

## INDEX

### A

- Ackerman correction factor, 147
- Acoustic vibration (*see* Tube vibration)
- ACHE (*see* Air cooled heat exchanger)
- Agitated vessels, heat transfer to, 307
  - Process side coefficients, 310
  - service side coefficients, 307
- Air-cooled heat exchangers, **197-255**
  - air recirculation
    - problems with, 208
    - use for control, 228
  - alternatives to (*see* Cooling, options for)
  - assessment of offers, 233
    - bid comparison, 235
    - checking of designs, manual, 233
      - fan power, 234
      - heat transfer rate, 233
      - mean temperature difference, 233
      - noise claims, 234
      - process pressure drop, 234
    - computer assessment, 235
      - process flow distribution, 235
      - air flow distribution, 235
  - bays, 198
  - bundles, 198
  - choice of system, 205
    - ambient conditions, 211
    - economic factors, 205
    - layout, 208
    - noise, effect on choice of system, 209
    - process considerations, 207
    - site conditions, 209
  - cleaning
    - air side, 245
      - methods for, 245
      - preferred contractors for, 247
      - results of, 247
  - clearances, air side, 222
  - costs, 13 ; 206
    - preliminary estimate of, 249
  - control, 227 ; 231
    - air flowrate, 227
      - fan blade pitch, 227
      - fan speed, 227
      - louvres, 228
    - air temperature, 228
    - combined units, control of, 229
    - natural convection performance, 230
    - process fluid, 227
    - weather, effect on control, 229
  - corrosion, 236
    - protective coatings, 226; 237
    - sacrificial tubes, 226; 237
  - description of, 197
  - design margin, 211
  - design methods, 13
  - dimensions, 13
  - fans, 199
    - blade pitch, use for control, 228
    - characteristics, 223

- use for air flow measurement, 243
  - maintenance of, 247
- fan drives, 199 ; 223
  - maintenance of, 247
  - variable speed, 227
- maintenance of, 247
- finned tube for
  - corrosion, 219
  - dimensions, 222
  - elliptical finned tubing, 221
  - temperature limitations, 222
  - types, 219
- fire relief, 230
  - assessment of necessity for, 230
  - heat input
    - estimation of, 232
    - means of reduction, 232
  - required relief rate, 232
- forced draft arrangement, 200 ; 225
- fouling, 12
  - air side, 225 ; 235
  - process side, suggested values
    - for preliminary sizing, 250
- headers, 198 ; 223
  - tubeside access for maintenance, 248
- heat balance, use for air flow
  - measurement, 244
- induced draft arrangement, 200 ; 225
- inspection maintenance & repairs, 12
- louvres, 200
  - use for control, 228
- maintenance, mechanical, 247
  - fans, 248
  - fan drives, 248
  - tubeside access for, 248
- maldistribution in, 238; 240
- manifolds, 200
- materials of construction, 12 ; 218
- natural convection performance, 230
- noise, 209 ; 223 ; 245
- operating limitations, 12
- options for cooling
  - (*see* Cooling, options for)
- performance testing, 237
  - air side measurements, 240
  - air flow, 241
    - anemometer method, 241
    - fan characteristics, 243
    - heat balances, 243
    - tracer method, 242
  - air humidity, 244
  - pressure measurements, 244
  - temperatures, 240
- maldistribution
  - process flow, 239
- mechanical checks, 239
- noise, 244
  - preparation for, 239
- plenum chambers, 198 ; 200
- pressure drop, process, 213
- pressure relief (*see* Fire relief)
- safety & reliability, 12
- size, estimation of, 249
- specification, 211
  - altitude, effect on design of, 214
  - ambient conditions for design, 213
  - air temperature, 213
    - frequency charts for, 215-217
    - variation over the day, 218
  - arrangement, 224
  - design margins, 211
  - economic factors, 226
  - fouling, 225
  - noise, specification for design, 223
  - physical properties, 214
  - pressure drop, 213
  - standard specifications, 218
  - thermal duty, 211
- steam coils, 200 ; 207 ; 228
- suitability, 200
- terminology, 197
- types of duty, 12
- weather, effect on control, 229
- 'winterization', 229
- Alfa-Laval, 16 ; 137
- Anemometer, use for air flow
  - measurement in ACHE, 241
- Annular distributor in shell & tube
  - exchanger (*see* Vapour belt)
- Area ratio (*see* Thermal design margin)
- ASME VIII pressure vessel code, 164
- ASME standard flange dimensions, 173
- Aspentech, 43 ; 44
- Available duty method for fouling
  - resistance, 110

