Karl Fischer titration 395, 396
- spectroscopy 396
- water vapor permeability of foils/ hoses 397, 398
- measurement station for liquid and solid materials 392
- with electromagnetic fields 394
- loss on drying method 392, 393
- water activity measurement 394, 395
- Lambert–Beer law 115, 129
- leaching effect 271
- LiCl dew point sensor 91
- LIDAR devices 217
- liquid water
- bonding typts 52, 53
- in soil 183
- lithium chloride (LiCl) dew point measurement 90
- low water content, detection in laboratory 307
- calcium hydride method 309
- combined methods 308
- gas chromatography 307
- Karl Fischer titrator 307
- thermogravimetry 308
- luminescence 199
- Lyman-alpha hygrometer 125

- m**
- magnetic properties, measurement 58–62
- magnetic resonance imaging in medicine 144
- Magnus formula 25
- mass ratio 19
- material fatigue 153
- material moisture 282
- material parameters 473–477
- material-specific reference curves 246
- measurement method, selection
- control tasks 162
- evaluation of
- application 165, 167
- moisture/humidity 167
- strategies 164, 165
- goals of 161, 162
- guidelines for
- material properties 277
- measurement and control parameters 278
- process parameters 278
- hardware, selection (*see* hardware selection, measurement)
- location, conditions 163, 164
- monitoring tasks 162
- outgoing goods, inspection 163
- random checks 163
- task, assessment 161–163
- measurement station, for
- residual water in tubes
- data analysis 290, 291
- pipe drying process 289
- moisture measurement at inner pipe walls 288

- technical specifications of the measurement station 289
- medical applications, humidity measurement 411
- applications in medical supply technology 419
- gas supply system 420
- incubator 419, 420
- room climate control 420
- sterilization 420
- humidity measurement in respiratory air 412, 415
- capacitive and resistive humidity sensors 415, 416
- optical measurement 417, 418
- psychrometric measurement 416, 417
- respiration process in humans 412–414
- humidity measurement on skin 419
- self-regulating systems for humidification of respiratory air 414
- heat and moisture exchanger 415
- heated tube system 414
- specialties of clinical applications 411, 412
- melting 4, 23, 213, 376
- metal oxide sensors 335
 - electrical resistance of 74
 - physical principle 73, 74
 - principal application 75
 - technical implementation 74, 75
- meteorological equipment 214
- meteorological stations 208
 - for specialized applications 209, 210
- metrological terminology 174
 - accuracy 175
 - adjustment 178
 - calibration 177
 - industrial standards 178, 179
 - measurand 174
 - measurement standard (etalon) 178
 - measurement uncertainty 176
 - precision 175
 - random error 176
 - reference material 178
 - reference standard 178
 - repeatability 176
 - reproducibility 175, 176
 - systematic error 176
- metrology 173
 - moisture and humidity 179
- Michelson interferometer 122
- microelectromechanical systems (MEMSs) 155
- microwave 59, 70
- electromagnetic spectrum, radiation 70
- moisture measurement devices, for paper, technical specifications 345, 350
- Mie scattering, by water droplets 130, 131
- physical principle 129–131
- technical implementation 131
- mixing ratio 18
- moisture 7
 - controlling technology
 - indicators 36
 - measurement range 37
 - Peltier effect 39
 - reference measurement 37, 38
 - Seebeck effect 38, 39
 - sensitivity 37
 - sensor 36
 - sensor characteristic 37
 - temperature 39–41
 - temporal behavior 41
 - gas humidity in solids 30–33
 - in solid and liquid materials 25
 - capillaries 27
 - density 29
 - dry substance 28, 29
 - gradation 27
 - gravimetric water content 28
 - parameters 27–29
 - surface pores 27
 - volumetric water content 28
 - water bonds in liquids 26, 27
 - water bonds in solids 25, 26
- moisture content, of paper 338
 - equilibrium relative humidity 338
 - influence of moisture, on paper
 - properties 339–341
 - methods to determine 338
 - sorption isotherm 338, 339
 - sorption isotherm of paper 338
 - moisture in agricultural products 188
 - grain 188, 189
 - moisture in insulation layers, detection of 301
 - tightness tests 301, 302
- moisture measurement 59, 282
 - in aggregates
 - baking processes 248, 249
 - bulk materials and textiles 63
 - device in a pipe, integration 281
 - different principles of 52
 - electrical components 63
 - evaluation of measurement methods 233–235
 - in fluids by optical transmission 123
 - gas humidity methods for 58

