

# Index

*Note:* Page numbers followed by “f” and “t” indicate figures and tables respectively

## A

- 3PM. *See* Plant Production Performance Model
- AAs. *See* Anti-agglomerants
- Absolute open flow, 20
- Absorber, 235–236, 492
  - side cooler, 192
- Absorption, 182, 419–420
- Acid gas
  - enrichment, 308
  - feed drums, 325–326
  - fuel burner, 308
  - treating system, 426
- Acid gas enrichment unit (AGEU), 308
- Acid gas removal unit (AGRU), 127, 171, 318
- Acoustical treatment, 400–401
- Activated alumina, 242–243
- Adsorbent, 336, 420
  - selection, 238–243
- Adsorption, 182
  - capacity, 238
  - isotherm, 237–238
  - principle, 243–244
- Advanced process control system (APC system), 132–133, 468, 471–473, 488–489, 488f
- Advanced regulatory control, 427
- Aerosols, 150–151, 151f
- AFE. *See* Authority for expenditure
- AGEU. *See* Acid gas enrichment unit
- AGRU. *See* Acid gas removal unit
- Alarm management, 449–450
  - alarm philosophy, 450–451
  - audit, 453
  - detailed design, 451–452
  - identification, 451
  - implementation, 452
  - maintenance, 452
  - management of change, 452
  - monitoring and assessment, 452
  - operation stage, 452
  - rationalization, 451
- Alkanolamine solvents, 183–195
  - amine processes, 186–191
  - amine unit operating problems, 194–195
  - special design considerations, 191–194
- American National Standards Institute (ANSI), 448
  - ANSI RP 755 Standard, 448
  - ANSI/API RP 755 Standard, 449
- Amine
  - processes, 186–191, 296–298
    - double absorption process, 190–191
    - two-stage absorption process, 189–190
  - unit operating problems, 194–195
- Annular flow, 44–45
- Annular mist. *See* Annular flow
- Annular velocity ( $V_{ann}$ ), 155–156. *See also* Media velocity ( $V_{med}$ )
- ANSI. *See* American National Standards Institute
- Anti-agglomerants (AAs), 80–82
- APC system. *See* Advanced process control system
- Application Service Provider (ASP), 521
- Aquifers, 34
- Aquisulf process, 322
- ASP. *See* Application Service Provider
- Asset
  - management, 425–426
  - values, 518
- ATC. *See* Available Technical Capacity
- Authority for expenditure (AFE), 547, 550
- Automation, 413
  - applications, 424–433
- Available Technical Capacity (ATC), 511

## B

- BAHX. *See* Brazed aluminum heat exchanger
- Baillie and Wichert method, 74–75, 77f
- Baselining, 432
- Bed refluxing, 256
- Beggs and Brill method, 52–56
- Benfield process, 195
- Bernoulli's equation, 384
- Bio-SR process, 314
- Brake horsepower (BHP), 366

Brazed aluminum heat exchanger (BAHX),  
270–271, 278–279, 338  
Breakdown maintenance, 455  
British thermal unit (Btu), 6  
Bubble flow, 45  
Bulk modulus of elasticity. *See* Isothermal gas  
compressibility  
Business  
owner representative, 547  
and project objectives, 546–548  
Butanes splitter, 499

## C

Calcium chloride, 258  
Capital expenditure (CAPEX), 397, 563  
Carbon aromaticity, 528  
Carbon dioxide (CO<sub>2</sub>), 11–12, 181  
removal for NGL, 129  
Carbon disulfide (CS<sub>2</sub>), 181  
Carbonyl sulfide (COS), 181, 242, 297–298  
Cascade  
flash separation, 170–171  
refrigeration, 268–270  
Casinghead gas, 3–4  
Catacarb process, 195  
Catalytic oxidation, 318  
sub-dew-point processes, 318  
SuperClaus process, 318  
Cathodic protection, 89  
Caustic processes, 294–295  
Centrifugal compressors, 268, 351–353, 352f,  
363, 369–376, 378, 422–423. *See also*  
Reciprocating compressors  
performance map, 370f  
recycle system layout for, 372f  
Centrifugal pumps, 423  
Centrifugal separators, 145–146  
CFD. *See* Computational fluid dynamics  
CFR. *See* Code of Federal Regulations  
CGR. *See* Condensate/gas ratio  
Checklist approach, 555  
Chemical absorption processes,  
183–195. *See also* Physical solvent  
processes  
alkanolamine solvents, 183–195  
potassium carbonate solution, 195  
Chemical inhibition, 80–86  
inhibitor types, 80–83  
injection system design, 85–86  
prediction of inhibitor requirements, 83–85  
Chemisorption, 237  
Chemsweet<sup>®</sup> process, 213

Churn (transition) flow, 45  
Clathrate, 68–69  
Claus  
converters, 306–307  
process, 418  
reaction, 303  
Clinsulf process, 311  
CNG. *See* Compressed natural gas  
Coal-bed methane. *See* Natural gas  
from coal  
Code of Federal Regulations (CFR),  
442–443  
Cold box, 478  
Coldfinger process, 230  
Columns, 475–476  
Combustion air blowers, 326  
Commercial software programs, 78–79  
Commissioning, 437–442  
control systems testing, 438–439  
mechanical completion, 437–438  
performance testing, 442  
precommissioning, 437–438  
process commissioning, 440–442  
start-up procedures, 440  
Communications medium, 415  
Compressed natural gas (CNG), 24–27  
Compression, 349  
model, 492–494  
power, 408  
calculation, 366–367  
Compression ratio (CR), 362–364  
Compressor stations, 394  
acoustical treatment, 400–401  
arrangements, 399  
facilities, 395–399  
reliability and availability, 401–402  
spacing, 404–408  
control, 399–400  
Compressor(s), 396  
control, 367–374  
drivers, 396–397  
performance maps, 375–376  
selection, 354–355  
Computational fluid dynamics (CFD), 163  
Computational pipeline monitoring. *See*  
Internally based methods  
Condensate  
effluent treatment, 176–178  
hydrotreating, 174–175  
production, 169–170  
stabilizer case study, 434–436  
storage, 178–180