## B

B-Jac, 44

Baffles  
 shell and tube exchangers, 2  
   double segmental, 194  
   leakage in shell-side flow, 158 ; 167 ;  
     168  
   longitudinal, 158 ; 283  
   pitch, 167 ; 169 ; 171  
     effect on vibration, 188 ; 189 ;  
       190 ; 194  
   rod, 33 ; 192  
 Banks of tubes (*see* Tube banks)  
 Batch systems  
   cooling water treatment for, 291  
   heating and cooling of, **299-330**  
     cases covered, 299  
     development of method, 302 ; 312  
     existing system performance, 305  
     new system design, 306  
 Bavex' exchanger (*see* Plate heat  
 exchangers, welded/brazed)  
 Bell & Ghally method  
   (*see* Silver/Bell & Ghally method)  
 Bellows  
   use of in fixed tubesheet exchangers, 157  
   for floating head, 160  
 Boilers (*see also* Reboilers)  
   suggested design margin for, 76  
 Brazed plate exchanger (*see* Plate heat  
 exchangers – welded/brazed)  
 'Brown Fintube' exchanger (*see* Double  
 pipe exchanger)  
 BS 5500, 164 ; 170 ; 173

## C

CFD (*see* Computational fluid dynamics)  
 CHECKING option, 48  
 Cleaning (*see also* Fouling, Maintenance)  
   air cooled heat exchangers – air side, 245  
   cooling water systems, 295  
   mechanical, 286  
   chemical, 286  
 Closed circuit cooling water systems,  
   270 ; 283  
 Coils, heat transfer to, 307  
   inside coefficient, 307  
   limpet, 308  
     coefficient for, 309  
   outside coefficient in agitated vessel, 310

Colburn & Hougen method, 127 ; **146-151**  
 approach, 146  
 calculation of interface temperature, 146  
 calculation of zone changes, 149  
 condensate behaviour  
   combined model, 148  
   separated model, 148  
   saturation calculations, 149  
 Colburn & Drew method, 127  
 Commissioning  
   cooling water systems, 291  
 'Compabloc' exchanger (*see* plate heat  
 exchanger -welded/brazed)  
 Computational Fluid Dynamics  
   use to predict heat transfer in agitated  
   vessels, 311  
 Computer platforms, 45  
 Computer programs (*see* Software)  
 Concentration factors, 290  
 Condensation  
   condensate film resistance, 125  
     effect of vapour shear on, 125  
   differential, 123  
   film theory methods for, 127  
   fog formation in, 127 ; 149  
   heat transfer resistances in, 124  
   immiscible condensates, 64  
   integral, 123  
   non-equilibrium, 123  
   vapour-liquid equilibrium, 123  
   vapour film resistance, 125  
     film theory, 127  
     Silver/Bell & Ghally method, 125  
 Condensers  
   air cooled heat exchangers as, 137  
   control, 115-123  
     methods, 119  
       boiling refrigerant, 120  
       condensing pressure, 120  
       condensing surface area, 122  
       coolant flow, 120  
       coolant temperature, 120  
       inert gas – use of, 120  
       system requirements, 116  
   coolant, choice of, 113  
   design margin for, 76  
   design of, 128  
     drainage of condensate, 130  
     inerts, handling of, 129  
     pressure drop, 129

- vapour inlet design, 129
- vapour velocities, 128
- direct contact, 131
- impingement plates, requirement for, 129
- internal, 138
- layout, 114
  - distillation column condensers, 114
  - process condensers, 114
- maldistribution in, 130
- plate heat exchangers as, 13 ; 138
- plate-fin heat exchangers as, 22 ; 138
- refluxing systems, 139
  - applications, 139
  - design of, 140
    - flooding, 142
    - thermal performance, 144
    - vapour-liquid equilibrium, 139 ; 144
  - geometry, 139
  - temperature-composition relationships in, 139
- selection, 131
- shell & tube, 133
  - shellside
    - baffled, 136
    - crossflow, 135
    - use of extended surface, 136
  - subcooling in, 137
  - tubeside, 134
- spiral plate, 137
- Control
  - air cooled heat exchangers, 227
  - of cooling water treatment, 291
  - condensers, 120
  - distillation columns, 115
  - electric heaters, 34
  - vertical thermosyphon reboilers, 102
  - water cooled exchangers, 285
- Cooling, options for, 113 ; 200
  - ACHE, direct use of, 205
  - ACHE, use of cooling water from, 204
  - choice of system, 205
    - (see also Air cooled heat exchangers, choice of system)
  - dry cooling tower, use of water from, 204
  - evaporative cooling tower water, 203
  - direct contact, 201
  - raw water, use of, 201 ; 281
  - secondary coolant, use of, 202
- Cooling towers
  - acceptance testing of, 292
  - dry tower, 204
  - evaporative, 203 ; 272
    - design of, 273
      - cooling range, 274
      - packing, 274
      - performance curves, 276
      - re-cool temperature, 273
      - return temperature, 273
      - safety margins, 274
      - water distribution, 275
      - water rate, 274
      - wet bulb temperature, 273
    - instrumentation for, 287
    - maintenance, 296
    - operation of, 293
    - performance testing of, 293
      - air flow measurement, 293
      - water distribution, 294
- Cooling water, **269-297**
  - alternatives to, 200 ; 269
  - closed circuit systems, 270
    - water treatment for, 289
  - comparison with air as coolant, 205
  - commissioning of systems, 291
  - corrosion, 272
  - evaporative systems, 271
    - treatment for, 289
    - (see also Water treatment)
  - fouling, 271
    - biofouling, 272
    - corrosion fouling, 271
    - effect on pressure drop, 281
    - resistances for design
      - (see Fouling resistance for cooling water)
    - scaling fouling, 271
    - sedimentation fouling, 271
    - temperature, effect of, 278
    - velocity, effect of, 278 ; 282
  - heat exchangers using,
    - design of, 276 ; 277
    - (see also Shell & tube exchangers - design using cooling water)
    - control, 285
      - recirculation for, 285
    - exchanger elevation, 282
    - fluid allocation, 276
    - inspection of, 295

