Index

A

abnormal situation management (ASM), 724 absorption, 108, 205–206, 254, 292, 323 (figure) absorption process, 292 acid, 161, 163, 167. See also specific acids acid corrosion, 440. See also naphthenic acid corrosion acid dew point, 336 acid gas, 250, 252-254 acid rain, 712 (table) acid sites, 229-230 active matrix, 146-147 activity-based management (ABM), 739-740, 740 (figure) additives fluid catalytic cracking (FCC), 149 (figure), 149-152 fuel, 476-477 gasoline, 476 See also specific additives Advanced Energy Initiative, 756 advanced process control (APC), 13, 362-364, 375, 689, 744. See also instrumentation; process control advisory system, 391 (figure) Africa crude oil reserves of, 43, 43 (figure), 45 (figure), 46 energy sources and, 770 (table) natural gas and, 48, 48 (figure), 50 (figure), 51 (figure), 64-65 oil imports and, 774 (table) refining in, 68-69, 609 (table), 612 (table), 613 (table) See also specific countries agricultural feedstock, 752, 754-755, 759-760, 762 (table), 763 agricultural land-use, 751, 752, 766 air cooled exchangers, 328-229, 330 (table) air fin fan coolers, 413 air grid, 142–143, 143 (figure) Albermarle technology, 231-232, 232 (table), 234 (table) algorithms genetic, 537, 678-682 optimization, 483 See also computer-aided process operations; mathematical methods alignment, 397-399, 398 (figure), 399 (figure) alkaline stress corrosion cracking (SCC), 443 alkanes, 21-22, 22 (figure), 80 (figure), 86 (figure), 159 alkenes, 22 AlkyClean[™] process, 212, 213, 237 (table) alkylation, 103, 113-114, 114 (figure), 115 (figure), 121 (table), 626 (table), 628 alkylbenzenes, 86 (figure) alkylbenzothiophene, 198 alkylcylopentanes, 86 (figure) Alkylene[™] process, 114, 210–213, 211 (figure), 212 (figure), 212 (table), 237 (table) alkylthinophenes, 198, 200 alloy analysis, 409 alloy N04400, 438 alternative energy, 769. See also biofuels; ethanol; specific sources

alumina Al₂0₃, 154, 224 γ -alumina, 236 catalyst technology and, 229-230, 246 American Gas Association (AGA), 558 American Petroleum Institute (API), 80, 89 105 (table), 562-563, 714. See also specific API standards American Petroleum Institute (API) gravity, 26, 773 (figure) American Society of Mechanical Engineers (ASME) standards, 550, 551, 561 American Society for Testing and Materials (ASTM), 88. See also specific ASTM standards amine, 74, 252-254, 253 (figure) amine sweetening unit, 75 (figure) ammonium corrosion, 440 ammonium chloride salts (NH₄Cl), 437 amorphous oxide, 163 angular misalignment, 398 (figure) antiknock compounds, 476 aniline point, 86 anti-icing additives, 476 anode coke, 117 antifriction bearings, 395 APCI single mixed refrigerant process, 268 AP-X® process, 264, 265 (figure) aquafuel technology, 793-794 aqueous effluents, 702 (table), 703, 704-705 (table), 808 (figure) area target setting, 663 aromatics, 22-23, 23 (figure), 30, 203, 462 (table), 474, 777-780. See also monoaromatic hydrocarbons; polyaromatic hydrocarbons (PAHs) artificial neural nets (ANN), 388, 391, 391 (figure) Asia crude oil reserves of, 43, 43 (figure), 45 (figure), 46 diesel fuel quality and, 95 energy sources and, 770 (table) natural gas and, 48 (figure), 50 (figure), 51 (figure), 65 oil imports and, 774 (table) refining in, 58, 71, 72 (table), 609 (table), 612 (table), 613 (table) Aspen MBO (Multi-Blend Optimization), 694 (table) Aspen PIMS (Process Industry Modeling System), 694 (table) Aspen Technologies, 694–695 (table) Aspen XT, 694 (table) asphalt, 29-30 asphaltene, 23 (figure), 60-61, 109, 179-180, 182 (table), 777-780, 778 (table), 790 (figure) Association Française de Narmalisation (AFNOR), 89 ASTM D975-09a, 95 (table) ASTM D1655-07, 94 (table) ASTM D2699, 460, 461 ASTM D7170, 460 ASTM subcommittees, 460 ASTM test methods, 457, 458-459 (table), 460-461, 462 (table)