- tank design considerations, 178–179
    - tank emission control, 180
  - Condensate stabilization, 127, 169–174, 420–421
    - cascade flash separation process, 170–171
    - design considerations, 173–174
      - stabilizer column pressure, 173
      - stabilizer system control, 174
    - distillation process, 171–172
      - condensate and LPG production, 172, 173f
      - condensate production only, 171–172
    - operating problems, 174
  - Condensate/gas ratio (CGR), 483
  - Condition monitoring. *See* Predictive maintenance
  - Containment, 525
  - Continuous monitoring systems, 114
  - Contractual agreements, 133–135
    - flat fees contracts, 134
    - keep-whole contracts, 134
    - percentage of proceeds contracts, 134
    - processing fee contracts, 135
  - Control
    - functions, 399
    - methods, 109–111
    - system, 476
      - checkout, 469–470
      - testing, 438–439
  - Control room, 416
    - alarm management, 449–453
    - fatigue mitigation, 448–449
    - HAZOP, 445–446
    - LOPA, 446–448, 447f
    - management, 442–443
    - operational excellence key components, 453f
    - process safety management, 443–445
    - roles and responsibilities, 443
    - training, 453–454
  - Conventional demethanizer, 285
  - Conventional gas, 3, 17–20. *See also* Unconventional gas
    - completion, 19
    - drilling, 18–19
    - electric logs, 18f
    - exploration, 17
    - production, 19–20
    - seismic survey, 17f
  - Conveying formed sulfur, 324
  - Cooling water system model, 500
  - Corrective maintenance, 456
  - Corrosion, 86–90
    - cathodic protection, 89
    - choice of corrosion-resistant metals, 87
    - inhibitors, 87–89
    - monitoring, 90
    - protective coatings, 89–90
  - Corrosion resistant alloy (CRA), 87–88
  - CR. *See* Compression ratio
  - CRA. *See* Corrosion resistant alloy
  - Cricondenbar, 4–5
  - Cricodentherm, 4–5
  - Cryogenic fractionation, 218
  - Cryogenic nitrogen rejection process, 338
    - double-column nitrogen rejection process, 340–342, 342f
    - process selection, 344–345
    - single-column nitrogen rejection process
      - classical design, 338–339, 339f
      - modified design, 339–340, 340f
    - two-column nitrogen rejection process, 343–344, 343f
  - Cryogenic process, 335–336
  - Cryogenic recovery, 421
  - CrystaSulf™ process, 313–314
  - CSB. *See* U.S. Chemical Safety and Hazard Investigation Board
  - Custom models, 492
  - Cyclone separators. *See* Centrifugal separators
- ## D
- D'GAASS process, 321–322
  - DAP. *See* Double absorption process
  - Darcy's law, 19
  - Data, 529
    - historians, 424
  - DBM. *See* Design Basis Memorandum
  - DCS. *See* Distributed control system
  - DEA. *See* Diethanolamine
  - Debutanizer, 498–499
  - Deep hydrocarbon dew pointing, 273–274
  - Deethanizer, 498
  - Dehydration, 130
  - Deliverability equation, 19–20
  - Demethanizer, 422, 498
    - feed chilling models, 499
  - Demisting device, 139
  - “Dense phase” compressor, 362
  - DEPG. *See* Dimethyl ether of polyethylene glycol
  - Depleted reservoirs, 34
  - Depropanizer, 498
  - Design Basis Memorandum (DBM), 545
  - Design power, 501
  - Desuperheating station (DS), 268

- DFM. *See* Drift-flux model
- DGA. *See* Diglycolamine
- Diethanolamine (DEA), 183–184
- Diethylene glycol, 227
- Differential pressure (DP), 157
- Digital multimeter (DMM), 461–462
- Digital technology, 399–400
- Diglycolamine (DGA), 183–184
- Diisopropanolamine (DIPA), 183, 185
- Dimethyl ether (DME), 27
- Dimethyl ether of polyethylene glycol (DEPG), 197, 202–207
- carbon capture process, 205
  - hydrocarbon dew point control, 207
  - landfill gas, 207
  - mercaptan removal, 207
  - process, 203–205
- DIPA. *See* Diisopropanolamine
- Direct oxidation processes, 309–311
- Clinsulf process, 311
  - Selectox process, 310–311
- Dispersed bubble flow, 42
- Distillation
- calculations, 496–499
  - process, 171–172
  - condensate and LPG production, 172, 173f
  - condensate production only, 171–172
  - towers, 425
- Distributed control system (DCS), 132–133, 413–416, 439, 462
- DME. *See* Dimethyl ether
- DMM. *See* Digital multimeter
- Doctor sweetening process, 294–295
- Double absorption process (DAP), 190–191, 319
- Double-column nitrogen rejection process, 340–342, 342f. *See also* Single-column nitrogen rejection process; Two-column nitrogen rejection process
- DP. *See* Differential pressure
- Drift-flux model (DFM), 57–59
- DRIZO™ process, 229
- Dry-bed processes, 182
- DS. *See* Desuperheating station
- Dual column reflux process, 281–282
- Dynamic analysis, 480–481
- Dynamic models, 468
- Dynamic simulation, 467
- areas of application, 467
  - plant design, 468–471
  - plant operation, 471–473
  - equipment
    - and process system control, 477–478
    - specific considerations, 474–476
    - fuel gas system start-up analysis, 478–481
    - in gas processing plants, 467
    - level of detail in model, 473–474
    - model speed, 474
    - trunk line online dynamic model, 481–485
- ## E
- EAM system. *See* Enterprise asset management system
- EDI. *See* External Data Interface
- EIA. *See* Energy Information Administration
- Elemental sulfur, 301
- Emergency shutdowns (ESD), 371, 373, 398, 469
- Emulsions, 157–158
- Energy Information Administration (EIA), 16
- Engineering, Procurement, and Construction (EPC), 544
- Enterprise asset management system (EAM system), 457
- Enterprise resource planning (ERP), 519
- Enterprise risk management (ERM), 558
- Environmental engineer, 548
- EOS. *See* Equation of state
- EPC. *See* Engineering, Procurement, and Construction
- Equation of state (EOS), 8, 59
- Equilibrium zone (EZ), 244
- ERM. *See* Enterprise risk management
- ERP. *See* Enterprise resource planning
- ESD. *See* Emergency shutdowns
- EUR. *See* Expected ultimate recovery
- Expander model, 494–496
- Expander thermodynamics, 494f
- Expected ultimate recovery (EUR), 20
- External Data Interface (EDI), 489
- EZ. *See* Equilibrium zoneF

Fatigue mitigation, 448–449

Fatigue risk management system (FRMS), 448–449

Fault Tree Analysis (FTA), 444

Feed

  - contaminants, 346–347
  - gas, 191, 338
    - characteristics, 345
    - cooling system, 268
    - preheating, 307

FEED. *See* Front-end engineering and design

FEF. *See* Front-end furnace  
 Ferro process, 211  
 Fiber-reinforced plastic (FRP), 27  
 Filters, 402  
 Finger-type slug catcher, 149f  
 Fischer–Tropsch process (FT process), 27  
 Fixed fee price, 548–549  
 Flare system, 399  
 Flat fees contracts, 134  
 Flexsorb, 316–317  
 FLEXSORB SE process, 186  
 Floating liquefied natural gas (FLNG), 26  
 Flow assurance, 68  
   risk management, 111–114  
 Flow pattern maps, 46–48  
 Flow sheet development, 505  
 FLUOR Solvent process, 198–200  
 Fluor twin column high absorption process, 285  
 Fluor twin-reflux absorption process, 285–287  
 Foaming, 195, 347  
 Formed sulfur storage, 324  
 Fractionators, 492  
 Friction factor model. *See* Homogeneous flow approaches  
 FRMS. *See* Fatigue risk management system  
 Front-end engineering and design (FEED), 546  
 Front-end furnace (FEF), 309  
 FRP. *See* Fiber-reinforced plastic  
 FT process. *See* Fischer–Tropsch process  
 FTA. *See* Fault Tree Analysis  
 Fuel gas system, 478, 479f  
   start-up analysis, 478–479  
   dynamic analysis, 480–481  
   dynamic model, 481  
   steady-state analysis, 479–480