- instrumentation for, 288
  - operation of, 292
  - pressure testing, 292
  - water quality for, 276
  - materials of construction for, 272 ; 282
  - open circuit systems
    - (see evaporative systems)
  - problems as coolant, 271
  - quality of water, 276
  - raw water, direct use of, 270
  - system design (see Cooling water systems)
  - temperature limits for, 278
  - treatment (*see* Water treatment)
  - towns water, direct use of, 270
  - velocity, 282
  - Cooling water systems, **269-297**
    - commissioning of, 291
    - design of, 272
      - evaporative cooling tower
        - (see Cooling tower, evaporative)
    - maintenance, 295
      - cleaning, 295
    - operation, 292
    - pressure testing, water quality for, 291
    - pre-treatment, 292
    - spares, storage of, 296
  - Corrosion, 6
    - air cooled heat exchangers, 236
    - cooling water, 272
  - Costing of exchangers, 7
    - air cooled heat exchanger, 13 ; 206 ; 249-253
    - 'compabloc', 29
    - double pipe exchanger, 32
    - electric heaters, 34
    - fired process heaters, 36
    - gasketed plate & frame, 15
    - graphite heat exchangers, 261
      - cubic block, 11 ; 261
      - cylindrical block, 10
    - printed circuit heat exchanger, 27
    - scraped surface heat exchanger, 25
    - shell and tube, 262
    - spiral plate heat exchangers, 18
  - Critical duties, 70
  - Critical velocity for vibration, 187
  - Crossflow condenser, 135
  - Cubic block graphite heat exchangers
    - (see Graphite heat exchangers)
  - Cylindrical block graphite exchangers
    - (see Graphite heat exchangers)
- ## D
- Damping, mechanical, 185 ; 186
  - Delaware method for shellside heat transfer, 41
  - Dephlegmators (see Condensers – refluxing systems)
  - Design codes, 163
  - Design margin (see Thermal design margin)
  - Design methods (see also Rating), 6
    - air cooled heat exchanger, 13
    - 'compabloc', 30
    - double pipe exchanger, 32
    - electric heaters, 34
    - fired process heaters, 37
    - gasketed plate & frame, 15
    - graphite heat exchangers
      - cubic block, 11
      - cylindrical block, 10
    - plate-fin heat exchangers, 23
    - printed circuit heat exchanger, 26
    - scraped surface heat exchanger, 24
    - shell & tube exchangers, 9
    - spiral plate heat exchangers, 18
    - tube-in-duct, 19
    - welded/brazed plate – plate & frame, 27
  - DESIGN option, 48
  - Differential expansion in shell & tube exchangers, 159
  - Diffusion bonding, 22; 24
  - Diffusion coefficient, 146
  - Dimensions & weight, 7
    - air cooled heat exchanger, 13
    - 'compabloc', 29
    - double pipe exchanger, 31
    - electric heaters, 33
    - fired process heaters, 36
    - gasketed plate & frame, 14
    - graphite heat exchangers
      - cylindrical block, 10
      - cubic block, 11
    - plate-fin heat exchangers, 23
    - printed circuit heat exchanger, 26
    - scraped surface heat exchanger, 24
    - shell & tube exchangers, 9
    - spiral plate heat exchangers, 18

- tube-in-duct, 19
- welded/brazed plate – plate & frame, 27
- Direct contact condensers, 131 ; 201
- Dirt (*see* fouling)
- Distillation
  - control of distillation column, 115
  - reboilers for, **81-112**
  - separation efficiency of, 81
- Distribution
  - (*see also* Maldistribution)
  - in ACHEs
    - air flow, 235
    - process, 235
  - in cooling towers, 275 ; 294
  - cooling water systems, 286
- Double pipe exchanger, 30-32
  - costs, 32
  - design methods, 31
  - dimensions & weight, 31
  - fouling, 31
  - materials of construction, 31
  - operating limitations, 31
  - repairs, 31
  - safety & reliability, 31
  - type of duty, 31
- Double segmental baffles, 194
- Drainage of condensate, 130
- Dry cooling towers, 204
- Duty ratio (*see* Thermal design margin)

