

Main Index

- accuracy, 4–6, 340, 494, 527, 558, 592, 599. *See also* uncertainty
- acoustic impedance. *See* impedance, acoustic
- adiabatic compressibility, 426, 506
- Allen Salt-Velocity method, 98–99
- anemometer
 - hot wire, 603
 - laser Doppler, 434, 603
- applications (examples of flowmeters suitable).
See Applications Index and Selection Table
- audit, 53, 62
 - questionnaire, 65–66
- bell prover, 85, 106–7
- benchmarking, 637
- Bernoulli’s equation, 35, 166
- bias. *See* systematic error
- block and bleed valving system, 78–79
- BS 1042. *See* ISO 5167
- bus protocols, 493, 630
- calibration, 1, 107, 489, 494, 498, 527, 536, 558, 585
 - accreditation table, 72t4.2
 - case study of, 108–13
 - dedicated facilities, 72, 101
 - dry, 73, 92, 95, 373, 386, 390, 395, 396, 399, 400, 433, 441, 442, 443, 457, 458, 481
 - environmental conditions, 70
 - expansion techniques, 103
 - gas calibration facilities, 105
 - gases at very low flows, 107
 - gravimetric gas, 105
 - in situ, 73, 91–92, 105, 603, 615
 - intercomparisons, 104
 - large water facility example, 113
 - manufacturer’s viewpoint, 71
 - master meters, 72
 - new developments in, 101
 - typical laboratory facilities, 70
- cavitation, 42, 122, 291–92
- CE, 4, 54, 64, 140
- CEN/CENELEC, 4
- centipoise, 14t1.1.
- centistoke, 14t1.1., 299
- Central Limit Theorem, 19
- clamp-on flowmeters, 95, 437–38
- Coanda effect, 352
- compact provers. *See* provers, compact
- compressibility, 54, 64, 171, 181, 582, 591
- compressible flow, 38–40
- computational fluid dynamics (CFD), 45, 50–51, 148, 171, 348, 357, 450–52
- conditioners. *See* straighteners and conditioners
- confidence level, 5–6, 7, 10, 12, 19, 20, 21, 69, 71t4.1, 141, 456, 463, 528
- continuity equation, 34
- critical flow function, 181, 185, 188
- critical nozzles, calibration by, 87
- DC systems, 366, 368, 371–72
- delay time, 454
- differential pressure flowmeter equation, 133, 501, 507
- Doppler probes. *See* probes, Doppler
- double chronometry. *See* provers, double chronometry method
- drain holes, 158
- drop test, 93–94
- droplets, 42–43
- dry calibration, 73, 92, 95, 373, 386, 390, 395, 396, 399, 400, 433, 441, 442, 443, 457, 458, 481
- electromagnetic compatibility (EMC), 4, 54
- electromagnetic probes. *See* probes, electromagnetic
- envelopes, uncertainty, 7, 11–12, 69, 205, 306, 313, 585
- error
 - types of, 22–23
- etoile flow straighteners. *See* straighteners and conditioners
- expansibility (expansion) factor, 120–21, 217
- expansion techniques, 103

- Fanning friction factor, 46
Fieldbus, 629
flow
 compressible, 38–40
 computers, 148
 conditioning, 47
 diverters, 103
 flow profile equations, 46
 laminar, 28, 223, 224, 225, 227, 348
 multiphase (multicomponent), 40–42, 105, 300, 345, 383, 454, 497, 508, 522, 585
 non-Newtonian flow, 28, 47
 oil-in-water, 138
 stratified, 42, 107, 456, 512, 525
 turbulent, 403, 409, 428, 449, 450
 unsteady, 36, 70, 131–36, 157, 228, 299, 308, 326, 454, 601
flowmeter audit, 62
flowmeter envelopes, 11–12
flowmeter selection, 1, 14, 62
 table, 58t3.1.
flowmeter, working definition, 11
flowmeters. *See* Flowmeter Index
FSD. *See* full scale deflection
FSR. *See* full scale reading
full scale deflection (FSD), 8, 11, 12, 13f1.2., 203, 209, 384, 505, 535, 538, 540, 542, 557, 562
full scale reading (FSR), 8

gamma-ray density sensor, 258, 506, 515, 517, 522, 523, 524f17.5.
gas entrapment, 43–45
gas flow standard, 102, 107
gas-to-oil ratio (GOR), 42
Gaussian quadrature, 429. *See also* log linear positioning of measurements
gravimetric gas calibration. *See* calibration, gravimetric gas
Guide, The, 9, 10
gyroscopic device, 101