## G

Gas. *See also* Natural gas  
   compressibility factor, 8–12  
   compressors, 425  
   condensate “A”, 92–93  
   condensate “B”, 93  
   dehydration, 419–420, 477  
     unit, 127  
   density, 13  
   flow fundamentals, 383  
     friction factor correlations, 385–388  
     general flow equation, 384–385  
     simplified flow equations, 388–390  
   formation volume factor, 12–13  
   gathering  
     system, 417–418  
     and transmission, 477  
   gravity method, 75–78  
   hydrates, 3–4, 68–86  
     locus for natural gas components, 70, 71f  
     prediction of hydrate formation conditions, 70–79  
     prevention techniques, 79–86  
   piping, 401  
   plant profitability, 518  
   specific gravity, 8  
   temperature profile prediction, 390–392  
   transmission pipelines  
     compressor station, 394f  
     transient flow in, 392–393  
   transmission system, 394  
   treating, 418, 477  
   viscosity, 14–15  
 Gas processing, 544  
   modeling, 467  
     and optimization strategy, 513–514  
   operations, 487  
   plants, 467  
     model speed, 474  
 Gas coalescers, 150–157, 152f. *See also*  
   High-efficiency liquid–liquid coalescers  
   aerosols, 150–151, 151f  
   applications, 157  
   construction/operation principles, 151–154  
   modeling liquid, 154–156  
   performance/operational limits, 157  
   effect of surface treatment, 153f  
 Gas compression thermodynamics, 355  
   basic relations, 356–357  
   isentropic model, 357–360  
   polytropic model, 360–361  
   real gas behavior, 361–362  
 Gas deviation factor. *See* Gas—compressibility factor  
 Gas horsepower (GHP), 366  
 Gas plant assets profitability, 517  
   challenges, 517  
   industrial relevance, 536  
   information hierarchy, 530f  
   integrated gas plant, 518–519  
   impact of living with information technology, 529–530  
   miscellaneous initiatives, 539  
   model-based asset management, 532  
   operations strategy, 531  
   optimization, 533  
     alternatives, 534–536  
     tools for, 534

- Gas plant assets profitability (*Continued*)
  - organizational behavior model, 519–528
  - scientific approach, 537–539
  - strategies for organizational behavior and information, 519
  - successful information strategy, 528–529
  - technology integration challenge, 537
  - vision of modern plant operation, 530–531
- Gas plant project management, 543–544.
  - See also* Integrated gas plant; Natural gas
  - commissioning and start-up, 566
  - industry perspective, 544–545
  - operation and evaluation, 566–567
  - process, 545
    - conceptual estimates and schedules, 549–551
    - contracting strategy, 548–549
    - defining business and project objectives, 546–548
    - pre-project planning measurement, 552
    - project execution planning, 551–552
    - responsibility matrix, 552–554, 553t
    - team integration phases, 554f
  - project closeout, 567
  - project controls, 554
    - project timeline, 555–556
    - risk management, 556–564
  - quality assurance, 564–565
- Gas processing plant automation, 413
  - applications, 424–433
  - centrifugal
    - compressors, 422–423
    - pumps, 423
  - condensate stabilizer case study, 433–436
  - early methods, 413–414
  - gas dehydration, 419–420
  - gas gathering system, 417–418
  - gas treating system, 418
  - liquids recovery, 420–422
  - microprocessor-based automation, 414–416
  - NGL fractionation, 422
  - reciprocating pumps, 423
  - sulfur recovery, 418–419
  - utilities, 423–424
- Gas processing plant operations, 437
  - commissioning and start-up
    - control systems testing, 438–439
    - mechanical completion, 437–438
    - performance testing, 442
    - precommissioning, 437–438
    - process commissioning, 440–442
    - start-up procedures, 440
  - control room management, 442–454
  - maintenance, 454–458
  - plant turnarounds, 464
  - troubleshooting, 458–463
- Gas subcooled process (GSP), 282–283
- Gas-condensate
  - flow regimes, 49
  - wax deposition envelope, 92–95
- Gas-to-liquids (GTL), 24–25, 27–28
- Gas-to-solids technologies (GTS technologies), 24–25, 28–29
- Gas-to-wire technologies (GTW technologies), 24–25, 29–30
- Gas-well gas, 3–4
- Gas-liquid cylindrical cyclone separator (GLCC separator), 145–146, 146f
- Gas-oil ratio streams (GOR streams), 141
- GCV. *See* Gross Calorific Value
- GHP. *See* Gas horsepower
- GLCC separator. *See* Gas-liquid cylindrical cyclone separator
- Glycol
  - circulate rate, 232–233
  - dehydration, 226–237
    - conventional TEG dehydration process, 227–228
    - enhanced TEG dehydration process, 229–230
    - future technology developments, 237
    - glycol injection process, 230–232
    - operational problems, 235–237
    - TEG unit design considerations, 232–234
  - gas dehydration process, 477
  - injection process, 230–232
  - purity, 234
- GOR streams. *See* Gas-oil ratio streams
- Granulated sulfur, 324
- Graphical user interface (GUI), 484, 513
- Gravity segregation, 137
- Gravity separators, 137–144
  - design considerations, 144
  - general description, 138–140
  - horizontal three-phase separator, 139f
  - selection, 140–142
  - theory, 142–144
  - vertical three-phase separator, 140f
- Gross Calorific Value (GCV), 506
- GSP. *See* Gas subcooled process
- GTL. *See* Gas-to-liquids
- GTS technologies. *See* Gas-to-solids technologies
- GTW technologies. *See* Gas-to-wire technologies
- GUI. *See* Graphical user interface