Athabasca bitumen, 215 (figure), 216 (table) atmospheric distillation, 4 (figure), 4 (table), 6, 7 (table), 8 (table), 25-26, 61 (figure), 121 (table), 606 (table) atmospheric emissions. See emissions; specific emissions atmospheric residue (AR), 233 See also bottom-of-thebarrel upgrading atmospheric unit, 380 attrition index (AI), 153-154 Australia, 94 (table) Auto Oil Programme, 92 automated control systems, 724-725 automatic tank gauging system (ATGS), 485 automation. See process automation automation effectiveness index, 494-495 automation incentives, 516-519 autothermal reforming (ATR), 277-278, 278 (figure) aviation fuel, 95 (table) axial compressor, 346

В

backcasting, 660 backwashing filter, 351, 352 balanced scorecard, 735 baseload plants, 261-262 basis refinery production (BRP), 664-665 basket pricing, 588 (table) batch distillation, 310-311 bearing fitting tool kit, 400 bearings, 395, 400 behavioral safety, 721 benchmarking, 733 (figure), 733-734 benefits model equation, 517 benzene, 22, 23, 103, 108, 109, 112, 113 best practice, 733 (table), 733-734, 734 (figure) bias, 461, 479, 480 (figure) binder pitch, 214 bioalcohols, 31 biobutanol, 759 bio-crudes, 764 biodiesel (FAME), 19 (table), 31, 54, 65-66, 66 (table), 752 production of, 757 (table), 759-763, 760 (figure), 761 (figure) quality control and, 461 specifications of, 96, 98 (table), 762 (table) bioethanol, 55, 754 biofuel, 31, 53, 26, 53-54, 747, 750 (figure), 752-753, 753 (figure), 766, 776 (table) demand for, 747-749, 749 (figure) economics of, 746-766, 765 (figure) production of, 54-55, 55 (table) regional consumption of, 66 (figure), 66 (table) sustainability and, 749-752 technology, 792-793, 794-795 for transportation, 753-754, 761 (table) See also biodiesel; bioethanol; ethanol biogas, 31 biohydrogen routes, 292 biomass, 749, 751, 752, 763-764 characteristics of, 53-54, 776 (table) technology, 792-793, 794-795 See also biodiesel; biofuel; agricultural feedstock biorefineries, 18-19

biosolid waste, 702 (table), 703 bitumen reserves, 46, 177, 178 (figure) black oils, 24, 25 (table), 26 blend equation, 483 (figure) blend headers, 492-493 blend nonlinearity, 477-480 blend water, 758 blending, 6, 90-91, 120, 457-458, 523-529, 524 (table), 526 (figure), 527 (figure), 528 (figure), 529 (figure) biofuels and, 753, 754, 757-759 configurations, 474 (figure), 484 (table) 485 (figure) instrumentation and, 485, 486 (figure), 486 (table) models, 477-481, 480 (figure) planning and, 491 (figure), 544 quality analysis and, 487 (figure) scheduling, 691, 692, 693 system, 483-490, 484 (figure), 484 (table), 486 (figure), 488 (figure), 489 (figure), 490 (figure) variables, 482 See also fuel blending block flow diagram, 276 BOG, 269, 270 boiler fuel, 214 boiler inspection, 427 boiling point, 4 (table), 6, 19 (table), 26, 27 n-alkanes and, 80 (figure) properties of, 79, 86 (figure) separation process and, 102 boil-off-gas (BOG), 256 bolt tensioners, 399 bonding systems, 404-405 boot, 344 Bohpal, India, 717-718 boroscopic/fiberoscopic inspection, 409 bottom-of-the-barrel upgrading, 233-237 box-type reformer, 240-241 Brazil, 754 breakdown maintenance, 393 breech lock exchanger, 413 bubble cap tray, 318 bucket and weir, 342, 344 bullet tank, 499 burns, 719-720 busbars, 403 business process, 732-733, 742, 743 (figure). See also markets; process control; refining industry butane, 21, 31, 115 butanol, 31 butene, 114. See also isobutene byproducts, 8 (table), 19. See also petroleum coke; specific products