- in incinerator flue gas 202
- in insulating materials 153
- in liquids, methods for 334
- low-frequency mobile measurement device 64
- in meat and sausage products 232, 233
- methods, classification of 49
- on moving filaments
- in oil and fuel 335, 336
- during oven drying of paper 347
- during particular stages of processing 238
- continuous measurement on conveyor belts 238, 239
- measurement in pipe systems 239, 240
- measurement inside silos 240–242
- measurement of exhaust air 242
- mixing and dispensing 238
- preprocessing of raw material 238
- in plastics 307
- product monitoring 233
- during running production processes 277
- continuous measurement
- in silos, pipes, and on conveyor belts 277
- during smoking 248
- surface measurement 124
- using infrared optical methods 123
- using the ERH method 166
- moisture measurement in aggregates 361, 362
- manufacture of prefabricated elements 365
- common measurement methods for microwave drying 366
- drying and firing of building material 365, 366
- furniture boards 365
- measurement conditions, efficient 362
- measurement in silos and on conveyor belts 362
- high-frequency measurement 364, 365
- optical measurement 363, 364
- using neutrons 362, 363
- water content ranges and characteristics 362
- moisture measurement, on moving filaments 350, 351
- complex electrical resistance measurement 352, 353
- ERH measurement 353, 354
- infrared measurement 351
- microwave measurement 353
- reference methods 354
- moisture parameters
 - electrical/humidity, analogies 54
 - electrical parameter 54
 - moisture-sensitive polyimide foil 98
 - moisture-sensitive products, storage of 324
 - warehouses and manufacturing facilities, monitoring of 324
 - control system 324
 - data documentation 324, 325
 - data transmission 324
 - measurement data acquisition 324
 - Mollier diagram 22, 47
 - moving cardboard 346, 347
 - museums and exhibition showrooms, climate control 379
 - critical influence of relative humidity on art objects 379
 - data logger, to record various climate parameters 381
 - miniaturized humidity sensors 380, 381
 - optimal room climate depends on 379
 - regular manual ventilation 380
 - thermohygographs with hair harps and bimetal strips 380
- n**
- nanograss polyimide-based humidity sensors 155
- nanostructured measurement devices 154
 - contact methods 154, 155
 - nanometrology 156
 - noncontact methods 155, 156
- nanostructured sensors 154
- nanotechnology 156
- National Institute of Standards and Technology (NIST) 173
- National Metrology Institutes (NMIs) 173
- National Physical Laboratory (NPL) 173
- natural/artificial materials, geometric changes
 - hygrometers with size-varying material 97, 98
 - physical principle 95
 - technical implementation 95–97
- neutron
 - measurement 350
 - radiation based devices 142
- NMR *see* nuclear magnetic resonance
- nozzle humidifier 382
- nuclear magnetic resonance spectroscopy
 - physical principle 143, 144
 - technical implementation 144, 145
- nuclear properties of water 141
 - gamma radiation 143

- physical principle 143
- technical implementation 143
- neutron measurement 141
- physical principle 141
- technical implementation 141–143
- nutrients 227

- o**
- offline methods, laboratory measurement
 - methods 167
- oil tanks, detection of water 336
- buoyancy probe 336
- microwave probe 336
- optical chopper 123
- optical fiber hygrometers 128
- optical fiber sensors 335
- optical measurement 349
- optimal measurement location, selection 164
- oscillating circuit devices 68
- oscillating electromagnetic field 144
- osmosis 35