**H**

- Hagen–Poiseuille equation, 386
- Hazard and Operability Study (HAZOP), 444–446
- analysis, 550
- HCN. *See* Hydrogen cyanide
- HE. *See* Hydrate envelope
- Health, Safety, and Environment (HSE), 518
- Heat exchangers, 476
- Heaters, 403
- Heating value
- natural gas, 387
  - of sales gas, 386
- Hexane plus ( $C_6^+$ ), 5–6
- High-efficiency liquid. *See* Gas coalescers
- High-efficiency liquid–liquid coalescers, 157–162, 160f
- applications, 162
  - emulsions, 157–158
  - limitations, 162
  - liquid–liquid coalescer performance, 161–162
  - mechanism of operation, 158–161
    - coalesced droplets separation, 160–161
    - coalescence, 159–160
    - solid separation /fluid preconditioning, 158–159
  - principles and materials of construction, 158
- High-pressure (HP), 126
- column, 343
  - services, 126
- High-voltage direct current (HVDC), 24–25
- Higher heating value, 6
- HMI. *See* Human Machine Interface
- Holdup, 38–39
- Homogeneous flow approaches, 50–56
- Beggs and Brill method, 52–56
  - Lockhart and Martinelli method, 51–52
- Horizontal flow regimes, 42–44. *See also* Vertical flow regimes
- annular flow, 44
  - dispersed bubble flow, 42
  - plug (elongated bubble) flow, 42
  - slug flow, 43–44
  - stratified (smooth and wavy) flow, 43
- Horizontal separators, 141
- Horizontal three-phase separator, 139f
- Horsepower (HP), 356
- Hot gas bypassing, 307
- Hot pot process, 195
- HP. *See* High-pressure; Horsepower
- HSE. *See* Health, Safety, and Environment
- Human Machine Interface (HMI), 414
- HVDC. *See* High-voltage direct current
- Hydrate
- curve, 70
  - formation, 347
  - prevention techniques, 79–86
    - chemical inhibition, 80–86
    - thermal methods, 79–80
- Hydrate envelope (HE), 95
- Hydrocarbon dew pointing
- control, 207
  - deep, 273–274
  - gas plant with, 125–128, 126f
    - acid gas removal unit, 127
    - condensate stabilization, 127
    - gas compression and transmission, 128
    - gas dehydration unit, 127
    - inlet facility, 125–126
    - nitrogen rejection, 128
    - sulfur recovery and handling unit, 127
  - with Joule–Thomson cooling, 271–272
  - with propane refrigeration, 272
- Hydrocarbon removal processes, 287–289
- membrane separation, 287–289
  - solid-bed adsorption process, 287
  - Twister<sup>®</sup> supersonic separation, 289
- Hydrodynamic slugging, 102–103
- Hydrogen cyanide (HCN), 202
- Hydrogen sulfide ( $H_2S$ ), 11–12, 181, 301
- scavenger, 311–312
    - liquid injection scavenger, 311–312
    - selective  $H_2S$  removal section, 316–317
- Hydrogenation section, 315–316
- Hydrostatic tests, 438

**I**

- I/O. *See* Input–output
- IFPEX-1<sup>®</sup>, 258
- IGCC. *See* Integrated gasification combined cycle
- IGT. *See* Institute of Gas Technology
- In situ velocity. *See* Phase velocity
- Incident analysis, 472
- Inclined flow regimes, 45–46
- Independent protection layer (IPL), 447
- Industrial relevance, 536
- Inflow performance relationship (IPR), 22
- Information, 529
- Inlet diverters, 142
- Inlet facility, 125–126
- Input–output (I/O), 415–416, 461
- Institute of Gas Technology (IGT), 388
- Insulation, 346

Integrated gas plant, 518–519  
 Integrated gasification combined cycle (IGCC), 203  
 Intelligent pigs, 66  
 Internally based methods, 65–66  
 Interstage cooling, 364  
 IPL. *See* Independent protection layer  
 IPR. *See* Inflow performance relationship  
 Iron sponge process, 210–211  
 Isentropic model, 357–360  
 Isothermal gas compressibility, 13–14

## J

Joule–Thomson (JT)  
   coefficient, 15–16, 390–391  
   cooling, 335–336  
   effect, 392  
   valve, 421, 478–479, 534

## K

K-factor method, 70–74  
 Kårstø gas processing plant, 505, 507f  
   implementation and usage, 512–513  
   large energy consumer, 509  
   modeling and optimization strategy, 513–514  
   off-line usage, 515  
   online usage, 514  
   optimization model features, 512  
   plant operation, 506–509  
   plant-wide model, 513  
   process description, 506  
   production objectives, 509  
   project drivers, 509–512  
   quantifying measurement errors, 514–515  
   use for planners, 515  
 Keep-whole contracts, 134  
 Kennelly equation, 391  
 Kerogen, 2–3  
 Key performance indicator (KPI), 526–527  
 Kinetic hydrate inhibitor (KHI), 80–82  
 K<sub>SB</sub>. *See* Souders and Brown  
   design coefficient

## L

Landfill gas, 207  
 Layer of protection analysis (LOPA), 446–448, 447f  
 LDHI. *See* Low Dosage Hydrate Inhibitor  
 Leak detection, 65–66  
 Lean acid gas operations, 307–308  
   acid gas enrichment, 308  
   acid gas/natural gas fuel burner, 308

  feed preheating, 307  
   hot gas bypassing, 307  
 Lean amine feed locations, 192  
 Lean oil absorption process, 279  
 Leveraging automation, 430  
   automation upgrade master plans, 430  
   benefits, 432–433  
 Linde's Clinsulf process, 309  
 Line sizing criteria, 403–404  
 Linear programming technique (LP technique), 427  
 Liquefied natural gas (LNG), 24–26, 124–125  
 Liquefied petroleum gas (LPG), 124, 171  
 Liquid  
   enthalpy, 497  
   injection scavenger, 311–312  
   recovery, 420–422, 478  
 LNG. *See* Liquefied natural gas  
 Load control, 380  
 Lockhart and Martinelli method, 51–52  
 LOPA. *See* Layer of protection analysis  
 Low Dosage Hydrate Inhibitor (LDHI), 80–82  
 Low-temperature separation (LTS), 482  
 LP technique. *See* Linear programming  
   technique  
 LPG. *See* Liquefied petroleum gas  
 LTS. *See* Low-temperature separation

## M

mA. *See* Milliamp  
 MAC. *See* Maximum Available Capacity  
 Maintenance, gas processing plant, 454  
   EAM system, 457  
   RCM, 457–458  
   types, 455–457  
 Man-Technology-Organization (MTO), 533  
 MAOP. *See* Maximum allowable operating  
   pressure  
 Mass transfer zone (MTZ), 244  
 Material balance  
   equation, 19–20  
   model, 502  
 Maximum allowable operating pressure  
   (MAOP), 405  
 Maximum Available Capacity (MAC), 511  
 MDEA. *See* Methyl-diethanolamine  
 MEA. *See* Monoethanolamine  
 Mechanical completion, 437–438  
 Mechanistic models, 56  
 Media velocity ( $V_{med}$ ), 154–155. *See also* Annular  
   velocity ( $V_{ann}$ )  
   effect of system conditions on, 155