## E

- E-type shells in shell & tube exchangers, 155
- Effectiveness (*see* thermal effectiveness)
- Effectiveness-NTU method, 157
- Efficiency of fins (*see* Fin efficiency)
- Electric heaters, 32-34
  - control, 34
  - costs, 34
  - design methods, 33
  - dimensions & weight, 33
  - fouling, 33
  - induction heaters, 32
  - inspection & repairs, 33
  - materials of construction, 33
  - operating limitations, 33
  - pipeline immersion heaters, 32
  - radiant electric furnaces, 32
  - safety & reliability, 33

- tank heaters, 32
- types of duty, 32
- End zone lengths, 171
- Enhancement of heat transfer
  - influence on fluid allocation, 163
- ESDU, 75
  - method for tube vibration prediction, 184 ; 186 ; 187 ; 284
- Exchanger types (*see* Types of exchanger)
- Extended surfaces (*see also* finned tubes), 136

## F

- 'F' correction factor to LMTD, 157
  - chart for E shell with even passes, 159
  - minimum value for safe design, 158
- F-type shells, 158 ; 283
- Fans for air cooled heat exchangers
  - (*see* Air cooled heat exchangers, fans)
- Film theory in condensation, 127
- Fin efficiency, 12 ; 19 ; 218 ; 309
- Finned tubes, 18 ; 219
- Fin types
  - finned tubes for ACHEs, 220
  - longitudinal, 30 ; 31
  - low fin tubing, 136 ; 163
  - plate-fin exchanger fins, 21
- Fire relief
  - in ACHEs, 230
- Fired process heaters, 34
  - costs, 36
  - design methods, 36
  - dimensions & weight, 36
  - fouling, 35
  - materials of construction, 35
  - operating limitations, 35
  - safety & reliability, 36
  - types of duty, 34
- Flanges
  - ASME standard dimensions, 174
  - suggested hub lengths for main flanges 175 ; 177
  - Thickness of main shell flange, 173; 175
- Floating heads for shell & tube exchangers, 160
- Flooding
  - in refluxing condensers, 142
- Flow distribution
  - (*see* Distribution & Maldistribution)

Flow induced vibration (*see* Tube vibration)

Fluid allocation in shell & tube exchangers, 160

- factors affecting fouling, 160
- materials of construction, 160
- pressures, 163
- pressure drops, 163
- enhancement, 163
- viscous fluids, 163

Fluid-elastic instability, 185

Fog formation in condensers, 127 ; 149

Fouling, 5

- air cooled heat exchanger, 12
  - air side, 225 ; 235
- 'compabloc', 29
- cooling water systems, 271
  - (*see also* Cooling water fouling)
- double pipe exchanger, 31
- effect on pressure drop, 74 ; 281
- electric heaters, 33
- fired process heaters, 35
- gasketed plate & frame, 14
- graphite heat exchangers
  - cubic block, 11
  - cylindrical block, 10
- influence on fluid allocation, 160
- plate-fin heat exchangers, 22
- printed circuit heat exchanger, 26
- scraped surface heat exchanger, 24
- in shell & tube exchangers, 8
  - effect on fluid allocation, 160
- spiral plate heat exchangers, 17
- tube-in-duct, 19

Fouling factor (*see* Fouling resistance)

Fouling resistance

- in condensers, 124
- for cooling water, 278 ; 282
  - compact exchangers, 281
  - plate heat exchangers, 281
  - tube-side flow, 279
  - shell-side flow, 279
- use to provide design margin, 69 ; 73
- vertical thermosyphon boilers, 95
  - estimation from plant data, 110

Friction factor, 74

Furnaces (*see* Fired process heaters)

## G

Gasketed plate & frame heat exchangers  
(*see* Plate heat exchangers – gasketed plate & frame)

Graphite heat exchangers, **257-267**

- cubic block, 11 ; 258
  - costs, 11 ; 262
  - design methods, 11 ; 264
  - dimensions, 11 ; 258
  - fouling, 11
  - inspection & maintenance, 11
  - materials of construction, 11
  - operating limitations, 11 ; 259 ; 260
  - rating, 264
  - safety & reliability, 11
  - types of duty, 11
- cylindrical block, 9 ; 259
  - costs, 10
  - design methods, 10 ; 263
  - dimensions, 10 ; 260
  - fouling, 10
  - inspection & maintenance, 10
  - materials of construction, 10
  - operating limitations, 9 ; 260
  - rating, 263
  - safety & reliability, 10
  - types of duty, 9
- plate & frame, 260
- shell & tube, 258
  - costs, 261 ; 262
  - design pressure, 258
  - operating limitations, 260
  - rating, 262
- thermal conductivity of graphite, 263
- types of graphite, 257
  - carbon impregnation, 9 ; 258
  - furane resin impregnation, 257
  - phenolic resin impregnation, 257
  - ptfe impregnation, 9 ; 258

