

Index

Page numbers in *italic* signify references to figures, while page references in **bold** denote references to tables.

- absolute filters 21, 24
- accreditation 42
- action limits 229
- active sampling *see* volumetric sampling
- aerosol tests 169–74
- airborne dispersion 288–95, 289
- airborne infection 12, 16
- airborne particle counters 179–81
- airborne particles 20, 25, 34, 35, 51, 133
 - concentration 63–4
 - counts 135, 137, 179–91
- airborne routes of transfer 206
- air change rate 62–4, **62**
- air cleanliness
 - classification 37, 43
 - grades 33, 34, **34**
- air conditioning 59, 59, 60, 61, 344
- air contamination 50
- air distribution system 60, 61
- air extract grilles 68
- airflow *see also* non-unidirectional airflow
 - cleanrooms *and* unidirectional airflow cleanrooms
 - between areas 69, 70
 - control 68–9, 151–65
 - direction 130, 132–3, 161–2, 161
 - in containment rooms 100
 - supply rate 143, 144
 - velocity 76, 77, 91, 119, 135, 141–3, 161–2, 161
 - visualisation tests 136
- airlocks 72, 101, 205, 215, 273–9
 - temporary 283
- air movement *see* airflow
- air pressure; *see also* pressurisation
 - across filters 119–20
 - measurement of differences 135, 145–9
 - monitoring 137
- air pressure difference tests 135
- air quantities 139–45
- air-raid shelters 16
- air sampling 186, 187, 193–7
- air showers 73–4
- air supply 61–8, 132
 - plenums 85
 - rate 59
 - volume calculations 144–5
 - volume monitoring 137
- air transfer disciplines 237–8
- air velocity tests 135
- air visualisation techniques 91
- air volume measurement 142–4
- air volume measuring hoods 142–3, 143
- alcohols 343
- alert limits 229
- allergies 234
- American Society of Heating Refrigeration and Airconditioning Engineers (ASHRAE) 133
- ancillary cleanrooms 71–4
- anemometers
 - multidirectional 161
 - thermal 141–2, 141, 162
 - use in non-unidirectional airflow
 - cleanrooms 144
 - vane 140–1, 140
- antiseptic method 14
- antistatic straps 311, **311**
- antistatic treatment 302
- army barracks 16
- as built* classification 32, 64, 115, 134, 163, 184, 193

- aseptic processing 15, 15, 37–9, 46
ASHRAE *see* American Society of Heating
Refrigeration and Airconditioning
Engineers *at rest* classification
32, 34, 36, 37, 134, 163, 184, 193
autoclaves 285, 304
automatic overhead handling systems 92
- bacteria 2, 16, 18, 293, 294, **308**; *see also*
micro-organisms
bag-type filters 65, 169
ballroom-type cleanrooms 82, 83, 84
barrier gloves 321
batteries 60
bead thermistors 142
behaviour 239–47
benches 274–9, 275–8, 352
 crossover 71, 259, 352
best estimates 222
biocontamination 44
blow-fill technology 39
body boxes 202, 307–8, 307, **308**
boiling 12, 15
British standards 45
British Textile Technology Group 312
Brownian motion 122, 327
brushes 331
- calibration 49, 228
carbolic acid 12
catalytic photo-oxidation 128
ceiling blanks 84, 85, 103
ceiling diffusers 21, 66, 66, 67; *see also*
diffusers
ceiling grids, 127, 127
ceilings 110, 111
Center for Drug Evaluation and Research 46
centrifugal air samplers 195, 196
changing areas 57, 71–4, 72, 106, 215, 253,
257–9
Charnley-Howorth 'greenhouse' 17–18,
17, 18
Charnley, Professor Sir John 16–18
- Chartered Institute of Building Services
Engineers (CIBSE) 133
chemical contamination 1, 3, 5, 39–40, 44,
112, 128, 206, 233–6, 271, 324
chlorine-based disinfectants 342
CIBSE *see* Chartered Institute of Building
Services Engineers
classification
 as built 32, 64, 115, 134, 163, 184, 193
 at rest 32, 34, 36, 37, 134, 163, 184, 193
 of airborne chemical contamination
 39–40, 44
 of airborne particulates 34, **34**, 35
 of air cleanliness **37**, 43
 of areas **37**, 345, 346, 351, 352
 of cleanrooms 33–40, 51
 of filters 124, 125, **125**
 of surface chemical cleanliness 44
 operational 32, 34–7, 64, 77, 134–5,
 163, 184, 185, 193
 standards 25–40
class limits 26, **28**
clean air devices 44, 49
clean air hoods 44
clean-build 112–16
clean construction protocol 113–15
clean down facilities 115–16
cleaning 327–56
 equipment 353
 frequency of 352–3
 implements for 331–9
 liquids 339–43, 353
 materials 25, 269
 methods 328–31, 343–50, 346, 353
 over-active 344
 programmes 350–4
 reasons for 327–8
 staff 344, 352
 standards 25
 testing 353–6
 time spent on 353
cleanliness recovery rate 162–4
Cleanroom Housekeeping Operating and
Monitoring Procedures 343

