
Index

- acoustical environment 7
- active thermal storage 202–4, 221
- activity level, and comfort 8, 35–6
- actuator 75, 168
- adiabatic process 18, 32
- air-and-water systems 26–7
- air-conditioning systems
 - basic system 20–4
 - choice of system 27–30, 32, 82, 87
 - components 20–2, 32, 87
 - controls 27
 - definition 4
 - economizer cycle 22–4, 32, 93
 - processes 3–4, 9
 - rooftop units 85–8, 90
 - single-zone systems 72–3
 - split systems 88–9
 - system performance requirements 83–5, 90
 - window air-conditioners 4, 27, 79–80, 112
 - zoned systems 24–7, 32
- air distribution systems 213–17, 221
- air handlers *see* single zone air handlers
- air inlet 74–5
- air quality, and comfort 6–8, 47–9, 60
- air-side economizers 190–1, 196
- air speed, and comfort 38, 41
- air temperature
 - and comfort 37
 - mixed-temperature sensor 75
 - variations 42
- all-air systems 24–5
 - advantages 93–4
 - bypass box systems 98–9
 - disadvantages 94
 - dual-duct systems 99–100, 101
 - dual-duct variable air volume systems 104–5
 - dual path outside air systems 105
 - multizone systems, 102–3
 - reheat systems 25, 94–6, 106
 - three-deck multizone systems 103
 - variable air volume (VAV) system 26, 104–5
- all-water systems 27
- analog electronic controls 156
- analog input and output 165
- art work preservation, HVAC systems 6
- ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)
 - ASHRAE/IESNA Standard 90.1–2004 *Energy Standard for Buildings Except Low-Rise Residential Buildings* 3, 168, 175, 179, 183–6
 - Guideline 13–2000 *Specifying Direct Digital Control Systems* 175
 - psychrometric chart 12–20
 - Standard 135–2004 *A Data Communication Protocol for Building Automation and Control Networks* 173
 - Standard 52.1–1992 *Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices* 50
 - Standard 52.2–1999 *Method for Testing General Ventilation Air Cleaning Devices for the Removal Efficiency by Particle Size* 51
 - Standard 55–2004 *Thermal Environmental Conditions for Human Occupancy* 35

ASHRAE (*Continued*)

- Standard 62 *Ventilation for Acceptable Indoor Air Quality* 54–9
- Standard 62.1–2004 *Ventilation for Acceptable Indoor Air Quality* 46, 54–9
- Standard 62.2–2004 *Ventilation and Acceptable Indoor Air Quality in Low Rise Residential Buildings* 46, 54
- axial fan 78
- BACnet 173
- bag filter 52, 53
- barometric dampers 194
- boilers
 - central plant 140–2, 145
 - condensing boiler, 187
 - replacement 144, 183
 - steam boilers 125, 145, 152
 - two boiler system 144–5
- boreholes 211
- breathing zone 55
- building design
 - and air-conditioning 28
 - and energy conservation 179–83
- bypass box systems 98–9
- bypass damper 98
- carbon dioxide 57–9
- carbon monoxide 47
- carcinogens 48
- ceiling plenum 99
- ceilings, radiant heating and cooling 198
- central plants 139–52
 - boilers 140–2, 145
 - chillers 145–8
 - comparison with local plants 140–2
 - cooling towers 148–51
- centrifugal compressor 146
- centrifugal fan 78
- changeover system, fan coils 116
- chilled water system 133–4, 171
- chilled water, storage 205–8
- chillers
 - central plant 139–42, 145–8
 - energy efficiency 142
- client issues 29
- climate
 - and dual-path systems 105
 - and economizer cycle 22–4, 32
 - effects of 4
 - and single zone air-handlers 87, 81
 - and thermal storage 201–11
 - and zones 62–9
- closed loop controls 158–60, 161
- closed water circuit 135, 136
- clothing, and comfort 8, 36
- Coanda effect 214
- Coefficient of Performance (COP), 185
- comfort
 - and environment 6–8
 - and indoor air quality 45, 47–9
 - see also* thermal comfort
- comfort cooling *see* air-conditioning systems
- comfort envelope 39, 40
- compressor, in refrigeration equipment 78
- computers *see* Direct Digital Controls (DDC)
- condensate, steam systems 123–5
- condenser, in refrigeration equipment 78
- condenser water 134–6, 140, 146
- condensing boiler 130, 187
- contaminants
 - filtration 50–3
 - health effects 47, 48, 54
 - indoor air quality 46, 47
 - source control 49–50
- control logic 76, 163
- controlled device 160
- controlled variable 159
- controller 160
- controls
 - basics 156–61
 - choice of 155
 - closed loop 158–60
 - Direct Digital Controls (DDC), 156, 163–8, 172–5
 - economizers 190
 - electric 155
 - electronic 156
 - languages 172
 - open loop 160–1
 - pneumatic 156
 - self-powered 155
 - thermal storage 198
 - time control 161