## H

Headers in shell & tube exchangers, 159

Heat balance, use for air flow  
measurement in ACHE, 244

Heat exchangers  
design, computer programs for, **41-57**

design using cooling water, 276  
 inspection of, 295  
 instrumentation for, 288  
 pressure testing of, 291  
 pre-treatment, 292  
 types of, 8  
*(see specific types for further details)*  
 using cooling water (*see* Cooling water,  
 heat exchangers using)

Heat storage (*see* Regenerators)

Heat transfer coefficient, 54

*(see also* Heat transfer resistance)

batch processes, 302 ; 307

agitated vessels

process side, 310

service side, 307

Heat transfer resistance

in condensation, 124

film theory methods, 127

Silver/Bell & Ghally method, 125

fouling (*see* Fouling resistance)

High finned tubes (*see* finned tubes for  
 ACHEs)

Horizontal thermosyphon reboiler, 87

HTFS, 42 ; 43 ; 48

HTRI, 42 ; 43

Hydraulic mean diameter, 144 ; 265

Hyprotech, 43

## I

Immiscible condensates, 64 ; 131

Impingement plate, 129 ; 183 ; 284

Induction heaters (*see* Electric heaters)

Inert gas

use to control condensation, 120

venting of, 129 ; 136

Inspection maintenance & repairs, 6

air cooled heat exchanger, 12; 247

double pipe exchanger, 31

electric heaters, 33

gasketed plate & frame, 14

graphite heat exchangers

cubic block, 11

cylindrical block, 10

heat exchangers using water, 295

plate-fin heat exchangers, 23

printed circuit heat exchanger, 26

scraped surface heat exchanger, 24

shell & tube exchangers, 9

spiral plate heat exchangers, 17

tube-in-duct, 19

Instrumentation

cooling towers, 287

heat exchangers, 288

Internal reboiler, 94

Interpass luting in multi-pass condensers,  
 134 ; 158

## J

J-type shells, use to reduce vibration, 194

Jacketed vessels, heat transfer to, 307

service side coefficient, 308

*(see also* coils, limpet)

types of jacket, 308

## K

Kettle reboilers, 90

separation efficiency of, 82

Knock-back condenser (*see* Condensers  
 - refluxing systems)

## L

Layout

vertical thermosyphon reboilers, 104

air cooled heat exchangers, 208

Leakage between streams on shellside,  
 41 ; 56 ; 75 ; 168

thermal leakage in 'F' shells, 158 ; 283

LMTD (*see* Logarithmic mean temperature  
 difference)

Logarithmic decrement, 186

Log mean temperature difference, 157 ; 302

'F' correction factor, 157 ; 265 ; 283 ; 302

Logarithmic decrement (*see* Tube

vibration – mechanical damping)

Longitudinal fins, 30 ; 31

Louvres in air cooled heat exchangers, 200

use for control, 228

Low-fin tubing (*see* finned tubing)



**M**

- Maintenance  
(see also Inspection maintenance & repairs)  
cooling towers, 296  
cooling water systems, 295  
  cleaning, 295  
exchangers using cooling water, 286
- Maldistribution  
(see also Distribution)  
air cooled heat exchangers  
  process side, 225 ; 238 ; 239  
condensers, 130  
cooling towers, 275 ; 294 ; 296
- Manifold-type headers for ACHEs, 224
- Manifolds for air cooled heat exchangers, 200 ; 225 ; 240
- Mass damping parameter in vibration, 187
- Materials of construction, 5  
air cooled heat exchanger, 12 ; 218  
‘compabloc’, 29  
for cooling water, 282  
double pipe exchanger, 31  
electric heaters, 33  
fired process heaters, 35  
gasketed plate & frame, 14  
graphite heat exchangers  
  cubic block, 11  
  cylindrical block, 10  
  types of graphite, 257  
influence on fluid allocation, 160  
plate-fin heat exchangers, 22  
printed circuit heat exchanger, 26  
scraped surface heat exchanger, 23  
shell & tube exchangers, 8  
  effect on fluid allocation, 160  
spiral plate heat exchangers, 17  
tube-in-duct, 19  
welded/brazed plate – plate & frame, 27
- Mean temperature difference, 270  
(see also Logarithmic mean temperature difference)
- Mechanical constraints on thermal design  
  of shell & tube exchangers, 163
- Modes of operation for computer programs, 47
- Multi-hairpin exchanger (see Double pipe exchanger)

- Multi-stream exchangers, 22 ; 25 ; 31  
Multiple pass shell & tube exchangers, 157

**N**

- Natural convection,  
  performance of ACHE under, 230  
NTU (see Number of transfer units)  
NTU-effectiveness method, 157  
Noise from air cooled heat exchangers, 209 ; 223 ; 244  
Number of transfer units, 157