- cleanroom tunnel 83, 84
- closed isolators 34
- clothing 8, 114, 205, 215, 216, 220, 287–331, 287
 - allergies to 235
 - change areas 71–4, 72, 205
 - choice of 300–1
 - comfort 301–2
 - construction 299–300
 - cotton 16, 290, 291
 - designs 295–7, 308
 - fabrics 251–2, 297–9
 - for surgery 13
 - frequency of change 305, **305**
 - occlusive 5, 5, 18
 - of cleaning staff 344
 - processing 302–5
 - recommended configurations **300**
 - standards 25
 - static-dissipative properties 310–12
 - storage 73
 - under cleanroom garments 252
 - worn by technicians 249
- Clo Values 302
- cold aerosol generators 170–1
- collection efficiency 228
- comfort indexes 302
- commissioning 140
- compliance 134–6
- construction 8, 9, 21
 - conventional techniques 105–7
 - materials 8, 21, 59, 70–1
 - methods 103–10
 - modular 107–9
 - of cleanrooms 9, 59, 43
 - of high efficiency filters 118
 - work sequence 115
- contact plates 202
- contact routes of transfer 206
- contact strips 200, 200
- contact surface sampling 199–200
- containment leak testing 132, 136, 151–3
- containment zones 99–102
- contaminants 266
- contamination
 - airborne 39–40, 44, 50, 76, 87, 128, 198–9, 217–21, 265–6
 - chemical 1, 3, 5, 39–40, 44, 112, 128, 206, 233–6, 271, 324
 - control 1–3, 16, 49, 53, 113, 152, 208–25
 - dispersion 63, 79–81, 80, 308
 - electrostatic 271
 - from machines 216
 - generation 2
 - microbial **36**
 - monitoring of sources 225–9
 - risk management 203–31
 - surface 40, 50, 87, 95, 221–5
 - transfer equations 209–10
- continuous manufacturing processes 96
- continuous monitoring apparatus 181–4
- conventional building techniques 105–7
- cooling capabilities 133
- cosmetics 235, 256
- cotton 16, 290, 291
- coveralls 258–9, 263
- cracks 71, 104
- critical areas 38, 59, 133, 159, 160, 208, 216–17, 228, 345–6, 347, 350–2
- crossover bench 71, 259, 352
- cumulative measurement method 180
- damp wiping 330–1, 344
- decay rate 162
- decomposition 12
- deep-pleated filters 118, 118
- DEHS *see* diethylhexyl sebacate
- demolition of walls 281–2
- design
 - of cleanrooms 9, 25, 43, 49, 57
 - standards 25
- detergents 303
- diethylhexyl sebacate (DEHS) 170
- differential pressure tests 145–9
- diffusers 16, 21, 58, 65–8, 66, 67, 144, 175