- MEG. *See* Monoethylene glycol
- Membrane separation, 287–289
- Membrane systems, 214–217
- membrane process, 216–217
    - advantages, 215
    - disadvantages, 215–216
  - pretreatment system, 217
- Membranes and Twister technology, 258
- MeOH. *See* Methanol
- Mercaptan, 7, 181
- removal, 207
- Mercury, 223
- Mercury removal
- natural gas hydration, 260–262
    - nonregenerative mercury sorbents, 260–261
    - process selection considerations, 261–262
    - regenerative mercury adsorbents, 261
  - NGL, 130
- Merox<sup>®</sup> process, 295
- Metal oxides (MO), 211
- Metering stations, 402–403. *See also* Compressor stations
- Metering system, 403
- Methanol (MeOH), 197, 207–208
- refrigeration, 258
- Methyldiethanolamine (MDEA), 183, 185
- Microbiological treatment processes, 218–219, 314
- Microprocessor-based automation, 414–416
- Milliamp (mA), 461–462
- Minimum housing diameter determination, 156
- Mixed refrigerants, 270–271
- Mixture
- density, 40
  - enthalpy, 41
  - pressure drop, 41
  - velocity, 38
  - viscosity, 40–41
- MO. *See* Metal oxides
- Model-based asset management, 532
- Model-based Predictive Control (MPC), 536
- Modern NGL recovery processes, 281–287.
- See also* Turboexpander NGL recovery processes
  - dual column reflux process, 281–282
  - Fluor twin column high absorption process, 285
  - Fluor twin-reflux absorption process, 285–287
  - GSP, 282–283
  - Ortloff single-column overhead recycle process, 283
  - residue gas recycle, 283–285
- Modified Claus process, 303–309
- lean acid gas operations, 307–308
    - acid gas enrichment, 308
    - acid gas/natural gas fuel burner, 308
    - feed preheating, 307
    - hot gas bypassing, 307
  - oxygen enrichment, 308–309
  - process description, 303–307
    - catalytic section, 305–306
    - Claus burner performance, 306
    - COS and CS<sub>2</sub> destruction, 306–307
    - thermal section, 303–305
- Molecular Gate<sup>™</sup> adsorbent, 336
- Molecular Gate<sup>™</sup> adsorption-based technology, 336
- Molecular sieves, 239–242
- technology, 295–296
- Molten sulfur handling system, 323
- Monoethanolamine (MEA), 183–184
- Monoethylene glycol (MEG), 126, 170, 227
- regeneration and reclaiming, 176–177, 176f
- Moody correlation, 386
- Moody friction factor, 387f, 388
- MPC. *See* Model-based Predictive Control; Multivariable Predictive Controller
- MTO. *See* Man-Technology-Organization
- MTZ. *See* Mass transfer zone
- Multiphase flow assurance, 68–114
- corrosion, 86–90
  - flow assurance risk management, 111–114
  - gas hydrates, 68–86
  - slugging, 102–111
  - wax, 90–102
- Multiphase gas flow, 59–60
- Multiphase pipeline operations, 65–68
- leak detection, 65–66
  - pigging, 66–68
  - pipeline depressurization, 66
- “Multiphase riser base lift” technique, 108
- Multiphase transportation technology, 37
- Multistage separation, 145
- Multivariable predictive control (MVPC), 427–428, 471
- Multivariable Predictive Controller (MPC), 472–473
- Murphree vapor tray efficiency, 497
- MVPC. *See* Multivariable predictive control
- ## N
- N-methyl-2-pyrrolidone (NMP), 197, 208
- Natural gas, 1, 383. *See also* Gas plant project management; Gas processing plant automation; Integrated gas plant

Natural gas (*Continued*)

- chemical and physical properties, 6–15, 7t
  - from coal, 3
  - comparison of methods, 30–33
  - composition and classification, 3–4
  - dehydration, 223
    - glycol dehydration, 226–237
    - mercury removal, 260–262
    - process selection, 259–260
    - processes, 258
    - solid-bed dehydration, 237–258
    - water content determination, 224, 226f
  - exploration and production, 16–23
  - heaters, 403
  - history, 1–2
  - origin and sources, 2–3
  - phase behavior, 4–6
  - processing, 33
    - contractual agreements, 133–135
    - industry, 520
    - objectives, 123–124
    - pipeline gas specifications, 124t
    - plant configurations, 124–131
    - route, 131
    - support systems, 132–133
  - reserves, 16
  - thermodynamic properties, 15–16
  - transportation, 24–33
  - treating, 181
    - chemical absorption processes, 183–195
    - cryogenic fractionation, 218
    - membrane systems, 214–217
    - microbiological treatment processes, 218–219
    - mixed physical and chemical absorption processes, 208–210
    - physical solvent processes, 196–208
    - processes, 182
    - selection, 219–220
    - solid bed absorption processes, 210–214
    - specifications, 181
- Natural gas compression
- antisurge and recycle system, 371f
  - centrifugal compressors, 351–353, 352f
  - comparison between compressors, 353–354
  - compressor
    - control, 367–374
    - design, 364
    - performance maps, 375–376
    - power calculation, 366–367
    - selection, 354–355

- CR, 362–364
  - example for operating compressor in pipeline system, 376–380
  - gas compression thermodynamics, 355–362
  - reciprocating compressors, 350–351, 350f
  - stages, 364–366
- Natural gas fuel burner, 308
- Natural gas hydrates (NGHs), 28
- Natural gas liquid (NGL), 124, 223, 265, 442, 478, 505, 508
- CO<sub>2</sub> removal, 129
  - dehydration, 130
  - fractionation, 292–293, 422, 478
    - column design and operation, 293
  - gas plant for, 128–131
  - hydrocarbon dew pointing
    - deep, 273–274
    - with Joule–Thomson cooling, 271–272
    - with propane refrigeration, 272
  - hydrocarbon removal processes, 287–289
  - liquid product processing, 293–298
    - dehydration, 298
    - NGL contaminant treating, 293–298
  - mercury removal, 130
  - modern NGL recovery processes, 281–287
  - recovery, 130–131, 265
  - refrigeration processes, 266–271
  - selection, 289–290
  - technology development, 290
  - turboexpander NGL recovery processes, 274–279
    - unit design considerations, 291
    - unit operating problems, 291
- Near-infrared equipment (NIR equipment), 93
- Neural network-based
- controllers, 534
  - models, 534
- NGHs. *See* Natural gas hydrates
- NGL. *See* Natural gas liquid
- NIR equipment. *See* Near-infrared equipment
- Nitrogen, 335
- cryogenic nitrogen rejection, 338–345
  - design considerations, 345–346
  - NRU integration, 336–338
  - operating problems, 346–347
  - rejection, 128
    - cryogenic process, 335–336
    - noncryogenic process, 336
    - options, 335
    - safety, 347
- Nitrogen rejection unit (NRU), 335, 434
- with helium production, 338f

integration, 336–338  
 for sales gas production, 337f  
 NMP. *See* *N*-methyl-2-pyrrolidone  
 NOGAT. *See* Northern Offshore Gas Transport  
 Noise, 400–401  
 Noncryogenic nitrogen separation process, 336  
 Noncryogenic process, 336. *See also* Cryogenic  
   nitrogen rejection process  
 Nonregenerative mercury sorbents,  
   260–261  
 Northern Offshore Gas Transport (NOGAT),  
   481–482  
   trunk line system, 482f  
 NRU. *See* Nitrogen rejection unit