С

cables, 403 cake feed, 118, 119 (table) calcinated coke, 98, 99 (table) calculated cetane index (CCI), 86, 462 (table) California Reformulated Gasoline specifications (CaRFGH), 92 California, 748–749 Canada, 46 crude oil and, 187 (table) gasoline quality and, 93–94

INDEX

803

heavy oil processing and, 191-192 refining in, 612 (figure) Canadian tar sand bitumen, 783 (table) capability assessment, 466 (figure) capacity cost, 592 capacity creep, 601 capital expenditures (CAPEX), 563 carbon dioxide (CO₂) emissions, 66, 712 (table), 713 (table), 713, 714, 714 (table), 750-751, 775 (figure), 775-776 biofuels and, 749, 751 sulfur and, 119 carbon monoxide, 719 carbon rejection, 9. See also solvent separation; thermal treatment carbon residue (CR), 86-87 carbon steel, 446 carburization attack, 446-447 cartridge filter, 351, 352 catalyst slide valve, 137 (table) catalyst, 1, 8, 9, 152, 236 (figure), 239 (figure), 245, 246 bottom-of-the-barrel upgrading and, 233-237 commercial, 164-165, 167-171, 168 (table), 226-227, 230 (table), 241 (table) conversion and, 72, 237 design, 147-149, 148 (figure) desulfurization and, 64, 202-203, 225-227 fixed-bed reactors and, 189-190, 278 fluid catalytic cracking (FCC) and, 129, 142 (figure), 144-149, 146 (figure), 147 (figure), 148 (figure) hydrodesulfurization (HDS) and, 201, 206, 210, 213, 225 (table), 225-230, 226 (figure), 226 (table), 244-245 hydrogen production and, 239-243 monitoring of, 152-153 properties of, 152 (table), 153-155, 154 (figure) reforming, 385 (figure) residuum hydrotreating and, 235 (figure), 235-237, 237 (figure) solid acid and, 237 (table), 237-239 supports and, 243-246 VGO hydrotreating and, 230-233 See also Co(Ni)-Al₂O₂; specific catalysts; zeolite catalytic conversion, 72, 103, 121, 208 (figure). See also catalyst; desulfurization; fluid catalytic cracking (FCC); hydrodesulfurization; hydroprocessing; isomerization catalytic cracking. See fluid catalytic cracking (FCC); hydrocracking; specific cracking methods Catalytic Crude Upgrading (CCU™), 224 catalytic fixed-bed process. See fixed-bed process catalytic hydrocracking. See hydrocracking catalytic isomerization. See isomerizatiaon catalytic pretreatment, 226-227, 227 (figure). See also fluid catalytic cracking pretreatment (FCC-PT) catalytic reforming, 60, 102, 111-113, 113 (figure), 114 (figure), 121 (table), 626 (table), 627. See also catalytic reforming unit (CRU) catalytic reforming unit (CRU), 383-385 Catalytic Research Associated (CRA), 197 catalytic technology, 232 (table), 233, 380-385. See also specific processes; specific technology catalytically cracked gasoline (CCG), 198-202, 198 (table), 199 (table), 201 (figure) hydrodesulfurization (HDS) and, 201-202, 227-228