- diffusion 121, 122
- dioctyl phthalate (DOP) 123, 170
- dioctyle sebacate (DOS) 123
- disciplines 8, 233–50
- discrete-particle counters 174, 179
- disinfectants 14, 20, 95, 104, 247, 302, 334, 341–3
- properties **342**
 - rotation of 343
 - testing 356
 - toxicity 341–2
- dispersion chambers 306
- dispersion from the mouth 315–17
- dispersion rate 63, 310, **310**
- documentation 50, 54–5, 231, 268, 351, 354
- door closing devices 237, 238, 239
- door handles 238
- doors 69, 109
- DOP *see* dioctyl phthalate
- DOS *see* dioctyl sebacate
- double door transfer chambers 95, 95
- double gloves 225
- droplet nuclei 316
- dry finishing 105
- drying out 114
- dry vacuuming 329–30, 329, 332–3, 344, 347
- dump system 67, 67, 68
- electro-dissipative construction materials 103
- electronic manometers 147, 148
- electrostatic charges 50, 105, 310, 328
- electrostatic contamination 271
- electrostatic discharge 324
- emergency exits 237, 277, 280, 281
- engineering industries 19
- enterozoal infections 12
- entrance zones 253, 259–62
- equipment 268–9
- ESPC *see* European Sterile Products Confederation 53
- ethanol 340, 343
- ethylene oxide 304
- EU GGMP *see* European Union Guidelines to Good Manufacturing Practice
- European Standard EN 1822 124, **125**
- European Sterile Products Confederation (ESPC) 53
- European Union Guidelines to Good Manufacturing Practice (EU GGMP) 33–6, 46, 301
- Eurovent 4/4 testing method 124
- exit changing procedures 262–3
- extractables 337
- extract quantities 132
- fabrics 16, 297–9, 306–12
- facemasks *see* masks
- Failure Mode and Effect Analysis (FMEA) 204
- Failure Mode and Effect and Criticality Analysis (FMECA) 204
- fans 60
- FDA *see* Food and Drug Administration
- fibres 32
- filter holders 353
- filter housing gel seal method 168–9, 169
- filter housings 126–8
- filter installation leak tests 132, 167–77
- filter integrity leakage tests 136
- filters 1, 7, 31, 59, 61, 63–5, 117–28, 167–77
- absolute 21, 24
 - bag-type 65, 169
 - classification 124, 125, **125**
 - construction 118–20
 - deep-pleated 118, 118
 - efficiency 122, 123, 125
 - HEPA filters *see* High Efficiency Particulate Air filters
 - in typical air conditioning plant 60
 - in vertical unidirectional airflow cleanroom 76
 - mini-pleat 119, 119
 - positioning 65
 - pressure across 119–20
 - terminal 65
 - testing 50, 123–6, 167–77

- ULPA *see* ultra low penetration air filters
- filtration media 50, 120, 120, 126
- final super clean 112, 113
- finger cots 48, 320–1
- finger dabs 202
- finishes 70–1, 103
- flash points 340
- floor grilles 21
- flooring 74, 106, 110, 255
 - tacky 350
 - metal grating 24
 - terazzo 16, 20
 - vinyl-covered 21
- floor scrubbing systems 338
- fluid seal systems 128
- FMEA *see* Failure Mode and Effect Analysis
- FMECA *see* Failure Mode and Effect and Criticality Analysis
- foggers 158
- folding area 304, 304
- Food and Drug Administration (FDA) 37–9, 45, 46
- footwear covering 256
- forceps 241, 241
- formers 322, 323
- forms 50
- framed wall systems 107–8
- furniture 268–9

- gamma radiation 304
- garment bags 263
- garments *see* clothing
- garment systems 48
- gasket leaks 168, 168, 175
- gas-phase adsorber cells 49
- gauntlets 98; *see also* gloves
- general zone 345, 346, 346, 350, 351, 352
- glass slides 355
- glazing 109
- glove boxes 34
- glove ports 96
- gloveboxes 44

- gloves 8, 14, 15, 48, 98, 205, 225, 240, 258, 261–2, 320–6
 - heat resistant 325
 - manufacturing of 322–3
 - natural/synthetic 324–5
 - polythene 325
 - polyvinyl chloride 324
 - reactions to 321–2
 - selection 323–5
 - testing 325–6
- goggles 260, 260, 319
- GoreTex 299, 309, 310
- gowns 14, 15, 245, 258–9, 288
- gyroscope production room 20
- gyroscopes 21