HART, 629–30
Hodgson number, 37f2.5., 133, 135f5.10.
hot tapping, 466, 612, 620
humidity, 13, 42

impedance, acoustic, 422, 435, 436, 446, 481
impulse lines. *See* pressure impulse lines
in situ calibration. *See* calibration, in situ
inferential mass flow measurement, 173, 315, 465, 501, 622
installation orientation, 295–97, 542–43, 574, 585, 591
instruments, intelligent, 140, 147, 148, 150, 371, 441, 499, 626, 629
instruments, smart, 140, 147, 148, 150, 441, 626
integration methods, 97
integration techniques, 95
intelligent instruments. *See* instruments, intelligent

isentropic exponent, 37, 39, 108, 120, 160, 161, 175, 182, 184
ISO 5167, 119, 124f5.4, 152, 156, 164f6.1, 340
ISO 9000, 636–37
ISO 17025, 636–37

K-factor, 299, 335t11.1., 576

Lamb waves, 437–39, 446
laminar flow. *See* flow, laminar
laminar flow bypass, 223, 531
laser Doppler anemometer. *See* anemometer, laser Doppler
linearity, 7
log linear positioning of measurements, 96.
 See also Gaussian quadrature
loss coefficient, 34, 121, 230, 527, 621, 622
lubricity, 54–55

manufacturing precision, 81
manufacturing variation, 202–3, 633, 634
MAP, 24, 99
mass flow measurement, 3, 15, 474. *See also*
 inferential mass flow measurement
 direct (true), 501
 indirect, 501
master meter. *See* transfer standard
Meter Factor, 297t10.3.
meter provers. *See* provers, meter
microprocessor-based protection systems (MBPS), 140
microsensors, 530, 537, 545, 638
microwaves, 624
momentum sensing, 507
Monte Carlo method, 10, 479
multicomponent flow. *See* flow, multiphase (multicomponent)
multiphase flows. *See* flow, multiphase (multicomponent)

National Measurement Institute Australia (NMIA), 107
neural network, 173, 214, 316, 452, 465, 510, 514, 525, 526, 528, 592, 601, 622
Newtonian fluid, 27
noise. *See* signal, noise information
non-Newtonian flow, 28, 47
nonslip condition, 28, 29, 391, 611
Normal distribution, 5
nuclear radiation, 520
nuclear sources, 520

oil exploration and processing, 409, 463, 464, 499, 508, 515–28, 585
oil-in-water flows. *See* flow, oil-in-water
opacity, 54, 63
operating envelope, 313, 535
operating range, 7
optical methods, 569