- p**
- packaged foods, changes of properties 257
- packed snow 213
- paper and textiles, storage and transport
 - of 356
 - climate control 356, 357
 - transport of hygroscopic materials 357, 358
- Peltier effect 39
- Peltier element 306
- pesticides 190, 193
- phase transitions 183
- phosphorous pentoxide 148
- photoacoustic spectroscopy (PAS)
 - water vapor, acoustic properties 135
- photosynthesis of a plant as a function of temperature 195
- Physikalisch-Technische Bundesanstalt (PTB) 173
- Planck constant 173
- plant wetting, methods for measuring 193
- plastics
 - moisture measurement, by calcium hydride method 309
 - trace moisture measurement within the material flow 310
- pneumatic motion 282
- P₂O₅ cell, sensor monitoring 105, 270
- polymer sensors 208, 303
- precision, of measurement 164
- printed circuit boards (PCB) 99
- probe buoyancy 335

- product freshness, measurement of 196
- production control 235
 - inspection of incoming goods 235, 236
- production stages
 - in food industry, monitoring and control 242, 243
 - coffee roasting 243, 244
 - interim storage in a silo 244, 245
 - milling process 245, 246
 - packaging process 246–248
- product moisture 163, 307
- proportional-integral-derivative (PID) 87
- psychrometer 76, 180, 314
 - mathematical description 80
 - physical principle 77
 - technical implementation 77–80
- psychrometric measurement, in flue gas 205
- PTFE tubes 103

- q**
- quality control, by random test
 - measurements 341
 - laboratory measurements 344
 - ERH measurement 344
 - microwave 344
 - thermogravimetry 344
 - moving goods 343, 344
 - nonmoving goods 341
 - electrical resistance, measurement 342
 - measurement of ERH 341
 - probes adapted, for measurement at different positions 341
 - paper quality parameters, monitoring 341
 - inspection of goods 341
 - laboratory measurement 341
- quartz microbalance
 - physical principle 75
 - principal application 76
 - technical implementation 75, 76
- quartz oscillator hygrometer 76
- quasi-continuous measurement 66, 310

- r**
- radar-based moisture measurement 72
- γ-radiation 141, 143
- random checks, of incoming goods 161
- random test measurements, and inspection of goods 337
 - climate of surrounding environment 337
 - paper properties 337
- rapid drying 150
- Rayleigh scattering 130
- redundancy 42

- reference measurements, using certified equipment 231, 232
 - Karl Fischer titration 232
 - thermogravimetric measurement 232
- refrigerated goods 256
- regular checks and maintenance, measurement instruments 162
- relative humidity 16
- remote transmission 250
- residual moisture, at inner walls of hoses and tubes 284
 - measurement methods 284
 - chemical water content measurement 285, 286
 - equilibrium relative humidity 286
 - ERH measurement setup with trace humidity sensor 286
 - moisture measurement in silo with Karl Fischer titration 285
 - static measurement of ERH 286–288
 - surface water content 287
 - thermogravimetry 284, 285
 - trace humidity measurement setup 287
- resistive sensors 98
 - physical principle 98, 99
 - technical implementation 99, 101
- resistivity, chemical 100
- resonance 144
- rime 213
- road conditions
 - evaluation of 210
 - general model 212
 - relevant parameters, measurements 213, 214
 - in winter 212
- road temperature, measurement 214
- road wetness, measurement 214
- rooms and buildings, climate control in 377
- rooms containing electrical systems, climate control in 383, 384
 - condensation at electrically conductive components
 - strategies to avoid 383
 - detection of condensation
 - on pipes, isolators, and electrical components 384
 - insulators monitoring 383
 - technical specifications of wetting sensors 384
- ruby laser, holographic system 132