- convection heating 110–13
- cooling
 - evaporative cooling 192–4
 - radiant cooling 113, 198–201
- cooling coil 18, 22, 77
- cooling towers 78, 135–6, 140, 148–51
- costs 29, 186, 204

- dampers
 - in air-conditioning system 20, 74–5
 - bypass damper 98
- data gathering panel (DGP), 174
- dead band 113, 163
- decoupled outdoor air systems 217–20
- dehumidification 105
- desiccant wheels 189–90
- dew point temperature 13
- digital/binary input and output 164
- dilution ventilation 54
- Direct Digital Controls (DDC) 156, 168–75, 210
 - inputs and outputs 163
 - naming conventions 165
 - sequence of operations 165–8, 171
 - single zone air handlers 168–72
 - system architecture 173–5
- direct evaporative cooling 192–4
- disease, and air quality 47–8
- displacement ventilation 214
- drafts 41
- drift eliminators 149
- dual-duct systems 99–102
- dual-duct variable air volume
 - systems 104–5
- dual-path outside air systems 105, 220
- dust spot efficiency 51

- economizers
 - air-side economizers 190–2
 - economizer cycle 22–4, 32, 93
 - water-side 190–2
- electric controls 155, 156
- electricity, costs, 77, 204
- electric thermal storage (ETS) heater 202
- electronic controls 156
- electronic filter 52
- energy conservation
 - air-side economizers 190–1
 - ASHRAE/IESNA Standard 90.13, 183–6
 - building design 179–83
 - building pressure control 194
 - evaporative cooling 192–4
 - heat recovery 195
 - water-side economizers 190–2
- energy-cost budget method 186
- Energy Efficiency Ratio (EER), 185
- energy efficiency, hot water
 - systems 130–33
- Enthalpy 15–16, 32, 76
- entrained air 117
- environment, for human comfort
 - 6–8, 9
- evaporative cooling 192–4
- evaporator 79
- expansion valve 79
- expectations, and comfort 8, 37, 38

- fan coils 114–17
- fan, in air-conditioning system
 - 75, 78, 89
- farm animals, HVAC systems 11
- filters 20, 52–3, 76
- firing rate 144
- float and thermostatic steam trap 123
- floors
 - radiant floor 113, 114, 120, 130, 187, 198
 - surface temperature 42
- four-pipe system, fan coil 116
- frozen food storage, HVAC systems 5

- gain 158
- greenhouse gas emissions 3
- ground, heat source and sink 198, 211

- head
 - pressure 192
 - water flow 81, 135
- health, and air contaminants 48
- heating
 - hydronic systems 110–13
 - psychrometric chart 12–20
 - radiant heating 198–201
 - steam systems 122, 123–5, 137
 - water systems 122, 133, 137
- heating coil
 - in air-conditioning system 20, 76–7
 - fan coils 114–17, 121
- heat pipes 188