Main Index

737

- Organisation International de Métrologie Légale (OIML), 3, 4, 256
- OSI, 630
- paddle-wheel probe. *See* probes, paddle-wheel
- particles, 42–43
- pattern recognition in two-phase flows, 455
- piezometer ring. *See* pressure, piezometer ring
- pipe provers. *See* provers, pipe
- pipe roughness, 29, 46, 125, 159, 172, 307, 361, 454
- pipework features, inlets & bends/elbows, calibration by, 93
- piston prover. *See* provers, compact
- pitot probe. *See* probes, pitot
- pneumatic transmission, 203, 209
- precision, 4–5
- pressure
- impulse lines, 144, 160
 - measurement, 144
 - piezometer ring, 143–45
 - sealant fluids, 144
 - stagnation, 35, 39, 177, 178, 179, 188, 220, 273, 604
 - tappings, 116, 117, 124f5.4., 151, 156, 166, 186, 213, 620
- pressure transducers, 37, 117, 131, 132, 133, 144, 151, 220
- smart, 60n. d, 140, 150
- probes, 95–96
- differential, 604–8
 - Doppler, 603
 - electromagnetic, 614
 - paddle-wheel, 280, 316
 - pitot, 604–8
 - propeller, 609–11
 - target, 609
 - thermal, 616
 - turbine, 609–11
 - ultrasonic, 615, 616f21.10.
 - Venturi, 607–8
 - vortex, 612
- Profibus, 629, 630
- profile measurement, 467, 483, 500
- protocols
- FOUNDATION Fieldbus, 629
 - HART, 629–30
 - Profibus, 629, 630
- prover spheres, 80
- provers
- bell, 85, 106–7
 - compact, 85–86, 108
 - double chronometry method, 82
 - pipe, 80, 81f4.9., 104
 - pulse interpolation, 82
- proving vessels/tanks, 75–79
- pulsation index. *See* flow, pulsation index
- pulsation, effects. *See* flow, unsteady
- pulse interpolation. *See* provers, pulse interpolation
- pVT method of calibration, 71t4.1, 87, 102
- quadrature. *See* Gaussian quadrature
- random error, 8, 99, 100, 580, 634
- range and rangeability, 8, 11, 12, 141, 534
- ratio of specific heats. *See* specific heats, ratio of
- RCM. *See* Reliability centered Maintenance
- reciprocity, 15, 440, 441, 459, 597
- reference meters. *See* transfer standard flowmeter
- Reliability-centred maintenance, 2
- repeatability, 4–6, 578
- reproducibility, 4
- research, 3, 34, 48, 129, 193, 223, 237, 263, 396–98, 474, 500, 552
- calibration case study, 108–13
 - circular oscillating piston positive displacement flowmeter, 273
 - Coriolis flowmeter, 578, 585, 592
 - Cranfield University, UK, 397, 403
 - electromagnetic flowmeters, 396, 398
 - orifice plates, 156, 157
 - rotary piston positive displacement flowmeter, 271
 - Tsinghua University, China, 397
 - turbine flowmeters, 307, 317
 - ultrasonic flowmeters, 473, 474
 - Venturi meters, 172
- Reynolds number, 28, 29, 46, 47, 51, 69, 95, 102, 118–20, 126, 128, 327, 394, 429, 450, 451, 453, 477, 494, 606
- sampling frequency, 454, 459, 466
- SCADA, 523
- sealant fluid. *See* pressure, sealant fluids
- selection, 56–62
- table, 58t3.1.
- sensitivity coefficient, 9, 10–11
- sensors. *See* instruments
- SI units, 13–14
- signals, 301, 338, 384, 439–41, 447, 493, 499, 640
- noise information, 399
 - types of, 626–28
- smart instruments. *See* instruments, smart
- Snell's Law, 433, 445
- soap film burette, 88
- specific heats
- ratio of, 120, 178, 182, 506, 531
- specification
- questionnaire, 63–65
- stagnation pressure. *See* pressure, stagnation
- stagnation temperature. *See* temperature, stagnation
- standard deviation, 8, 9, 17, 19, 21, 99, 172, 308
- standard time, 189
- standard uncertainty, 9, 21, 102, 105, 106, 112t4.A.1
- steam, 40, 136
- effect on orifice plate, 45
- Stolz equation. *See* Flowmeter Index, orifice plate
- straighteners. *See* straighteners and conditioners

- straighteners and conditioners, 31–34, 47–50, 113, 127–28, 455
 - box (honeycomb), 31f2.2
 - etoile, 31f2.2
 - Gallagher, 34
 - K-Lab, 32, 33f2.3
 - Laws, 33f2.3, 34
 - Mitsubishi, 33f2.3
 - tube bundle, 31f2.2
 - Vortab, 33f2.3, 34
 - Zanker, 33f2.3
- strainers, 290
- strapping tables, 94
- stratified flow. *See* flow, stratified
- Strouhal number, 324, 327, 331, 333, 334, 339, 340, 348, 353, 359, 360, 360t11.A.1, 361, 506
- Student t value, 9–10, 20
- swirl, 31–34
- systematic error, 9, 22, 99
- temperature
 - stagnation, 39, 177, 178, 180, 186, 187
- thermal mass flow probe. *See* probes, thermal
- traceability of calibration, 100, 618
- tracers, calibration by, 105
- transfer standard flowmeter, 80, 88, 90, 104, 109
- true mass flow measurement
 - See* Flowmeter Index
- tube bundle flow straightener. *See* straighteners and conditioners
- turbulence. *See* flow, turbulent
- turndown ratio, 8
- two-phase flow. *See* flow, multiphase
- ultrasonic probes. *See* probes, ultrasonic
- ultrasound, 419–23
- uncertainty, 7, 72, 98, 108, 125, 304, 351, 384, 442, 444, 445, 535, 542, 578, 581, 618, *See also* accuracy
- pipe provers, 104
- units
 - conversion, 11, 13–14
- universal viscosity curve (UVC), 299, 324
- unsteady flow. *See* flow, unsteady
- upper range value (URV), 8
- utilities, 357, 474
- variance, 17, 19, 20, 172
- velocity in pipes, 360t11.A.1, 485, 487, 493
 - for various flow rates, 16t1.2.
- verification, 398–400, 640
- verification, in situ, 73, 92, 341, 474, 587, 617–20, 624
- volume sensing, 56, 507
- vortab. *See* straighteners and conditioners
- vortex probes. *See* probes, vortex
- vortex shedding, 223, 286, 328–29, 334, 336, 339, 345, 358–61
- vortices
 - gas entrapment, 43–44
- weigh tank, correction factor, 109
- weighing method for calibration rigs
 - conventional value of mass, 111
 - dynamic, 75
 - static, 75, 76f4.4.
 - substitution, 77
- weight function/vector for flowmeters, 15, 389, 392–96, 400, 595
 - Coriolis, 575
 - electromagnetic, 398
 - thermal, 548, 551
 - ultrasonic, 478
- Youden analysis, 25f1.A.6, 26, 100
- Zanker flow straightener. *See* straighteners and conditioners
- zero drift, 12, 388, 389, 403, 580–81, 597