**O**

- Operating limitations, 5  
air cooled heat exchanger, 12  
‘compabloc’, 29  
double pipe exchanger, 31  
electric heaters, 33  
fired process heaters, 35  
gasketed plate & frame, 13  
graphite heat exchangers  
  cubic block, 11  
  cylindrical block, 9  
plate-fin heat exchangers, 22  
printed circuit heat exchanger, 26  
scraped surface heat exchanger, 23  
shell & tube exchangers, 8  
spiral plate heat exchangers, 16  
tube-in-duct, 19  
welded/brazed plate – plate & frame, 27
- Optimisation of exchanger duties, 71
- Orifice plates, use for control, 286
- Over design (see Thermal design margin)

**P**

- Packed gland for floating head, 160  
‘Packinox’ heat exchanger (see Plate heat exchangers - welded/brazed)
- Pass partition lanes, 167
- PCHE (see Printed circuit heat exchanger)
- Performance calculations, 48
- Phase separation in headers, 134 ; 158
- Physical properties, 46 ; **59-65**  
ACHE specification, 214  
adjustment to provide design margin, 73

- component data, 60
  - automatic property codes, 60
  - direct input, 60
  - use for mixtures, 60
- data requirements, 59
- DIPPR, 59 ; 61
- mixture curves, 61
  - extrapolation, 62
  - immiscible condensates, 3.5
  - generation, 61
  - selection of temperature points, 61
- PPDS, 59 ; 61
- program input, 46
- program output, 54
- Plate heat exchangers
  - fouling resistance for cooling water, 281
  - gasketed plate & frame, 13
    - condenser, use as, 13 ; 138
    - costs, 15
    - design methods, 15
    - dimensions, 14
    - fouling, 14
    - graphite plates, 260
    - inspection maintenance & repairs, 14
    - materials of construction, 14
    - operating limitations, 13
    - use in closed circuit cooling system, 203 ; 270
    - safety & reliability, 14
    - types of duty, 13
  - spiral plate, 15
    - costs, 18
    - counter-current flow, 16 ; 17
    - cross flow, 16 ; 17
    - design methods, 18
    - dimensions, 18
    - fouling, 17
    - inspection maintenance & repairs, 17
    - materials of construction, 17
    - operating limitations, 16
    - safety & reliability, 17
    - types of duty, 16
  - welded/brazed plate exchanger, 27
    - 'Bavex', 30
    - plate & frame type, 27
      - design methods, 27
      - dimensions & weight, 27
      - materials of construction, 27
      - operating limitations, 27
      - types of duty, 27
    - 'Packinox', 31
    - 'Platular', 31
    - 'compabloc', 28
      - costs, 29
      - construction, 29
      - design methods, 29
      - dimensions, 29
      - fouling, 29
      - materials of construction, 29
      - operating limitations, 29
      - safety & reliability, 29
      - types of duty, 29
- Plate-fin heat exchangers, 20
  - arrangement of, 20
  - condenser, use as, 138
  - design methods, 23
  - dimensions, 23
  - fins for, 21
  - fouling, 22
  - inspection maintenance & repairs, 23
  - materials of construction, 22
  - operating limitations, 22
  - safety & reliability, 23
  - types of duty, 22
- 'Platular' heat exchanger (see Plate heat exchangers - welded/brazed)
- Pressure
  - influence on fluid allocation, 161
- Pressure drop
  - accuracy of prediction, 73
  - air cooled heat exchangers
    - process, 213
  - condensers – influence on design, 129
  - distribution, 55
  - effect of fouling on, 74 ; 281
  - influence on fluid allocation, 161
- Pressure testing, water quality for, 291
- Pre-treatment of exchangers, 292
- Printed circuit heat exchanger, 24
  - construction of, 24
  - costs, 27
  - design methods, 26
  - dimensions and weight, 26
  - fouling, 26
  - operating limitations, 26
  - materials of construction, 26
  - repairs, 26
  - safety & reliability, 26
  - types of duty, 25
- Protective coatings, use to prevent

corrosion, 237

Purge

**R**

Radiant furnaces, electrical, 32

Rating (see also Design Methods)

Raw water, use for cooling, 201

Reboilers (*see also* Boilers), **81-112**

- bayonet tube, 91
- direct vapour injection, 84
- external generation of vapour, 84
- forced circulation, 88
- internal, 93
- kettle, 82 ; 90
- selection, 81
- separation efficiency, 82
- suppressed vaporisation, 89
- thermosyphon, 82 ; 85
  - horizontal, 87
- vertical thermosyphon, 86 ; 94
  - control of, 102
    - using condensing pressure, 102
    - using condensate level, 103
    - using heating fluid flowrate, 103
  - control of column level for, 105
  - design of, 94
    - adjustments to design, 100
    - analysis of program results, 99
    - fouling, 95
    - heating medium temperature, 95
    - process specification for, 96
    - tube diameter, 97
    - tube length, 97
    - liquid head, 98
    - pipng arrangement, 98 ; 99
  - fouling resistance – estimation
    - from plant data, 110
  - layout, 104
    - differential expansion, 105
    - factors influencing design, 104
    - standard layouts, 105
  - operating range, 101
  - stability, 98 ; 99 ; 101
  - types of reboiler, 84