- HACCP method *see* Hazard Analysis and Critical Control Point method
- half suits 96, 96, 98
- hand contamination control 320–1
- handkerchiefs 246
- handling materials 247–8
- hand washing system 256, 258
- hangers 73
- hatches 283–5, 284
- hats 14
- hay fever 235
- Hazard Analysis and Critical Control Point (HACCP) method 204–5
- hazard analysis *see* risk assessment
- hazards 226, 226–7, 228
- healthcare industry 5
- heating capabilities 133
- heavy machinery 279–83
- HEPA filters *see* High Efficiency Particulate Air filters
- High Efficiency Particulate Air filters (HEPA filters) 20, 21, 48–51, 65
 - compared with ULPA filters 120
 - fitting 114, 115
 - in RABS 97
 - removal efficiency curve 122, 123
 - use in cleanrooms 117
- high-intensity light 355

- hip replacement surgery 17
- holding isolators 96
- hoods 44, 142–3, 142
- horizontal unidirectional airflow cabinet 80, 88
- horizontal unidirectional airflow cleanrooms 78–81
- hospitals 2, 12, 288; *see also* operating rooms
- hot air ovens 285
- Howorth, Hugh 16–18
- humidifiers 60
- humidity 2, 133
- hydrogen peroxide 99

- ICCCS *see* International Confederation of Contamination Control Societies
- ICEB *see* International Cleanroom Education Board
- ice-spray methods 268, 329
- ido-propanol 343
- IEST *see* Institute of Environmental Sciences and Technology
- impaction 121, 122
- impaction samplers 194
- inches water gauge 145
- inclined tube manometers 146, 146
- indicator lights 239
- inertial impaction samplers 194–5, 196
- infection 12, 16
- infiltration problems 152–3, 153
- information sources 41–55
 - books 46–7
 - documents 54–5
 - DVDs 53
 - International Confederation of Contamination Control Societies (ICCCS) 41–2
 - International Cleanroom Education Board (ICEB) 42
 - Institute of Environmental Sciences and Technology (IEST) 42, 45, 47–53
 - journals and magazines 52–4
 - standards 43–6
 - videos 53
- Institute of Environmental Sciences and Technology (IEST) 45, 47–53, 124, 297
- instrumentation 19
- interception 121, 122
- interlocks 239
- interlock timers 95
- International Cleanroom Education Board (ICEB) 42
- International Confederation of Contamination Control Societies (ICCCS) 41–2
- International Organization for Standardization (ISO) 25, 28–30, 29, 30, 32, 38–40, 43–5, 129–30, 133–7
- irritant contact dermatitis 322
- ISO-AMC descriptor format 39
- isokinetic sample heads 35
- isolators 36, 38–9, 44, 88, 89, 91, 92–6, 93, 268

- jewellery 235–6, 256

- labelling 268
- Laskin nozzles 170–1
- latex 321–2
- laundries 302–4, 303, 304
- leaks 104, 109, 143, 151–3
 - repairs to 177
 - testing for 5, 125, 167–77, 167
- light fittings 110
- lighting 2, 21, 133
- linting 297
- Lister, Joseph 11, 12, 14, 15
- Lister steam spray 12, 13
- local efficiency 125
- locker rooms 21
- lockers 71, 73
- London–van der Waals force 328
- Macewen, Sir William 14
- machinery 279–83
- macroparticles 32, 51
- magnehelic pressure gauge 147, 147