Flowmeter Index

- acoustic, 484–500
- acoustic chemometrics, 499, 500
- acoustic scintillation, 471
- angular momentum, 60t3.1., 126, 280, 306, 553–54, 555, 562, 563, 593–94
- Annubar. *See* averaging pitot
- Arnold and Pitts’ patent, 258, 259f9.20.
- averaging pitot, 45, 51, 58t3.1, 195, 220–23
- axial current, 404

- bearingless, 290, 314
- Bendix meter, 553
- bends, 48–49, 125
- Brand and Ginsel, 503f16.2.
- bypass meter, 552

- charge sensing, 338, 403, 520
- clamp-on, 95, 437–38, 491–92, 617, 620, 622–23
- classical Venturi. *See* Venturi
- cone. *See* V-cone
- Coriolis
 - cross-talk, 576, 583
 - drive mechanism, 569
 - flow tube, 569, 585
 - meter secondary, 570–72
 - pressure sensitivity, 569, 576–77, 578, 580
 - secondary containment, 570
 - sensor types, 569–70
 - temperature sensitivity, 570, 571, 576–77, 578, 580
- correlation flowmeter. *See* cross-correlation
- critical flow Venturi nozzle, 45, 177–194
 - coefficient of discharge, 183–85
 - critical flow function, 185
 - cylindrical throat, 179
 - maximum outlet pressure, 181–83
 - toroidal throat, 191–92
- Crometer tube. *See* V-cone
- cross-correlation, 339
- CVM, 258

- Dall tubes, 45, 209–12
- diaphragm, 204–7
- differential pressure, 191, 195, 204–5, 210, 213, 216, 217, 225–26, 227
- domestic gas, 85, 204–5, 234
- Doppler, 419–20, 434, 437, 464, 466–68, 482–83
 - range-gated, 473, 474
- drag plate. *See* target meter

- eccentric orifice plates, 51, 128, 168, 379–80
- eddy current, 288, 396, 397, 398, 400, 404, 407
- elbow. *See* flowmeter, bend
- electromagnetic, 362–407
 - AC, 366, 369, 370–72, 374, 377, 383, 387, 388
 - DC, 366, 370–72, 383, 387
 - differential, 377, 385
 - dry calibration, 373
 - dual frequency, 373, 398
 - electrodes, 363–66, 367–70, 373, 374, 375–77, 380–81, 384, 386f12, 391, 396–97
 - empty pipe detection, 373, 386
 - end shorting, 366
 - entrained gases, 377, 385
 - flux linking of signal leads, 369, 403
 - for liquid metals, 362, 390, 407
 - for non-conducting dielectric liquids, 362
 - ground/earth links, 367, 370, 378, 387, 401
 - liner, 366, 367–68
 - magnetic field, 362–67, 369–70, 371, 373, 377–78, 379, 382, 384, 385–86, 391–94
 - primary element, 366, 370
 - quadrature signal, 369–71, 372, 401
 - sensitivity, 385, 389, 394
 - sensor (primary) element, 366–70
 - Shercliff weight function, 364–66
 - transmitter (secondary element), 373
 - weight functions, 364–66
 - zero drift, 389, 403
- Elliot-Nathan, 608
- Epiflo, 195, 211f8.12.