- s**
- scanning tunneling microscopy (STM) 156
- Seebeck effect 38, 39
- self-monitoring system 270
- sensor
 - for acid dew point measurements in flue gas 204
 - aluminum oxide 73
 - coating with plastic 279
 - curve, by contamination 89
 - equipment 190
 - filter 43
 - installation 279
- sensor modifications 330–334
 - equilibrium relative humidity 331, 332
 - optical measurement methods 331
 - properties
 - material, measurement 330
 - measurement location 331
 - water content in nonpolar fluids 332
- sensor mounting 279
- sensor parameters
 - bit rate 43
 - control behavior 44
 - hysteresis 43, 44
 - load resistance 43
 - physical property 36
 - relaxation 44
 - resolution 44
 - test function 45
- sensors, controlling technology
 - indicators 36
 - measurement range 37
 - Peltier effect 39
 - reference measurement 37, 38
 - Seebeck effect 38, 39
 - sensitivity 37
 - sensor 36
 - sensor characteristic 37
 - temperature 39–41
 - temporal behavior 41
- shelf life 196
- influence of water activity/enzymatic activity 198
- signal
 - contact measurement 51
 - noncontact measurement 50, 51
- sleeping effect 271
- snow moisture 208
 - measurement devices, typical parameters 209
 - portable instruments for 208
- soil moisture
 - gypsum block sensor 187
 - measurement 184
 - challenges in 184
 - parameters 184

- measurement
 - measurement of gravimetric soil moisture 184, 186
 - measurement of volumetric soil moisture 186
 - methods 185
 - soil substance 183
 - solar energy 213
 - solar irradiation 213
 - solid materials
 - characteristics 49
 - classes of 49
 - interactions of water 57
 - thermal properties 150
 - moisture measurement in insulating materials 153
 - physical principle 150, 151
 - technical implementation 151
 - water movement, measurement 151–153
 - water, bonding types 52, 53
 - sorption isotherm 226, 338
 - characteristic sections of sorption isotherm 227
 - characteristic shapes 228
 - influence of surface pores, gradation, and capillaries 226, 227
 - laboratory-based measurement 229
 - steps 229
 - measurement of 229
 - sorption isotherms 32, 226
 - specific enthalpy 22
 - specific humidity 18, 19
 - deficit 19
 - specific saturation humidity 19
 - spring hygrometers 98
 - static water activity measurement 222, 223
 - measurement time 222
 - method of estimation 223, 224
 - method of extrapolation 223
 - method of recirculating air 223
 - setup for dynamic measurement 223
 - sources of measurement errors 224
 - stationary sensors 189
 - Stokes–Raman spectroscopy 151
 - storage and transport of food 251
 - storage conditions 251
 - active climate regulation by air conditioning 253, 254
 - characterization, for different food products 251
 - bread and pastry 252
 - fruit and vegetables 251
 - energy-efficient storage 252, 253
 - food storage with active ventilation 254
 - large warehouses 252
 - passive regulation of container climate 253
 - structural changes of biological products 230
 - sublimation 23
 - suction pressure 136, 140
 - in peat substrate and humus soil 139
 - suction pressure, in solid materials
 - gypsum block method 139
 - physical principle 139
 - special designs 140
 - technical implementation 139, 140
 - tensiometry 136
 - physical principle 136, 137
 - technical implementation 137–139
 - sulfur hexafluoride (SF_6) 304, 305
 - surface acoustic wave dew point measurement instrument 90
 - surface acoustic waves (SAWs) 90
 - surface and atmosphere, interactions between 424, 425
 - formation of a water cycle 427–429
 - soil water 427
 - water at low temperatures 425–427
 - surface moisture, measurement in electronic devices with a large surface 304
 - surface pores, influence of 226
 - surface resistance of synthetic webs 342
 - surface temperature 213
 - surface water 230, 231
 - switch stations 305
 - synchrotron radiation X-ray scattering 155
 - small-angle X-ray scattering (SAXS) 155
 - grazing-incidence small-angle X-ray scattering (GISAXS) 155
- t**
- tables and diagrams, of thermodynamics 463–467
 - TDR *see* time domain reflectometry
 - temperature
 - compensation 316, 317
 - and humidity variation of coffee in a silo 247
 - influence on processability of cardboard 347
 - inside a pipe 282
 - variations 148
 - temperature-controlled measuring chamber 220
 - temperature-dependent resistor 40
 - temperature gradient 214
 - temperature measurement 163
 - temperature sensor 203