caustic stress corrosion cracking (SCC), 442-443 caustic sodium hydroxide (NaOH), 442 Central America. See South and Central America centralized control, 355 centrifugal compressor, 346, 348 (figure) centrifugal pump, 348-350, 416 cetane index (CI), 203 cetane number (CN), 86, 462 (table), 474-475 CFHT/HyC-10, 207 (table) C/H ratio, 82 change management, 736 (table), 736-737 chargers, 405 Chemical Safety and Hazard Investigation Board (CSB), 720, 722 Chen's friction factor equation, 555 Chevron, 172, 189. See also ISOCRACKING Chiba, 71, 217, 796 Chiyoda, 217-218 chloride stress corrosion cracking (SCC), 442 chloride, 440 chlorination, 161 chromatography, 82. See also specific types civil maintenance, 407-408 cladded columns, 411 clathrates, 282 Claus process, 120-121 clay-based catalysts, 223 Cleveland Open Cup method, 84 Climate Challenge Programs, 714 Closed Tag method, 83-84 cloud point, 84-85, 85 (table), 462 (table) CO combustion promoter, 150-151, 152 Co/(Co+Mo) ratio, 225, 226 (figure) coal, 5 (figure), 5, 23, 52-53, 763, 776 (table) consumption of, 52-53, 54 (figure) history of, 35 processing of, 76 production of, 54 (figure) coal-bed methane (CBM), 42 cobalt, 226 (figure); hydrotreating and, 232 coke combustion, 131-132, 132 (figure); regeneration and, 141-142 coke. See also petroleum coke; specific coke types coke-laid-down catalyst, 152 coking refineries, 614, 615 coking, 117-119, 118 (table), 119 (table), 121 (table) cost and, 626 (table) delayed, 184-185, 184 (figure), 185 (table) flexi-, 185 fluid, 185, 186 (table) hydrodesulfurization and, 226–227, 227 (figure) refineries, 614, 615 cold filter plugging point (CFPP), 462 (table) Colebrook equation, 555, 557, 558, 559-560, 568 column commissioning, 319 column inspection, 411 combined reformer, 278 combustion, 150-151, 334-335 commercial catalyst. See catalyst, commercial commercial scheduling, 544 commercial simulation, 322, 648 (figure) commercial software, 641-643 Co-Mo/γ-Al₂O₃, 225, 229 (figure)

CoMoS phase, 229 companies. See refining companies complex refineries, 613 complexity index, 625 (table) compositional analysis, 81-83 compressed natural gas (CNG), 74, 279-281, 549-550 compressibility, 250, 260, 279 compressor, 345-348, 348 (figure), 569 compressor map, 347-348, 348 (figure) computational approach, 636 computational fluid dynamics (CFD) model, 670 computer-aided process operations, 685, 686-696, 687 (figure) developments, 693 instrumentation for automation and, 686, 696-698 See also computer process control refining units; computer systems computer process control refining units, 357-377, 376 (table), 388-391 catalytic processing and, 380-385 coking, 386-387 hydrocracking and, 385-386 See also computer systems; computer systems computer systems, 686 blending and, 490–492 future considerations and, 795-796 personal, 647 pipeline equations and, 554 process operations and, 685, 686-698, 687 (figure) See also computer-aided process operations; computer process control refining units; software concarbon (CCR), 187, 462 (table) condition monitoring, 402 conductivity, 309 C-1/2Mo steel, 449 ConocoPhillips, 263-264, 606 Conradson carbon (CCR), 133 consumption. See energy consumption contaminant control, 230-231, 231 (table), 515 natural gas and, 251-252 technology, 274 (figure), 275 (table) contamination. See contaminant continuous catalyst regeneration (CCR), 112 continuous compressor, 345, 346. See also compressor continuous distillation column, 312 (figure) contract pricing, 588 (table) contracts, 578 (table). See also refining economics control loop, 356 (figure), 485 control matrix, 480 control problems, 366 control process. See process control control schemes, 357-362 control valve, 357, 360-362 (table) conventional reserves. See crude oil, conventional, reserves; natural gas, conventional, reserves conversion process, 102 (figure), 103, 110-119, 112 (figure), 113 (figure), 114 (figure), 115 (figure), 116 (figure), 117 (figure), 597. See also catalytic conversion; fluid catalytic cracking (FCC); specific processes cooler arrangement, 142 (figure) copper, 155 correlation index, 88