- flap-type. *See* rotating diaphragm
 float-in-tube. *See* variable area
 flow computers, 148
 flow diverters, 103
 flow profile equations, 34, 46
 fluidic, 352–55
 as Venturi bypass, 356
 force flowmeter, 405–6, 407
 fuel flow transmitter, 554–57
- gas turbine flowmeter. *See* turbine flowmeter,
 for gases
 Gentile tube, 211, 212f8.14.
 Gilflo, 205f8.7
- Hastings, 549–51
 helical multiphase, 259
 helical rotor, 242–43, 259, 273
 high precision gas meter. *See* turbine flowmeter,
 for gases
 high precision liquid meter. *See* turbine flowmeter,
 for gases
 hybrid, 507
- inlet, 92, 93, 116, 151, 156, 164, 173, 179, 185–87, 188,
 189, 195, 204, 210, 211, 214, 217, 238, 272, 273,
 282, 283, 284f10.6., 286, 288, 298, 306, 307, 312,
 348, 351, 357, 381, 459, 502, 512, 513, 536, 541,
 543, 544, 549, 564, 565, 566, 622
 insertion. *See* Main Index, probes
 integral, 163, 209, 297, 307, 314
 integral orifice, 163, 209
 ionic, 390
- Katys meter, 553
 Kratzer and Kefer meter, 516f17.1.
- laminar, 28, 29, 61, 223–27, 530–31
 Lehde-Lang, 404, 405f12.A.5., 407
 Li and Lee, 560–61
 liquid plugs, 261f9.22.
 Lorentz force, 407
 low loss, 195, 211
- magnetic resonance (MR), 59t3.1, 408–18, 519, 520
 manometer, 146
 mass flow sensing meters, 501–7
 Massa Stroon Meter (MSM1), 503
 McCrometer tube. *See* V-cone
 micro flowmeters, 107, 385, 589, 592, 638
 microwave devices, 624
 MTI. *See* undulating membrane (MTI)
 multiphase, 40–42, 59t3.1, 71, 102, 105, 169,
 176, 300–1, 383–84, 409, 416, 418f13.11.,
 454–55, 471, 472, 474, 497, 501, 508–28, 572,
 579f20.11., 585, 592, 641
 helical, 259
 nuclear radiation, 520
 multirotor PD, 237
- nozzles. *See also* Venturi
 coefficient of discharge, 183–85
 critical flow Venturi. *See* critical flow
 Venturi nozzle
 ISA1932, 167
 long radius, 166f6.4, 167
 sonic. *See* critical flow Venturi nozzle
 nuclear magnetic resonance (NMR). *See* magnetic
 resonance (MR)
 nutating disc, 234, 236–37
- orifice plate
 chordal, 128, 129
 coefficient of discharge, 118–20, 156
 conical, 128, 150
 contamination, 157–59, 162
 deflection at high pressure, 129–31
 eccentric, 128
 edge sharpness, 209, 212
 expansibility factor, 120–21
 flange tappings, 123–24
 flatness, 122, 131, 131f5.8
 flow conditioning, 158
 gas conditions, 160
 impulse lines, 144, 160
 lagging pipes, 160
 metering run assembly, 141
 plate carrier assembly, 141
 pressure loss, 121
 pressure measurement, 144–47
 pressure tappings, 123–24, 142–43
 quadrant, 128, 163
 sizing, 142
 slotted, 195, 216–17
 smart orifice meter, 160
 steam quality, 161
 Stolz equation, 118–19, 152
 study of flow through, 148
 thickness, 122–23, 129–31, 160
 Orlando and Jennings, 553–54
 oscillating circular piston, 57, 237–38,
 273–76
 oscillating membrane (MTI). *See* undulating
 membrane
 oscillating vane, 195, 216, 356
 oval-gear meter, 238–40
- paddle wheel, 280, 316, 611
 pattern recognition, 455, 511, 525, 528, 641
 PD. *See* positive displacement (PD)
 Pelton wheel, 195, 216, 280, 314
 piston. *See* reciprocating piston
 positive displacement (PD), 234–78
 calibration systems, 246–48, 253–54
 pressure effects, 252–53
 slip, 251–52
 temperature effects, 252–53
 Potter twin rotor turbine, 553
 probe. *See* main index, probes, turbine