- maintenance 248–50
- manifold monitoring system *see* sequential monitoring system
- manometers 146, 146, 147, 148
- masks 8, 14–16, 205, 258, 315–19
 - veil-type 319, 319
- materials
 - choice of 266–9
 - from outside manufacturers 270–1
 - production 266–8
 - transfer of 57, 273–9, 279, 280
 - transportation 271–3
 - wrapping 271–3
- mats 254, 255, 262, 274, 278, 350
- measurement
 - cumulative method 180
 - of aerosol penetration 173–4
 - of macroparticles 51
 - of micro-organisms 44, 193
 - of particle concentrations 185–7
- measuring hoods 142–3, 142
- Medical Research Council 18
- medications 235
- medicinal products 33
- membrane filtration sampling 197
- method statements 250
- microbes
 - concentrations 133
 - contamination limits 36
 - dispersion 293–5, 315, 315
 - sampling 193–202, 228
- microbiological action levels 37
- microbiological containment room 100
- microbiological monitoring 36, 137
- microbiological safety cabinets 100–1, 101
- microbiological warfare 16
- microelectronics 50, 71–2, 310
- micro-organisms 1, 5, 100, 104, 105; *see also* bacteria
 - airborne dispersal 16
 - measurement 44
 - on clothing 304–5
 - sampling 193–202
 - screening personnel for 234
 - sources 293
- microprocessors 4
- microspheres 172, 173
- mini-environments 44, 50, 83, 84, 88, 89–92, 109, 268
- mini-pleat filters 119, 119
- mixed airflows 134
- modular construction 107–9
- monitoring 8, 9, 49, 136–7
 - continuous 181–4
 - microbiological 36, 137
 - of contamination sources 225–9
 - of RMC system 230
 - of standards 9
 - sequential system 181–2, 182
 - simultaneous system 181, 182, 183
- mopping 331, 333–6, 333, 334, 344, 348, 348, 349
- most penetrating particle size (MPPS) 122, 124, 125
- mouse holes 96
- MPPS *see* most penetrating particle size
- multidirectional anemometers 161
- multiple nozzle aerosol generators 171
- nanotechnology 4, 5
- nanotubes 4, 5
- nebulisers 158, 159
- neoprene gasket sealing 126, 127
- non-unidirectional airflow cleanrooms 6, 6, 7, 16, 25, 58–71
 - air movement control in 154
 - ceilings 110
 - filter leaks 125
 - measurement of air quantities in 143
 - smoke testing in 159
 - testing 134, 159
 - ventilation 58
- Norden bombsights 19, 19
- no-touch techniques 240, 241, 242
- occupancy states 32, 34, 36, 37, 115, 134, 163, 184–5, 193

- off-gassing *see* outgassing
- Ogston, Sir Alexander 12, 13
- operating rooms 5, 5, 12, 13, 14, 14, 287, 288
- ventilated 16–18
- operational classification 32, 34–7, 64, 77, 134–5, 163, 184, 185, 193
- operation of cleanrooms 35, 36, 44, 49, 50, 203–31
- optical particle counters 49, 355
- optical surfaces 105
- optional tests 136
- organic compounds 51
- outgassing 51, 103, 105, 111–12, 172, 267, 324
- outside manufacturing sources 270–1
- overall efficiency 125
- packaging 51, 114, 216, 270, 271–3, 273
- removal 272, 273, 273
- painting 106
- paint-spray operations 50
- panels 281
- PAO *see* poly-alpha olefin
- Parenteral Drug Association (PDA) 53, 54
- particle counters 35, 124, 153, 171–4
- discrete 174, 179
 - for airborne particles 179–81, 181
- particle-generating operations 250
- particles
- aerodynamics 16
 - airborne *see* airborne particles
 - class limits 26
 - concentrations 28–31, 28, 31, 185–7
 - contamination of semiconductors by 4
 - counting 135
 - diameters 27, 27
 - dispersion 239–40, 240, 288–95, 289, 310, 310, 315, 315, 316, 316
 - in cleaning solutions 340
 - measurement 326
 - obstruction of nanotubes by 4, 5
 - particle removal efficiency 122, 123, 125
 - removal mechanisms 120–3, 121
 - standards 25
 - surface 40, 44
 - ultrafine 32, 33, 51
- pass-through hatches 239
- pass-through washers 303
- Pasteur, Louis 12
- PDA *see* Parenteral Drug Association
- perfumes 235
- personal hygiene 235, 252
- personnel
- as source of contamination 205
 - cleaning 352
 - entry and exit of 251–63
 - movement 239–40
 - procedures 50
 - sampling 202
 - service 248–50
- Petri dishes 198
- Pharmaceutical and Healthcare Sciences Society (PHSS) 54
- pharmaceutical cleanrooms 33–9
- pharmaceutical manufacturers 193
- pharmaceutical production room 20
- pharmaceutical standards 45–6
- phenols 12, 342
- photoelectron ionisation 128
- photometers 171, 173–4, 174, 176, 355
- PHSS *see* Pharmaceutical and Healthcare Sciences Society
- phthalates 111
- pipng 116
- piston effect 16, 17
- plasterboard 104, 106
- plastering 105
- plasticisers 111
- point-of-use system 183, 183 *see also*
- simultaneous monitoring system
- poly-alpha olefin (PAO) 123, 170
- polyesters 298, 298, 299
- polyvinyl chloride gloves 324
- powered exhaust headgear 319, 320
- pre-change zone 253, 255–7