## O

Object Linking and Embedding for Process  
   Control (OPC), 416  
 OEE. *See* Overall equipment effectiveness  
 Off-line  
   simulators, 535  
   system, 515  
   usage, 515  
 Oil well gas. *See* Casinghead gas  
 Online model, 483, 513  
 Online-adaptive control, 488  
 OPC. *See* Object Linking and Embedding for  
   Process Control  
 Operating expenditure (OPEX), 397  
 Operational decisions, 530  
 Operationally induced slugging, 111  
 “Operations wall”, 521  
 Operator decision support, 472  
 Operator training, 472  
 Operator training simulator (OTS), 567  
 OPEX. *See* Operating expenditure  
 Optimization, 429–430  
   gas plant assets, 533  
     alternatives, 534–536  
     tools for, 534  
   objective function, 492  
 Organizational behavior model, 519–520  
   behavior, 528  
   capability to perform, 524–526  
   information quality, 520–522  
   levels of readiness, 524f  
   organizational hierarchy of needs,  
     526–528  
   perception of information, 522–523  
   Vollman Triangle, 527f  
 Ortloff single-column overhead recycle process,  
   283

OSHA. *See* U.S. Department of Labor  
   Occupational Safety & Health  
   Administration  
 OTS. *See* Operator training simulator  
 Overall equipment effectiveness (OEE), 454  
 Oxygen enrichment, 308–309

## P

Panhandle  
   “A” equation, 389–390  
   “B” equation, 389–390  
 PC. *See* Propylene carbonate  
 Peng–Robinson equations of state (PR equations  
   of state), 489–491  
 Performance management, 425–426  
 Performance testing, 442  
 Periodic maintenance, 456  
 PHA. *See* Process hazard analysis  
 Phase separation, 137  
   centrifugal separators, 145–146  
   gas coalescers, 150–157, 152f  
   gravity separators, 137–144  
   high-efficiency liquid–liquid coalescers, 157–162  
   multistage separation, 145  
   practical design, 162–165  
     analysis, 164–165  
     case study, 163  
     modified situation, 165, 165f  
     objective and methodology, 164  
     situation, 164, 164f  
   slug catchers, 148–150  
   Twister™ supersonic separator, 146–147  
 Phase velocity, 39  
 PHMSA. *See* U.S. Department of Transportation  
   Pipeline and Hazardous Materials Safety  
   Administration  
 Physical absorption, 418  
 Physical adsorption, 237–238  
 Physical solvent processes, 196–208  
   DEPG, 202–207  
   methanol (rectisol process), 207–208  
   NMP, 208  
   PC, 198–202  
 PID. *See* Proportional, integral, and derivative  
 Pigging, 66–68, 67f  
 Pipe-type slug catcher, 148–149  
 Pipelines, 25  
   depressurization, 66  
   operations, 409–410  
 Piping, 325  
   equipment, 475  
   and valves, 398