- quadrant orifice. *See* orifice plate, quadrant
- quadrature signal, 369
- Quantum Dynamics meter, 314, 418
- reciprocating piston PD, 243
- Roots. *See* rotary positive displacement gas meter
- Rotameter. *See* variable area meter
- rotary piston. *See* oscillating circular piston meter
- rotary positive displacement gas meter, 257–58
- rotating diaphragm, 206, 207f8.8
- saddle coil, 404, 405f12.A.4., 407
- sensitivity coefficients, 10
- sliding vane PD, 240–42, 245–46, 250f9.14., 255–56, 261, 263
- slotted orifice, 195, 216–17
- sonar, 484–500, 641
 - active, 484
 - passive, 484–85
- sonic nozzle. *See* critical flow Venturi nozzle
- spring loaded diaphragm meter, 204–7
- spur gear, 244
- static charge. *See* charge sensing
- surface-acoustic-wave (SAW), 473
- swirl meter, 351
- target, 208–9
- thermal mass flow measurement
 - capillary thermal mass flowmeter (CTMF for gas), 530–37
 - capillary thermal mass flowmeter (CTMF for liquid), 537–38
 - in-line thermal mass flowmeter (ITMF), 541–42
 - insertion thermal mass flowmeter (ITMF), 540–41
- Torbar. *See* averaging pitot
- toroidal throat Venturi nozzles. *See* nozzles, critical flow Venturi
- true mass flowmeter, 560–61, *See also* Li and Lee
- turbine, 279–326
 - dual rotor, 288
 - equations, 317–26
 - for gases, 303–11
 - for liquids, 419–20
- twin Venturi, 502–3
- ultrasonic, 61, 419–83
 - beam sweeping, 472, 472f14.17
 - clamp-on, 437–38
 - gases, 419–20, 422, 446–47, 457–63
 - liquids, 419–20, 422, 444–46, 456–57
 - correlation, 419
 - custody transfer, 442, 446, 456, 458, 463, 465, 466
 - Doppler, 419–20, 434, 437, 464, 473, 474, 482–83
 - mass flow measurement, 426–27
 - retrofit, 95, 101, 419, 437
 - sing-around, 425
 - transducers, 432–36
 - transit-time, 419, 423–25
 - for pulses, 424–25
- undulating membrane (MTI), 262
- vane-type, 253, 315
- variable area, 196–204
 - manufacturing variation, 202
 - spring loaded, 204–7
- V-cone, 213–15
- Venturi, 163–64
 - coefficient of discharge, 165, 171
 - design details, 167
 - two-phase flow, 169–70
 - upstream installation spacings, 168
 - with fluidic bypass, 356
- Venturi nozzle, 163–64, 167, 356f11.16. *See also*
 - critical flow Venturi nozzle
- vibrating nozzle, 560–61
- vibrating tube, 560–61
- viscous. *See* flowmeter, laminar
- vortex
 - cavitation, 331, 347, 352
 - K* factor, 329, 331, 339, 341
 - measurement of steam flow, 345–48, 351
- vortex shedding, 223, 327, 329, 334, 336, 339, 357, 358–61
- waste air, 543
- water, 311–14
- wedge, 212–13, 512
- wet gas, 51, 60t3.1, 139, 150, 169, 170, 171, 174–76, 215–16, 217, 234, 334, 346, 464, 493, 509, 511–14, 520, 521t172, 641
- Wheatstone bridge, hydraulic, 504–5
- Woltmann, 279

Flowmeter Application Index

In referring to this index the reader should note that:

- a) the applications recorded are those examples which I have encountered in reading the literature on meters **and are obviously not in any sense exhaustive**. In a few general cases I have, therefore, included references to other flowmeters;
- b) the references to a particular flowmeter do not imply that other flowmeters are unsuitable, but rather that I was not aware of manufacturers specifically recommending other flowmeters for the application;
- c) even if a particular flowmeter is referred to, it does not necessarily mean that it will, in practice, be suitable for the application;
- d) the reader should always check suitability of a flowmeter for a particular application with the manufacturer, and the other factors set out in Chapter 3.