Recirculation of water for control, 285

Refluxing condensers (see Condensers – refluxing systems)

Refrigerant, use of boiling refrigerant as

coolant, 120

Regenerators, 37

- applications, 39
- fixed bed, 37
- rotary, 37
- thermal storage media, 37

Reliability (see Safety & reliability)

Repairs (see Inspection maintenance & repairs)

River water, use as coolant, 201 ; 202

Rod-baffle exchangers, 192

Rod baffles, use in electric heaters, 33

## S

Safety & reliability, 6

- air cooled heat exchanger, 12
- ‘compabloc’, 29
- double pipe exchanger, 31
- electric heaters, 33
- fired process heaters, 36
- gasketed plate & frame, 14
- graphite heat exchangers
  - cubic block, 11
  - cylindrical block, 10
- plate-fin heat exchangers, 23
- printed circuit heat exchanger, 26
- scraped surface heat exchanger, 24
- shell & tube exchangers, 9
- spiral plate heat exchangers, 17
- tube-in-duct, 19

Safety margins (*see* Thermal design margins)

Scaling, 271

Scraped surface heat exchangers, 23

- costs, 24
- design methods, 24
- dimensions, 24
- fouling, 24
- maintenance & repairs, 24
- materials of construction, 23
- operating limitations, 23
- safety & reliability, 24
- types of duty, 23

Sealing devices (*see* Shell & tube heat exchangers)

Selection of heat exchangers, **1-40**

- factors influencing, 4
  - cost, 7
  - delivery, 7

- design methods, 6
- dimensions & weight, 7
- duty, 4
- fouling and cleaning, 5
- inspection, maintenance & repairs, 6
- materials of construction, 5
- operating limits, 5
- safety & reliability, 6
- Self-venting flow, 130
- Serrated fins in plate-fin exchangers, 21
- Separation efficiency of boiler, 81
- Setting plans, 57
- Shell & tube exchangers, 8 ; **155-196**
  - clearances in, 166
  - cleaning, 2 ; 8
  - design codes, 9 ; 163
  - design methods, 9
  - design of, using water, 276-287
    - (*see also* Cooling water, design of exchangers using)
  - baffle arrangement, 277 ; 278
  - control, 285
  - elevation of exchanger, 282
  - fluid allocation, 276
  - maintenance, 286
  - materials of construction, 282
  - pressure drop, 281
  - removable bundles, 278
  - shell orientation, 278
  - sludge blowdown, 278
  - temperature limitations, 278
  - water velocity, 282
- dimensions and weight, 9
- end zone geometry, 171
- end zone lengths, 171 ; 178-182
- enhancement of heat transfer, 163
- fouling, 2 ; 5 ; 8
  - effect on fluid allocation, 160
  - resistance for cooling water, 279
- flange thickness, 173 ; 175
- fluid allocation, 160 ; 276
- graphite tubes, 258
- head types, 159
  - advantages and disadvantages, 161
- hydraulic diameter, 2
- impingement plates, 129 ; 183 ; 277
- inter-pass luting, 158
- inspection maintenance & repairs, 9
- kettle boilers, 158
- limitations of design, 2
  - materials of construction, 8
    - effect on fluid allocation, 160
  - mean temperature difference in, 2
  - mechanical constraints, 163
    - clearances, 166
  - operating limitations, 8
  - pass partition lane width, 167
  - pressure drop, 2 ; 73
  - safety & reliability, 9
  - sealing rods and strips, 56 ; 183 ; 283
  - shell types, 155
    - multiple tube pass, 157
    - two shell pass (TEMA 'F'), 158
    - single tube pass, 155
  - standard dimensions, 164
  - TEMA designations, 156
  - thermal effectiveness, 2 ; 157
  - tie rods, 183
  - tube counts, 177
    - graphical layout, 183
    - program correlations, 178
    - tubecount tables, 178
    - tubesheet design programs, 183
  - tube pitch, 166
  - tubesheet thickness, 169
  - tube vibration (*see* Tube vibration, shell and tube exchangers)
  - types of duty, 8
  - U-bends, 167
  - viscous fluids, 163
- Shell diameters, standard, 165
- Silver/Bell & Ghally method, 125
- SIMULATION option, 49
- Single phase duties
  - suggested design margin for, 76
- Software for exchanger rating
  - data input for, 45
  - flexibility of, 45
  - in-house, 42
  - interpretation of results, 51
    - advisory messages, 54
    - ancillary calculations, 56
    - detailed conditions, 55
    - error messages, 52
    - flow distribution, 55
    - input data, 51
    - main results, 54
    - physical properties, 54
    - pressure drop distribution, 55
    - setting plans, 56