- for detection of heat emission 215
 - temporal behavior 41
 - tensiometer, for soil moisture
 - measurement 138
 - tensiometers 140, 167, 186
 - requirements, requirements to fulfill 186
 - tensiometers, components 137
 - tensiometric moisture measurement,
 - principle 136, 137
 - tensiometric pressure difference
 - measurement 138
 - tensiometry 136
 - testing and calibration of aerospace technology
 - in the laboratory 436
 - test measurements, in real environment of
 - application 170
 - thermal black body radiation 117
 - thermal conductivity 302
 - thermal drying 320
 - contact drying 321
 - convection drying 320
 - thermal equilibrium 214
 - thermal insulation 250
 - thermistor 40
 - thermocouple 39, 40
 - thermodynamics, physical constants 22
 - thermodynamics relevant units 457–462
 - thermogravimetric measurement 197
 - thermogravimetry 188, 231
 - drying with desiccants 148, 149
 - oven drying method 149
 - rapid drying 150
 - physical principle 145, 146
 - technical implementation 146, 147
 - halogen lamps 148
 - heat sources 147, 148
 - infrared sources 148
 - microwave generators 148
 - three-dimensional map of water
 - distribution 145
 - tightness tests 301, 302
 - time domain reflectometry (TDR) 59, 66, 67
 - tolerance 271
 - traceability
 - establishing, by unbroken chain of comparison measurements 174
 - of a measurement 173
 - triple point 23
 - tunable diode laser spectrometer (TDL) 120
 - turbulences 283
 - typical equipment for a research aircraft with humidity measurement equipment 217
 - typical phases of an implementation project 171
 - typical tasks and applications in different sectors of industry 162
- u**
- ultrasonic humidifier 382
 - uncertainty, measurement 44, 45, 176
 - unconditioned air 237
 - Ultra violet hygrometer *see* UV hygrometer
 - UV hygrometer
 - block diagram of 126
 - for high-velocity gas flows 126
 - UV hygrometers 125
 - UV radiation 124
- v**
- vacuum drying 321
 - vapor mole fraction 19
 - vegetables, water potential measurement 199
 - ventilation 380
 - volume ratio 20
- w**
- waste management 199
 - measurement in recycling products 199
 - moisture in biofilters 199, 200
 - moisture in compost 200, 201
 - water
 - amphoteric substance 5
 - chemical properties 5, 6
 - water molecule 2, 3
 - crystal/chemically bound 33
 - density of 4
 - electrical properties of 60
 - gravimetric 34
 - as natural resource 1, 2
 - nutritional function 1, 2
 - phase diagram of 16
 - pH-value 6
 - physical properties 3–5
 - significance of 6, 7
 - water absorption 31
 - water activity
 - influence of the addition of other components 228
 - influence of the material temperature on 227
 - measurement 219, 221
 - methods 222
 - as parameter in food industry 219
 - water adsorption, in products 479–482
 - water-color mixture layers, film thickness measurements 354, 355