abrasive liquids, 57, 387, 388, 496, 574, 579	calibration. <i>See</i> transfer standards
acids, 350, 362, 388, 468, 588t20.1, 589	catalysts in petrochemicals, 538
additives, 243, 388, 538	chemical vapour deposition, 536
adhesives, 240, 243, 245, 263	chemicals, 203, 240, 261, 387, 388
air, 28, 43, 204, 310, 388, 464, 536, 543, 544, 589	chromatograph flows, 538
compressed, 350, 446	clean fluids, 209, 218, 261, 289, 297, 302, 306, 336, 350, 468, 496, 530, 536
entrained, 487, 492, 496	coffee extract, 587
preheated and combustion, 540, 543	combustion gas flows, 540
air conditioning, 540	compressor efficiency and surge control, 612
aircraft, 558	condensate production, 498
fluid systems, 466	contaminated oil, 468
fuel flow, 559	corrosion inhibitors, 538
alcohol, 240	corrosive gas, 543
asphalt, 587	corrosive liquids, 218
auto industry, 245	cream, 245
	creosote, 350
bases, 388	crude oil, 463, 464
batching, 245, 261, 388, 398	cryogenic, 290, 302, 350, 466, 587, 589, 590
beer, 388, 588t20.1	custody transfer, 261, 262, 388, 463, 589, 612.
benzene, 350	<i>See also</i> transfer standards
black liquor, 213, 388, 587	
blast furnace flows, 388	diesel, 245, 350
bleaching chemicals, 388	digester flows, 388
blending, 243, 536, 588	dirty fluids, 57, 212, 213, 261, 290, 306, 352, 454, 461.
boiler applications	<i>See also</i> gas conditions, dirty; liquids, dirty
combustion air, 540	dispensing, 261
efficiency testing, 505	distillates, 205
preheater, 540	domestic gas, 85, 234, 459, 474
brown stock, 388	

drilling mud, 455, 498	hydrogen, 302, 536
dyes, 245, 587	hydrogen coolant flow, 540
emulsions, 138, 170, 171f6.6, 388, 468	hydrogen sulfide, 536
engine	krypton, 536
testing, 243, 350, 436	methane, 350, 446, 536, 540, 543
engine lubricant, 466	natural, 204, 310, 446, 464, 538, 587
enzymes, 538	neon, 536
erosive liquids, 387, 388	nitrogen, 302, 306, 310, 464, 536, 543
ethylene oxide, 587, 589	nitrous oxide, 536
	oxygen, 204, 302, 310, 536, 543
fats, 261, 587	propane, 310, 536, 587
fertilizers, 261	propylene, 536
flavorants, 538	refinery, 310
flavouring, 388	silane, 536
flocs, 472	xenon, 536
foods and beverages, 203, 302, 388, 496, 543,	gasoline, 205, 240, 245
588t20.1, 589	glycol, 325, 350
glucose, 240, 468	greases, 245
ice cream, 388	green liquor, 587
juice, 388, 468, 587, 588t20.1	
liquid chocolate, 587	heating flows, 540
milk, 388	helium service, liquid, 170
peanut butter, 587	hydraulic oils, 245, 350
processed egg, 587	hydrocarbons, low viscosity, 350
sugar, 388	hygienic, 348, 388, 638
fuel consumption, 243, 245, 538	
fuel oil, 240, 243, 587, 589	in situ measurement, 94
	industrial effluent, 468
gas conditions	industry, 496
clean, 209, 218, 224, 261, 289, 297, 302, 306, 336,	chemical engineering and processing
350, 352, 468, 530, 536	technology, 543
dirty, 57, 212, 213, 261, 290, 306, 352, 454, 461	mechanical engineering, 203, 302
gas flow measurement, 190, 191, 499, 536	nuclear, 362, 388, 407, 464, 465, 496,
blending, 536, 588	508, 515, 543
brewery, 543	plant, 204
burner flow control, 543	power plant, 456, 463, 465, 496
flare, 464, 540	process, 301, 496, 536
flue, 543	pulp and paper, 203, 387, 388, 468, 496, 587
high temperature, 436	semiconductor, 534, 536, 543
gases. <i>See also</i> air; steam	steelworks nitrogen and oxygen flows, 543
acetylene, 204, 310, 536	water, 203, 388, 463, 464, 465, 496, 587
ammonia, 204, 536	ink, 245
argon, 204, 302, 464, 536, 543	inventory control, 261
arsine, 536	
butane, 204, 310, 536, 587	kerosene, 245
carbon dioxide, 302, 310, 536	
carbon monoxide, 536	latex solutions, 388
chlorine, 204, 464, 536	leak detection, 464, 466, 543, 576, 612
coke-oven, 310	lime slurries, 468
ethane, 310, 536	liquids
ethylene, 310, 536	clean, 209, 218, 261, 289, 297, 302, 306, 336, 350,
fluorine, 536	352, 468, 496, 530, 536
freon, 536	conducting, 387
fuel gas, 310, 612	dirty, 57, 212, 213, 261, 290, 306, 352, 454, 461
HCFC22, 189	erosive, 387, 388
helium, 204, 302, 536, 543	general, 204, 538
HFC134a, 189	high pressure, 302, 306, 496, 587
high temperature, 436	high temperature, 302
	lubricity, 54, 55