Planning interface, 513

Plant

design, 468

APC, 471

control system checkout, 469–470

controllability, 468

operability, 468

operator training, 470

safety analysis, 468–469

safety integrity system checkout,  
469–470

start-up procedure, 469

manager, 547–548

model integration, 502

measurement errors, 502–504

model fidelity, 502–504

operation, 471

APC system, 472–473

incident analysis, 472

operator decision support, 472

operator training, 472

plant performance enhancement, 471

troubleshooting, 471

optimum operation, 489

turnarounds, 464

utility system, 426

Plant Production Performance Model (3PM),  
505, 514

PLC. *See* Programmable logic controller

Plug (elongated bubble) flow, 42

Polytropic compression, 356

Polytropic model, 360–361

Potassium carbonate solution, 195

Power factor, 501

Power loss, 501

PR equations of state. *See* Peng–Robinson  
equations of state

Pre-project planning measurement, 552

Precommissioning, 437–438

Predictive maintenance method, 456

Pressure

control, 346

ratio, 363

reduction and regulation system, 403

relief system, 398

Pressure swing adsorption (PSA), 252, 336

Pressure–volume diagram (PV diagram),  
350–351, 356f

Prevention, 525

Preventive maintenance, 456

Prilled sulfur, 324

Primary thermogenic gas, 2–3

Proactive “life extension” maintenance,  
456–457

Process commissioning, 440–442

Process engineer, 548

Process hazard analysis (PHA), 444

Process safety management (PSM), 437

Processing fee contracts, 135

Production engineer, 548

Programmable logic controller (PLC), 400,  
414, 439

Project

charter, 547

execution planning, 551–552

management, 543

manager, 543, 547

risk management methodology, 558–559

team roles and responsibilities, 547–548

timeline, 555–556

Project coordinator. *See* Project—manager

Propane refrigeration, 266–268

Proportional, integral, and derivative (PID),  
413–414

Proprietary solvents, 316–317

Propylene carbonate (PC), 197–202

FLUOR solvent unit, 198–200

innovations in FLUOR solvent process, 201–202

Protective coatings, 89–90

Proved reserves, 16–17

PSA. *See* Pressure swing adsorption

PSM. *See* Process safety management

PURASPEC<sup>TM</sup> technology, 211

PURASPEC<sup>TM</sup> materials, 260–261

Purchasing representative, 548

“Purisol” process, 208

PV diagram. *See* Pressure–volume diagram

Pyrobitumen, 2–3

## Q

Qualitative project risk management, 560–561

Quality

assurance, 564–565

control, 565

planning, 564

Quantitative project risk management  
assessment, 561

“Quick cycle” units, 242–243

## R

Rationalization, 451

Raw gas transmission  
multiphase flow

- assurance, 68–114
  - design parameters, 49–60
  - regimes, 42–49
  - terminology, 37–41
  - multiphase pipeline
    - operations, 65–68
    - temperature profile prediction, 60–64
    - velocity criteria for sizing, 64
  - RCM. *See* Reliability Centered Maintenance
  - Re. *See* Reynolds numbers
  - Real gas behavior, 361–362
  - Real-time control model, 534
  - Real-time optimization (RTO), 487
    - APC system, 488–489, 488f
    - EDI interface, 490f
    - functions, 489
    - Kårstø gas processing plant, 505–515
    - level, 533
    - model interface, 490f
    - optimization models, 491–502
    - physical properties, 489–491
    - plant model integration, 502–504
    - process plant online economic optimization, 487–488
    - project considerations, 504–505
    - RTS interface, 491f
  - Real-Time Scheduling system (RTS system), 489
  - Reboiler, 236–237
    - duties, 345–346
    - hydraulics, 346
  - Reciprocating compressors, 350–351, 350f, 363, 368, 375, 378–380. *See also* Centrifugal compressors
  - Reciprocating pumps, 423
  - Redox process, 312
  - Reducing gas generator (RGG), 315
  - Reduction, 402–403
    - hydrogenation section, 315–316
    - processes, 314–317
    - selective H<sub>2</sub>S removal section, 316–317
  - Reflux
    - duties, 345–346
    - exchanger, 274
  - Refrigeration, 421
    - models, 499
    - processes, 266–271
      - cascade refrigeration, 268–270
      - mixed refrigerants, 270–271
      - propane refrigeration, 266–268
    - system, 423–424
    - unit, 266–268
  - Regenerator, 236
  - Regulatory risk, 563–564
  - Reid Vapor Pressure (RVP), 169–170, 433
  - Reliability Centered Maintenance (RCM), 457–458
  - Remote control panel, 415
  - Remote Transmission Unit (RTU), 415
  - Reservoir engineer, 548
  - Residue gas recycle, 283–285
  - Responsibility matrix, 552–554, 553t
  - Retrograde condensation, 4–5
  - Return on Capital Employed (ROCE), 518
  - Revenue stream stabilization, 564
  - Reynolds numbers (Re), 156, 385, 388
  - RGG. *See* Reducing gas generator
  - Rhombic sulfur, 301
  - Riser base gas injection, 108–109
  - Riser-induced (severe) slugging, 103–111
    - mechanism, 105–106
    - prevention and control, 107–111
      - control methods, 109–111
      - riser base gas injection, 108–109
      - topside choking, 109
    - stability analysis, 107
  - Risk management, 556–557
    - developing risk response strategies, 559–560
    - interaction with other management processes, 562–563
    - project risk management methodology, 558–559
    - qualitative project risk management, 560–561
    - quantitative project risk management
      - assessment, 561
    - risk matrices, 560f
    - risk mitigation concepts, 563–564
    - risk process modeling, 561–562
    - risk response planning, 559
  - ROCE. *See* Return on Capital Employed
  - Rod loading, 417
  - Rotating equipment models, 492
  - RTO. *See* Real-time optimization
  - RTS system. *See* Real-Time Scheduling system
  - RTU. *See* Remote Transmission Unit
  - RVP. *See* Reid Vapor Pressure
  - Ryan–Holmes process, 218
- ## S
- S3. *See* Slug suppression system
  - Safety
    - analysis, 468–469
    - integrity system checkout, 469–470

- Safety (*Continued*)  
 systems, 133
- Safety instrumented system (SIS), 446
- Sales gas, 506  
 carbon dioxide concentration, 508–509  
 heating value, 386  
 NRU for, 337f
- Sales gas transmission, 33  
 compressor stations, 394–402  
 design considerations, 403  
 compression power, 408  
 compressor station spacing, 404–408  
 line sizing criteria, 403–404  
 gas flow fundamentals, 383–390  
 gas temperature profile prediction, 390–392  
 pipeline operations, 409–410  
 reduction and metering stations, 402–403  
 transient flow in gas transmission pipelines, 392–393
- Salt caverns, 34–35
- SCADA system. *See* Supervisory control and data acquisition system
- SCORE. *See* Single-column overhead recycle process
- SCOT. *See* Shell Claus Off-gas Treating
- Scrubbers, 138, 396
- Secondary thermogenic gas, 2–3
- SEEHT. *See* Skin effect electrical heat tracing
- Selectox process, 310–311
- Selling, general, and administrative (SG&A), 539
- Shell Claus Off-gas Treating (SCOT), 314–315
- Short cycle units, 242–243
- Shutdown system, 398
- Silica gels, 242
- Single-column nitrogen rejection process.  
*See also* Double-column nitrogen rejection process; Two-column nitrogen rejection process  
 classical design, 338–339, 339f  
 modified design, 339–340
- Single-column overhead recycle process (SCORE), 283
- Single-phase flow approaches, 50
- SIS. *See* Safety instrumented system
- Skin effect electrical heat tracing (SEEHT), 323
- Slating, 323
- Slip, 39  
 law, 58  
 velocity, 39
- Slug  
 catchers, 148–150  
 flow, 43–45
- Slug suppression system (S3), 110
- Slugging, 102–111  
 hydrodynamic slugging, 102–103  
 operationally induced slugging, 111  
 riser-induced (severe) slugging, 103–111  
 terrain-induced slugging, 103
- Slurry processes, 213  
 Chemsweet<sup>®</sup> process, 213  
 Sulfa-Check<sup>®</sup> process, 213
- Small- and medium-scale processes, 311–314  
 CrystaSulf<sup>™</sup> process, 313–314  
 H<sub>2</sub>S scavenger, 311–312  
 microbiological treatment processes, 314  
 Redox process, 312
- SNPA. *See* Societe Nationale des Petroles d'Aquitaine
- SO<sub>2</sub> scrubbing processes, 317
- Soave–Redlich–Kwong equations of state (SRK equations of state), 489–491
- Societe Nationale des Petroles d'Aquitaine (SNPA), 185
- Solid bed absorption processes, 210–213  
 iron sponge process, 210–211  
 PURASPEC<sup>™</sup><sub>JM</sub> technology, 211  
 slurry processes, 213  
 zinc oxide process, 211
- Solid desiccants properties, 243, 243t
- Solid-bed adsorption process, 213–214, 287
- Solid-bed dehydration, 237–258  
 adsorbent selection, 238–243  
 adsorption capacity, 238  
 adsorption technology, 243–247  
 adsorption principle, 243–244  
 solid-bed design considerations, 244–247  
 operation, 247–251  
 2 + 2 mode of operation, 250  
 3 + 1 mode of operation, 247–250  
 mode operations, 250–251  
 operational problems, 253–258  
 unit design considerations, 251–253
- Solidification. *See* Wax precipitation
- Solution-diffusion type, 214
- Sorbead<sup>™</sup> gel, 242
- Souders and Brown design coefficient (K<sub>SB</sub>), 143
- Sour  
 gas, 181  
 water stripping, 177–178, 177f
- Spare capacity, 505
- Specific heat, 15
- Specific speed, 495