- heat pumps
 - air-to-air system 82
 - closed loop systems 120
 - ground source heat pumps 90, 118, 130
 - water source heat pumps 118, 121
- heat recovery 119, 142, 186, 195
 - desiccant wheels 189
 - heat pipes 178, 188
 - run-around energy recovery coils 187
- HEPA filter 52
- hospitals
 - ceiling panel heating 114, 201
 - dual-duct systems 100
 - filters 50, 76
 - HVAC systems 3
- hotels
 - expectations 8, 37
 - four-pipe fan-coil system 116
 - ventilation 55
- hot-water fan coils 116
- hot water systems 129, 130, 137
 - boilers 142–5, 152
 - energy efficiency 130, 179
- human comfort *see* comfort
- humidification, psychrometric chart 17–18
- humidifier, in air-conditioning system 22, 77
- humidistat 22, 69
- humidity
 - and comfort 5, 38, 43
 - dehumidification 4, 18–20, 105
 - relative humidity 13–15
 - and zones 62, 64
- humidity ratio (W) 12, 38
- HVAC (Heating, Ventilating and Air Conditioning)
 - history of 2–3, 8–9
 - system objectives 4–6, 9
- hydronic circuits 123
- hydronic systems 108–21
 - advantages 109
 - architecture of 122–38
 - control of 109, 111–13
 - disadvantages 109
 - fan coils 114–17
 - natural convection and low temperature radiation systems 109–13, 120
 - panel heating and cooling 113–14, 120
 - steam piping systems 125, 137
 - two pipe induction systems 117, 121
 - and ventilation 106, 109, 113
 - water piping systems 120, 140
 - water source heat pumps 118, 121
- ice, storage 204, 208
- IESNA (Illuminating Engineering Society of North America) *see* ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), ASHRAE/IESNA *Standard* 90.1–2004
- indirect evaporative cooling 192, 193
- individuals, and comfort 6, 8, 48
- indoor air quality (IAQ) 3, 45–60
 - contaminants 46
 - dilution 49, 53
 - filtration 50–2
 - source control 49–50
 - ventilation 45–60
- Induction Reheat Unit 95
- induction, two pipe induction systems 117, 121
- infiltration 14, 78, 117
- Integrated Part-Load Value (IPLV) 185
- Internet 27, 141, 173
- interoperability 173
- languages, controls 172–3
- latent heat 15, 17, 32, 84
- latent heat of fusion 205
- Leadership in Energy and Environmental Design (LEED) 186, 195
- legionella 48, 151
- lighting
 - and comfort 7
 - energy conservation 181, 185
 - and HVAC 7
- low-grade heat 186
- Low-Temperature Reheat Unit with Induced Air 95, 96
- mechanically conditioned spaces, comfort conditions 40
- MERV (Minimum Efficiency Reporting Values) 51–2, 116
- mixed temperature sensor, in air-conditioning system 75
- mixing chamber, in air-conditioning system 20

- modulating controls 156, 157
- mold, control of 47, 194
- multiple zone air systems 92–107
- multizone systems 102, 103

- offset 158, 176
- on-off controls 157
- on-off input and output 164
- open loop control system 160
- open water circuit 136
- outdoor air, dual-path system 105, 107
- outdoor reset 112, 130, 160, 161
- outside air damper, in air-conditioning system 20, 59
- overshoot 158, 176

- panel filter 52
- panel heating and cooling 108, 113, 120, 198
- passive thermal storage 202, 220
- personal environment model 7
- physical space, and comfort 9
- pipng, water systems 128–9
- pleated filter 53
- pneumatic controls 156
- pollutants *see* contaminants
- ponding, steam systems 125
- pressure
 - building pressure 194, 196
 - and zones 67
- proportional control 157, 158
- protocols 173
- psychosocial situation 8
- psychrometric chart 12–20, 31
 - acceptable temperature and humidity 41
 - cooling coil 19, 22
 - cooling towers 148, 153
 - design of 12
 - evaporative cooling 192
 - heating 16
 - humidification 17
 - relative humidity 13–15
- pump curve 128
- pumps
 - hot water systems 129–33, 137
 - water systems 137