- optical comparative measurement 356
- optical water film thickness determination 355
- thermography 355, 356
- water mass determination using a Belt Weigher 355
- water content 183
- measurement
- radar 72
- in nonpolar fluids 332
- water content measurement, in coarse materials 291
- control of mixing processes 293, 294
- moisture measurement in coal and ore 292, 293
- sample extraction systems for bulk materials 291, 292
- water content measurements, using chemical methods 101
- coulometric measurements 101, 102
- specialties 104, 105
- technical implementation 102–104
- water content of solid materials 261
- water cycles 183
 - evolution process in planet 424
- water diffusion
 - equivalent electric circuit diagram for modeling 55
- water distribution/formation
 - gravitational force of planet 424
 - hydrogen fusion channels 423
 - model representations 423
 - proton–proton chain reaction 423
 - retention of liquid water on planet 424
 - simulation of planetary atmosphere 429–431
 - surface and atmosphere, interactions between 424, 425
 - formation of a water cycle 427–429
 - soil water 427
 - water at low temperatures 425–427
 - water vapor, generation 424
- water droplets
 - digital holography 134
 - holographic measurement of
 - digital holography 132, 133
 - physical principle 131, 132
 - technical implementation 133, 134
 - inline holography 133
 - operation principle 133
 - light impinges 131
 - Mie scattering
 - physical principle 129–131
 - physical principle 129–131
- technical implementation 131
- water exchange
- permanent 183
- between water, soil, and atmosphere 184
- water incorporation, in capillaries 27
- water molecule
 - binding angles 2
 - clustering of 3
 - freezing, clusters formation 3
 - vibration states 2
- water–oil mixture 335
- water release 31
- water saturation curve, of oils 335
- water-sensitive microcapacitance 155
- water steam 7
- water vapor 7
 - acoustic properties
 - photoacoustic spectroscopy (PAS) 135
 - physical principle 134
 - technical implementation 134
 - transmittance and absorption wavelengths of 117
- water vapor, optical properties
 - measurement 114–134
- holographic measurement, of water droplets
 - digital holography 132, 133
 - physical principle 131, 132
 - technical implementation 133, 134
- infrared spectral range 116
- double-beam method without chopper 119, 120
- Fourier transform infrared spectroscopy (FTIR spectroscopy) 121, 122
- liquids, measurement 123
- opaque materials, measurement 123, 124
- optical chopper 119
- physical principle 116, 117
- single-beam method 118, 119
- technical implementation 117
- tunable diode laser spectroscope (TDL) 120, 121
- Lambert–Beer law 115, 116
- Mie scattering, by water droplets
 - physical principle 129–131
 - technical implementation 131
- optical fibers
 - physical principle 127
 - with sensitive coating 129
 - technical implementation 127–129
- UV radiation, measurement 124
 - technical implementation 125, 126
- water vapor pressure 183
 - above liquid water 12

- chamber pressure, functional dependency of 107
 - saturated 11
 - temperature *vs.* dew point 14
 - weather conditions
 - measurement 207, 208
 - weather forecasting 208
 - weather shelter with electrical humidity 210
 - wetness state of the road surface 214
 - wet thermometer, psychrometric constant 15
 - wetting 230
 - conditions 194
 - determination, optical methods for 194
 - wetting/dewing of plants 190
 - wetting measurement
 - directly at the plant 195, 196
 - with heater in standby 193, 194
 - with permanent heating 194
 - wetting measurement, without heating 192
 - wetting of plantations 191, 192
 - wetting of plants 191
 - wetting sensor for cultivations 196
 - wetting sensors 304
 - criteria to fulfill 195
 - technical data 197
 - Wilson pilot tube 282
 - circular pipes 285
 - dimensioning 283
 - for flow measurement 282–284
 - pipe cross-sectional area 283
 - rectangular pipes 285
 - setup for volume flow measurement in airway 283
 - wind directions
 - abbreviations 212
 - wind velocity 214
 - winter sports, weather forecasting 208
 - wood 62
- x**
- X-ray computed tomography 143
 - X-ray diffraction 155
 - xylem 151
 - flow in wood 152
 - measurements 151
- z**
- Zeeman effect 144
 - zirconium oxide humidity measurement devices 92, 93
 - technical implementation 94
 - error compensation 94, 95
 - zirconium oxide sensors 206, 207, 249, 314
 - technical specifications 206
 - ZnO thin film based sensors 155