corrosion, 14, 23, 414 dry, 443-445 inhibitors, 476 prevention and, 450-451, 726 rates, 447-449 resistance, 438 wet, 437-441 See also specific types corrosion-resistant material, 438, 439 Coselle[™], 280 cost. See refining economics cost control, 739 cost estimation, 621 cracking refineries, 613-614, 614 (figure) creep, 409, 446, 601 crisis management systems, 688 critical equipment, 396 critical vapor locking index (CVLI), 83 crude atmospheric tower, 381 (figure), 381 (table) crude distillation unit (CDU), 104–107, 106 (figure) crude oil assays, 89, 90 (table), 660 blending, 524-525, 526 (figure), 527 (figure). See also blending characteristics of, 1, 2-3, 2 (figure), 3 (table), 42, 651 (figure), 774, 779 (figure), 780 (figure) consumption of, 53 (table), 56–57, 57 (figure) conventional, 55, 56 (figure) conventional, reserves, 35 (table), 42-45, 43 (figure), 44 (figure), 45 (figure), 46 (figure), 769 desalting units, 306. See also desalting units distillation, 771 (figure) production of, 2, 51-52, 51 (figure), 52 (figure), 53 (figure), 56 (figure), 56 (table) products, 4 (figure) quality of, 89, 466-467, 649-650, 650 (figure), 777-780. See also quality control refining of, 6, 7 (table), 9 (figure) streams, 649; sulfur content in, 119; supply, 581, 598, 599 trade, 577-580, 578 (table). See also markets unconventional, reserves, 46, 46 (figure), 47 (figure) upgrading, 780-790, 790 (figure), 791 (table), 780-785 See also crude oil refining; heavy crude; heavy oil; light crude; markets, crude oil trade and; petroleum products; pricing, crude oil and; reserves-toproduction ratio (R/P) Crude Oil Entitlement Program, 600 crude oil refining, 124-125, 380 evolution of, 121-124, 121 (figure), 122 (table), 122 (figure), 123 (figure), 124 (table) flow and, 102 (figure), 102-103 history of, 101, 121 (figure) objectives of, 101-102 process of, 103-121, 105 (figure), 106 (figure), 109 (figure), 110 (figure), 112 (figure), 113 (figure), 114 (figure), 115 (figure), 116 (figure), 117 (figure), 122 (figure) scheduling and, 543-544, 544 (table) See also computer process control refining units; crude oil; process control; refining; refining process crude overhead units, 437, 438 crude vacuum tower, 382 (table)

cryogenic energy, 271–272, 272 (table) cryogenic separation, 272, 294–295, 295 (figure), 297 (figure) cryoscopy method, 81 C3–C4 olefins, 113 C3-MR process, 262–263, 236 (figure) Cu corrosion, 462 (table) cubic equation of state, 250–251 culverts, 407 customer relations management (CRM), 464, 469 Cu-Zu-Al type catalysts, 243 cycloalkanes, 22 cyclone device, 345 cyclones, 137 (table), 143, 145 (figure) cylindrical tanks, 499, 500 (figure), 510 (figure)