- warning messages, 53
- limitations of, 49
- links to other programs, 46
- methods used, 45
- modes of operation, 46 ; 47
  - checking, 48
  - design, 48
  - simulation, 49
- output from, 46
- physical property input to, 46
- platforms for, 44
- range available, 44
- research organisations, 42
- selection, 44
- software houses, 43
- technical support for, 47
- upgrades for, 47
- Spares, storage of, 296
- Spiral plate heat exchangers (*see* plate heat exchangers – spiral plate)
- Standard dimensions, 164
- Standards (*see* also Design codes, TEMA), 163
- Stirred tanks (*see* Agitated vessels)
- Stream analysis method, 42 ;56 ; 75
- Supersaturation as cause of fogging, 127; 149

## T

- TEMA, 2 ; 8 ; 50 ;130 ; 135 155 ; 164 ; 175
  - nomenclature, 156
- Temperature difference
  - use of to provide design margin, 72
- Thermal design margins, **67-80**
  - accuracy of thermal design methods, 73
    - heat transfer, 75
    - pressure drop, 73
  - air cooled heat exchanger, 211
  - combining margins, 69
  - critical & non-critical duties, 70
  - effect of over-design on performance, 76
  - penalties of over-design, 70
  - reasons for, 67
  - suggested values, 75
  - ways of providing, 71
    - design temperature difference, 72
    - excess surface, 71
    - fouling resistance, 73
    - physical property adjustment, 73
    - process flowrate, 72

- temperature approach, 73
- Thermal effectiveness, 2 ; 8 ; 16 ; 23 ; 157
- Thermal leakage in F-type shells, 158 ; 283
- Thermal length, 76
- Thermal resistance
  - (*see* Heat transfer resistance)
- Thermal storage media, 37
- Thermosyphon reboilers (*see* reboilers)
- Tinker, 41 ; 75
- Tracers, use for air flow
  - measurement in ACHE, 243
- Tube banks, 19 ; 35
- Tube counts in shell and tube exchangers
  - (*see* Shell & tube exchangers)
- Tube dimensions, 164 ; 165
- Tube-in-duct heat exchangers, 18
  - design methods, 19
  - dimensions, 19
  - fouling, 19
  - inspection maintenance & repairs, 19
  - materials of construction, 19
  - operating limitations, 19
  - safety & reliability, 19
  - types of duty, 18
- Tube lengths, standard, 164
- Tube pitch, 166
- Tubesheet thickness, 169
- Tube vibration
  - condensers, 130
  - shell & tube exchangers, **184-195** ; 284
    - acoustic resonance, 185
    - assessment of risk, 188
    - critical velocities, 187
    - designing to avoid vibration, 188
      - auxiliary baffles, 189
      - baffle spacing, 189
      - double segmental baffles, 194
      - no tubes in window designs, 192
      - rod-baffle exchangers, 192
      - TEMA J-shell, 194
      - twisted tube exchangers, 194
      - U-bend problems, 194
      - vapour belt, 189
    - fluid-elastic instability, 185
    - mechanical damping, 186
    - mechanisms, 184
    - natural frequencies, 186
    - turbulent buffeting, 185
    - wake shedding, 185
- Tubular Exchanger Manufacturers

Association (*see* TEMA)  
 Twisted tube exchanger, 194  
 Types of duty, 4  
   air cooled heat exchanger, 12  
   ‘compabloc’, 29  
   double pipe exchanger, 31  
   electric heaters, 32  
   fired process heaters, 34  
   gasketed plate & frame, 13  
   graphite heat exchangers  
     cubic block, 11  
     cylindrical block, 9  
   plate-fin heat exchangers, 22  
   printed circuit heat exchanger, 25  
   scraped surface heat exchanger, 23  
   shell & tube exchangers, 8  
   spiral plate exchangers, 16  
   tube-in-duct, 18  
   welded/brazed plate – plate & frame, 27  
 Types of exchanger, 8-40

## V

Vapour belt, 130 ;189  
 Velocity, effect on fouling in water systems,  
 278 ; 282  
 Venting,  
   condensers, 129 ; 135 ;136

water cooled exchangers, 10.5.2.10  
 Vertical thermosyphon reboiler  
   (*see* Reboilers - thermosyphon)

## W

Water treatment (*see also* Cooling water), 289  
   batch systems, 291  
   closed circuit systems, 289  
   evaporative systems, 289  
     blowdown, 290  
     chemical treatment companies, 291  
     chemical treatment programs, 289  
     concentration factors, 290  
     control of treatment, 291  
     filtration, 290  
     make-up water, 290  
     pressure testing, quality for, 291  
     pre-treatment, quality for, 292  
 Wiped film exchanger (*see* Scraped surface  
 exchanger)  
 Weight (*see* Dimensions & weight)

## X

X-type shells, 135