- pre-filters 120, 122
- pressure *see* air pressure
- pressurisation 59, 68–9, 70, 92, 103, 139, 152, 215; *see also* air pressure
- process tunnels 69
- prohibited items 236–7
- prohibited materials 250

- quaternary ammonium compounds 343
- Quats *see* quaternary ammonium compounds

- RABS *see* restricted access barrier systems
- radioactive substances 101
- rate of particle dispersion test methods 355
- raw materials 216
- Recommended Practices 47–51
- recovery tests 136, 151, 162–5
- re-entry 263
- removal efficiency curves 122, 123, 125
- replicate organism detection and counting (RODAC) dishes 199, 200
- respiratory conditions 234
- restricted access barrier systems (RABS) 88, 89, 97–9, 97, 98, 109, 134
- re-testing 134
- rings 235, 236, 252, 256
- risk
 - assessment 208–25, 231
 - definition 210–11
 - descriptors 211–12
 - diagrams 206–8, 207
 - management 203–31
 - scoring 211–12, 212
- Risk Management of Contamination (RMC) system 204–31
- RMC system *see* Risk Management of Contamination system
- robotic manipulation 244
- RODAC dishes *see* replicate organism detection and counting dishes
- rubbish bins 350
- Rules Governing Medicinal Products in the European Union, The 46

- safety cabinets 100–1, 101
- saliva 316–17
- sampling
 - air 186, 187, 193–7
 - for cleanroom classification 32
 - frequency 227–8
 - impaction 194
 - limits 229
 - methods 228–9
 - microbial 193–202, 228
 - of personnel 202
 - probes 175, 176
 - sequential 51
 - settle plate 193, 197–8
 - surface 199–201
- Sandia Corporation 26
- Sandia Laboratories 21, 23
- scanning 175–6
- scan testing 125–6
- screening 121, 122
- scrubbing 15
- sealing 104
- self-closers 109
- separative devices 87–99, 220
- separative enclosures 44
- sequential monitoring system 181–2, 182
- sequential sampling 51
- service chases 83, 84, 90, 90, 91
- service personnel 248–50
- services 8
- settle plate sampling 193, 197–8
- Shell Ondina EL mineral oil 170
- shoe cleaners 254, 255
- shoe coverings 302
- short circuits 4
- sieving *see* screening
- silicon wafers 91, 92, 355
- simultaneous monitoring system 181, 182, 183
- skin 234, 290, 293, 294
- SMIF *see* Standard Mechanical Interface Format
- smoke alarms 175
- smoke generators 156, 156, 157

- smokers 236
- smoke visualisation tests 145, 156–60
- soil areas 302
- solvents 104, 334, 339, 340
- SOPs *see* standard operating procedures
- sorbency 337
- sound 50
- sound control 2
- sound levels 133
- spare parts 249
- sponges 333
- squeegees 339, 350
- staff *see* personnel
- stainless steel 20
- Standard Mechanical Interface Format (SMIF) 91–2, 92
- standard operating procedures (SOPs) 350
- standards
 - British 45
 - cleanroom classification 25–40
 - clothing 25
 - design 25
 - history 25–6
 - international 43–5
 - in the USA 45
 - monitoring 9
 - operating procedures 25
 - pharmaceutical 33–9, 45–6
- staphylococci 12
- sterile drug products 37–9
- sterilisation 36, 98, 99, 251, 299, 302, 304, 331, 334
- sterilisers 285
- sterilising tunnels 92
- sticky tape 355
- storage 248, 269, 270
 - temporary 115–16
- straining *see* screening
- streamers 155–6, 155
- streptococci 12
- studless wall systems 107
- substrates 50
- supervision 248
- supplier audits 270
- supply tunnels 145
- supporting clean areas 38
- surface chemical cleanliness 40, 44
- surface concentration tests 354
- surfaces
 - cleanliness 50, 246, 246, 347–8
 - contamination 40, 50, 87, 95, 221–5
- surfactants 340, 341
- surgical-style masks 318, 318
- swabbing 201, 201
- synthetic fibres 288, 292