Flowmeter Application Index

745

- metal, 362, 387, 404, 483, 623
- organic and inorganic, 240
- liquefied gases
 - CO₂, 350, 587
 - LPG, 253, 588t20.1
 - N₂, 350, 588t20.1
 - O₂, 350, 588t20.1
- low flows, 205, 229, 471, 530, 536, 538
- low head, 43
- low loss, 195
- lubricants, 240, 310, 466
- lubrication, 538
- medical, 228, 543, 589
- mercaptan odorant injection, 243
- metals, liquid, 362, 387, 404, 483, 623
- microfiltration, 538
- milk, 388
- mineral oil, 245
- molten sulphur, 588t20.1
- multiphase, 102, 259, 409, 508, 511, 514, 517, 522, 523, 524, 525, 526, 528, 587
- nitrogen purges, 540
- odorants into natural gas, 538
- odorisers, 612
- oil, 238, 302, 464, 515, 526
- oil-in-water/water-in-oil, 170, 171f6.6, 455, 514
- paints, 240, 245, 261, 468, 589
 - pigments in, 538
- paraffin, 205, 245
- paste, 245
- petrochemical raw materials, 446
- pharmaceuticals, 203, 388, 538
- pipeline leak detection. *See* leak detection
- pipeline management, 464
- plant
 - coal liquefaction, 587
 - dosing, 543
 - pilot, 243
- polymers, 240, 243, 388, 587, 588t20.1
- polypropylene, 237, 588t20.1
- polyurethane, 245
- porosity of rocks, 538
- potassium hydroxide, 588t20.1
- processes involving
 - chemical vapour deposition, 536
 - crystal growth, 536
 - diffusion, 536
 - ion implantation, 536
 - plasma etching, 536
 - sputtering, 536
 - thermal oxide, 536
- pulsating, 103, 201, 228, 326, 348, 454
- pulsation, 132, 223
- pulverized coal in nitrogen, 584
- radioactive flows, 388
- reagents
 - in fermenters, 538
 - in pharmaceuticals, 538
- refinery flows, 310
- resin, 245
- samplers, 612
- sand, 362
- sanitary products, 302
- sewage, 388, 464, 468
- sludge, 213, 218, 388, 468, 543
- slurry, 56, 170, 213, 218, 362, 388, 468, 496, 587, 588t20.1
 - magnetic, 588t20.1
- soda, 388
- sodium hydroxide, 588t20.1
- solid-liquid, 212
- solvents, 240, 261, 587
- sour crude, 588t20.1
- space applications
 - rocket fuel and oxidiser metering, 466
 - space vehicle coolant, 466
- spray coatings, 388
- stack effluent, 543
- steam, 204, 446, 463, 464, 540, 543, 562
- tar, 205, 350
- tar sands, 588t20.1
- test rigs, 302
- thixotropic, 243
- titanium chloride closing, 538
- titanium dioxide, 587
- toothpaste, 388
- transfer standards, 590, 635. *See also* custody transfer
- unsteady. *See* pulsating
- utilities, 357, 474
- velocity, very low, 398, 450
- ventilation, 540
- viscous fluids, high, 243, 261, 457, 464
- waste air, 543
- water, 203, 240, 362, 388, 463, 464, 496, 524
 - distilled, 350
 - raw, 468
 - sea, 468, 588t20.1
 - sludge, 218, 388
 - sour, 587
 - waste, 203, 388, 464, 496
- water-in-oil. *See* oil-in-water/water-in-oil
- wax, 612
- wet-gas, 51, 139, 150, 171, 213, 214, 216, 217, 254, 255, 306, 334, 346, 352, 446, 464, 498, 513, 514, 520, 521t172, 641
 - correlation, 169, 170, 174–76, 215
- white liquor, 388