- radiant cooling 201, 220
- radiant floor 113–14, 130, 198
- radiant heating
 - high temperature 198, 220
 - low temperature, 109, 120
- radiant temperature 37, 42
- radiators, heating system 110, 120
- radon 47
- reciprocating compressor 146
- recuperator 142
- refrigerant-based systems 27
- refrigeration
 - equipment 78–83, 89
 - history of 2
 - see also* chillers
- reheat system 25, 94, 106
 - Induction Reheat Unit 95
 - Low-Temperature Reheat Unit with Induced Air 95, 96
- relative humidity 13–15
- relief air 74
- reset
 - chilled water 182
 - heating 182
 - outdoor reset 112, 130, 160–1
- reset controller 161
- return fan 78
- rooftop units 85, 90
- room air distribution systems 213–17, 221
- run-around energy recovery coils 187

- safety issues, steam systems 122, 123, 137
- saturation line 13, 32
- saturation point 13
- seasonal efficiency 141, 152
- secondary air *see* entrained air
- self-powered controls 155
- sensible heat 15, 84
- sensor 160
- setpoint 160
- setpoint temperature 69, 160
- sick building syndrome 49
- single zone air handlers 71–90
 - components 73–8
 - direct digital control (DDC) 168–72
- solar gain 66
- solar heating, water 202

- spaces
 - attributes for comfort 6
 - and zones 63
 - speed of reaction 176
 - split systems 88, 90
 - standalone panel 166, 174
 - static lift 135
 - steam systems 122, 123–5, 137
 - boilers 142, 152
 - safety issues 125, 140
 - steam traps 125, 140
 - storage heater 202
 - stratified tank 221
 - system choice matrix 30, 32
 - system curve 128
 - system head 128
- Task/Ambient Conditioning system (TAC) 217
- temperature *see* air temperature; radiant temperature
 - thermal comfort
 - conditions for 6, 38, 43
 - definition 34
 - factors 35, 43
 - non-ideal conditions 41
 - non-standard groups 42
 - thermal storage 198, 201–11, 220
 - active 202
 - chilled water storage 205–11
 - controls 208
 - ice storage 208–11
 - passive 202
 - thermal variation, zones 66
 - thermostatic steam trap 123
 - thermostats 69, 114, 161
 - three-deck multizone systems 103
 - time control 161
 - timing, and zones 116
 - tobacco smoke 48, 53
 - transducer 156, 165
 - turn-down ratio 144, 152
 - Turn it off, Turn it down, Turn it in 183
 - two pipe induction systems 117, 121
- Under Floor Air Distribution (UFAD) 215
- unitary refrigerant-based systems 27
 - variable air volume (VAV) systems 26, 96–8, 104
 - controls 155
 - direct digital control (DDC) 163–8
 - dual-duct system 106, 107
 - variable input and output 165
 - ventilation
 - acceptable indoor air quality 60
 - air distribution 213–17, 221
 - and hydronic heating systems 113, 120
 - occupant-operated windows 41, 113, 212, 221
 - zones 66
 - vertical temperature difference 42
- water heating, passive 202
 - water piping systems 120, 140
 - chilled water systems 122, 133, 210
 - condenser water 134–6
 - hot water systems 130, 137
 - water-side economizers 191, 196
 - water source heat pumps 118, 121
 - water systems *see* hydronic systems
 - water vapor, humidity ratio 12
 - web server 175
 - wells 118, 211
 - window air-conditioners 4, 27, 112, 213
 - windows
 - and energy conservation 179, 183
 - occupant-controlled 212–13, 221
 - and zones 63
 - zone air distribution effectiveness 55, 56
 - zoned air-conditioning systems 24, 32
 - all-air systems 25, 99–102
 - see also* single zone air handlers
 - zones
 - control of 68–9
 - definition 62, 63
 - design 63–8