- tacky mats 350
- tacky rolling 331, 338, 338
- technology 8–9, 8
- temperature 2, 133
- temporary airlocks 283; *see also* airlocks
- temporary storage 115–16
- temporary transfer areas 114
- terminal filters 65
- terminal sterilisation 36
- terrazzo flooring 16, 20, 110
- testing 115, 129–36
 - additional 135
 - cleaning 353–6
 - for leaks 5, 125, 167–77, 167
 - IEST recommended practices 124
 - methods 43
 - of clean-air devices 49
 - of cleanrooms 8, 9, 49
 - of clothing 306–10
 - of disinfection 356
 - of filters 50, 123–6, 167–77
 - of gloves 325–6
 - optional 136, 153
 - principles 130–1
 - reasons for 129
 - schedule 134, 135
- tests
 - containment leak 132, 136, 151–3
 - filter installation leak tests 132, 167–77
 - filter integrity leakage tests 136
 - recovery 136, 151, 162–5
 - smoke 145, 156–60

- surface concentration 354
- visualisation 132, 145, 151–62
- thermal aerosol generators 171, 172
- thermal anemometers 141–2, 141, 162
- three-bucket mopping system 334, 335, 336
- tools 249, 269
- training 50, 231, 234, 248, 351, 354
- transfer areas 228
- transfer-docking device 92, 93, 93, 94
- transfer tunnels 96
- trolleys 278–9
- two-bucket mopping system 334, 335
- types of cleanrooms 6–8, 75–7
- Tyvek 299
- ULPA filters *see* ultra low penetration air filters
- ultrafine particles 32, 33, 51
- ultra low penetration air filters (ULPA filters) 48, 49, 50, 65
 - compared with HEPA filters 120
 - fitting 114, 115, 117
- ultrasonic baths 268, 329
- ultra-violet light 355
- unidirectional airflow cabinets 87, 88
- unidirectional airflow cleanrooms 6–8, 7, 17, 18, 23, 25, 26, 75–85, 98
 - air movement control 154
 - ceilings 110
 - filter housings in 127–8
 - filter leaks in 126
 - horizontal 78–81
 - measurement of air quantities in 143
 - testing 134, 159–60, 176–7
 - types 75–7, 76
 - vertical 75–8, 76, 83
- unidirectional airflow devices 5, 87–9
- unidirectional flow clean-air devices 48
- unidirectional ventilation 21
- vacuuming 329–30, 329, 332–3, 332, 344, 347
 - vacuum wands 244
 - van der Waals forces 121
 - vane anemometers 140–1, 140
 - vapour sterilisation 98
 - veil-type masks 319, 319
 - ventilation
 - early industrial 20
 - for contamination control 16
 - in operating rooms 16–18
 - laminar air 21
 - methods 6
 - plant 78
 - unidirectional 21
 - vertical unidirectional airflow enclosure 88, 89
 - vibration 2, 50, 82, 133
 - viewing windows 234
 - vinyl sheet flooring 110
 - visualisation tests 132, 145, 151–62
 - volumetric air sampling 193
 - wall extracts 77, 78
 - wall panels 107, 108
 - washing 247
 - water penetration 104
 - water vapour permeability 302
 - wear 306
 - wet pick-up 344, 350
 - wet vacuuming 330, 332, 332
 - whistling 69
 - Whitfield Ultra-Clean Room 23
 - Whitfield, Willis 21, 22, 23, 26
 - whole clothing system tests 306
 - windows 109
 - wipers 248, 336–7, 337, 348, 348, 349, 349, 350, 355
 - wiping materials 48
 - wrapping 271–3; *see also* packaging
 - Wrightington Hospital, Manchester 16
 - yashmak-type masks *see* veil-type masks