- SRK equations of state. *See* Soave–Redlich–Kwong equations of state
- SRU. *See* Sulfur recovery unit
- Stabilizer
- column pressure, 173
  - system control, 174
- Standards and protocols, 416
- Start-up procedures, 440, 469
- Statistical analysis, 432
- Statistical process control, 426–427
- Steady-state
- analysis, 479–480
  - detection, 489
  - model, 467
  - process model, 534
  - three-phase flow, 56–57
  - two-phase flow, 50–56
    - homogeneous flow approaches, 50–56
    - mechanistic models, 56
    - single-phase flow approaches, 50
- Steam boiler system, 426
- Steam water system model, 500
- Sterically hindered amines, 186
- Stratified (smooth and wavy) flow, 43
- Stretford process, 211
- Strippers, 492
- Sub-dew-point processes, 318
- Sulfa-Check<sup>®</sup> process, 213
- Sulfrex<sup>™</sup> process, 295
- Sulfur
- condensers, 327
  - degassing, 320–322
  - disposal by acid gas injection, 332–333
  - forming, 323–324
  - handling unit, 127
  - pit, 327
  - properties, 301–302
  - recovery, 302–314, 418–419, 477
  - selection, 331–332
  - storage and handling, 322–324
- Sulfur recovery unit (SRU), 127, 303
- design considerations, 324–327
    - acid gas feed drums, 325–326
    - combustion air blowers, 326
    - main burner and reaction furnace, 326
    - piping, 325
    - waste heat boiler, 326–327
  - operation problems, 327–331
    - carbon deposits, 329
    - catalyst support screens, 330
    - combustion air control, 330–331
    - excessive COS and CS<sub>2</sub>, 329
    - leakage of reheat exchanger, 329
    - proper air ratio, 327–328
    - reactor activity, 328
    - reactor pressure drop, 329
    - steam heater, 330
    - water vapor and carbon dioxide, 330
- Super-compressibility factor, 8, 13–14
- SuperClaus process, 318
- Superficial velocity, 38
- Supervisory control and data acquisition system (SCADA system), 65–66, 132–133, 395, 415, 443
- Support systems, 132–133
- process control, 132–133
  - safety systems, 133
  - utility and off-site, 132
- Surfactants, 157–158
- Sweet gas, 181
- ## T
- Tactical decisions, 530–531
- Tail gas cleanup, 314–319
- catalytic oxidation, 318
  - reduction processes, 314–317
  - SO<sub>2</sub> scrubbing processes, 317
  - tail gas treating configurations, 318–319
    - integration with AGEU, 319
    - integration with AGRU, 319
- Tail gas treating unit (TGTU), 305
- Tank design considerations, 178–179
- Tank emission control, 180
- TCHAP. *See* Twin column high absorption process
- TEG. *See* Triethylene glycol
- Temperature control, 346
- Temperature swing adsorption (TSA), 252
- Terrain-induced slugging, 103
- Tetraethylene glycol, 227
- TFM. *See* Two-fluid model
- TGs. *See* Turbogenerators
- TGTU. *See* Tail gas treating unit
- Thermal methods, 79–80
- Thermodynamics
- expander, 494f
  - gas compression, 355
    - basic relations, 356–357
    - isentropic model, 357–360
    - polytropic model, 360–361
    - real gas behavior, 361–362
  - inhibitors, 80–83
  - second law, 359–360
- Thiol. *See* Mercaptan

THIOPAQ<sup>™</sup> process, 218, 219f, 314

Three-phase flow regimes, 48–49. *See also* Two-phase flow regimes

“Tie-back” model, 470

Time and expense contract, 548–549

Time-based maintenance, 456

Titanium oxide (TiO<sub>2</sub>), 306–307

Topside choking, 109

TPC. *See* Tubing performance curve

Transient flow

- in gas transmission pipelines, 392–393
- multiphase flow, 57–59
  - DFM, 58–59
  - TFM, 57–58

Transportation tariffs, 32f

TRAP. *See* Twin reflux absorption process

Tray-to-tray distillation models, 496–498

Triazine, 312

Triethylene glycol (TEG), 130, 227

- unit design considerations, 232–234

Troubleshooting, 458

- documentation, 461
- instrumentation, 461–463
- process troubleshooting, 463
- steps, 459–461

Troubleshooting, 471

True Vapor Pressure (TVP), 169–170

Trunk line online dynamic model, 481–485

TSA. *See* Temperature swing adsorption

Tubing performance curve (TPC), 22–23

Turbine model, 500–502, 500f

Turboexpander NGL recovery processes, 274–279

- BAHXs, 278–279
- lean oil absorption process, 279

Turboexpander process. *See* Cryogenic recovery

Turbogenerators (TGs), 478–479

Turbomachinery control, 475

Turn-key project. *See* Fixed fee price

Turndown, 371

TVP. *See* True Vapor Pressure

Twin column high absorption process (TCHAP), 285

Twin reflux absorption process (TRAP), 286

Twister<sup>™</sup>

- separation, 289
- supersonic separator, 146–147

Two-column nitrogen rejection process, 343–344, 343f. *See also* Double-column nitrogen rejection process; Single-column nitrogen rejection process

Two-fluid model (TFM), 56–58

Two-phase flow regimes, 42–48

- flow pattern maps, 46–48
- horizontal flow regimes, 42–44
- inclined flow regimes, 45–46
- vertical flow regimes, 44–45

Two-stage absorption process, 189–190

## U

U.S. Chemical Safety and Hazard Investigation Board (CSB), 448

U.S. Department of Labor Occupational Safety & Health Administration (OSHA), 437

U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA), 443

Unconventional gas. *See also* Conventional gas

- completion, 21
- drilling, 21
- exploration, 20
- production, 21–22
- resources, 3

Underground gas storage, 33–34

- aquifers, 34
- depleted reservoirs, 34
- salt caverns, 34–35

## V

Validity checking, 503

Valves, 474–475

Vapor enthalpy, 497

Vapor-solid equilibrium constants, 71–72

- carbon dioxide and hydrogen sulfide, 76f
- isobutane, 74f
- methane and ethane, 72f
- for n-butane, 75f
- propane, 73f

Vapor-liquid equilibrium definition, 497

Variable speed planetary gear (VSPG), 396–397

Venting system, 398

Vertical flow regimes, 44–45. *See also*

- Horizontal flow regimes
- annular flow, 45
- bubble flow, 45
- churn (transition) flow, 45
- slug flow, 45

Vertical separators, 141–142

Vertical three-phase separator, 140f

Vessel-type slug catchers, 148–149

Vetrocoke process, 195

Virtual Private Network (VPN), 521



Void fraction, 39  
Volatile organic compound (VOC), 227–228  
Vollman Triangle, 527, 527f  
Volume Optimized Transport and Storage  
(VOTRANS<sup>TM</sup>), 27

## **W**

Waste heat boiler (WHB), 303–304, 326–327  
Water  
    content determination, 224, 226f  
    refluxing, 256  
    wash trays, 191  
    water-washing process, 138–139  
Wax, 90–102  
    controlled production of wax deposits,  
        101–102  
    deposition, 90–95  
        gas-condensate wax deposition envelope,  
            92–95  
        inhibition/prevention, 98–100  
        problems identification, 97–98  
        remediation, 101  
    WDE, 91–92

    formation in multiphase gas-condensate  
        pipelines, 95–102  
    precipitation, 90–91  
    slush, 99  
Wax deposition envelope (WDE), 91–92  
Wax precipitation, 90–91  
Web-based optimization, 535  
Well deliverability, 22–23, 23f  
Wet-prilled sulfur, 324  
Weymouth equation, 388–390  
WHB. *See* Waste heat boiler  
Wobbe Index (WI), 6, 482–483, 506  
Wobbe number, 6

## **Y**

Y-Grade, 265, 266t

## **Z**

Z-factor, 8–11  
Zeolites. *See* Molecular sieves  
Zinc oxide process, 211