D

DAO, 18 Darcy-Weisbach equation, 552 dead legs, 440-441 deasphalted oil (DAO), 107, 109-110 deasphalting, 109-110, 110 (figure), 121 (table), 18 debottlenecking, 666 decane, 166 (table) decision making, 633, 635, 676, 686, 687 (figure). See also computer-aided process operations; refinery planning deepwater projects, 52 dehydration, 255-257, 255 (figure), 256 (table), 257 (figure), 257 (table) dehydration unit, 255 (figure), 257 (figure) delayed coker unit, 386-387, 389 (figure), 389 (table) delayed coking, 117-118, 118 (table), 119 (table), 184-185, 184 (figure), 185 (table) demand, 3, 598, 599, 773 (figure) evolution of, 122 (table), 609 (figure) global, 776 natural gas and, 5-6, 75-76 transportation fuel and, 61-67, 63 (figure), 64 (figure) See also biodiesel; crude oil; diesel; gasoline; natural gas; petroleum; utilization Demet catalysts, 230, 231 demulsifiers, 476 denitrogenation, 228 density, 80, 203, 462 (table), 506 deposit-control additives, 476 desalting, 6, 25, 103-104, 105 (figure) desalting units, 306-309, 307 (figure), 308 (figure) desulfurization, 62-64 cost of, 67 of diesel fuel, 202-203, 227-229 of gas oil, 228-229 reactor, 204-206, 209 (figure) See also hydrodesulfurizaton (HDS); sulfur content deterministic model, 637-640, 638 (table), 639 (table), 640 (figure), 642–643 dew point, 27 dewaxing, 108-109, 109 (figure), 121 (table), 172-173, 174 dibenzothiophene (DBTs), 228 diesel, 19 (table), 29, 474-476 catalysts and, 227-230 fuel grades, 94-96, 95 (table), 96 (table) hydrodesulfurization (HDS) and, 202-206, 202-203, 203 (figure), 205 (figure), 245 (figure)

specifications for, 761 (figure) sulfur content and, 119 (table) supply and demand, 62-65, 65-66 synthetic, 64-67, 752, 763-764 ultralow sulfur, 62-64, 792 vield, 224 See also biodiesel; natural gas, as transportation fuel diesel index (DI), 86 diesel oil, sulfur-free, 229 Dimersol®, 115 dimethyl disulfide (DMDS), 189 dimethylether (DEM), 752, 764 Direct DeSulfurization site (DDS), 210 discrete optimization method, 543 disengagement theory, 337 dissolved gas, 350 distillation, 104-108, 106 (figure), 106 (table), 203, 462 (table), 476, 597 batch, 310-311 biofuel and, 762 capacity, 606, 610 cost of, 626 (table) extractive, 372-373 flash, 310 (figure) with reflux, 311-313 temperature, 782 (figure), 783 (figure) See also distillation columns distillation column, 106–107, 313 (figure) design of, 309-313, 311 (figure), 312 (figure) energy requirements and, 314-315 multicomponent systems and, 313-314, 313 (figure), 315 (figure) operational aspects and, 317-319 size calculations and, 319-322 tray, 312 (figure), 317 (figure), 318 (figure) See specific column types; distillation column tray distillation model, 654-655 distillation point, 474 distillation unit, 62 (figure). See also atmospheric distillation; distillation column; vacuum distillation distributed control system (DCS), 355, 366, 489, 686, 687, 688, 698 DMR high performance random packing, 318 (figure) DMTP high performance random packing, 318 (figure) downflow distribution devices, 209 (table) downside risk, 634 (figure), 636 downstream process, 732 (figure) drag reducers, 476 drainage system, 407 Dranchuk and Abou-Kassem correlation, 568 drill down, 736 (figure) dry gas, 24 Dual Independent Expander Refrigeration Cycle (Niche LNGSM), 268 dual mixed refrigerant (DMR), 266 DuPont, 479, 480 (figure) DuPont interaction coefficients, 478-480 dye penetrant test, 408 dyes, 476 dynamic compressor, 346 dynamic model, 65 (figure), 668 dynamic pump, 348 dynamic simulation, 670

Е earthing systems, 404-405 eddy current examination, 409 efficiency, 335-336 ejectors, 346 electrical systems, 401-406 electricity generation, 41 (figure) electrolysis of water, 291 electrostatic desalter, 307 (figure) elemental analysis, 82-83 emission reduction, 71, 701, 703, 706 (table), 708, 709, 710 (table), 713-714. See also specific emissions emissions, 702, 703, 710-711 (table), 712 (table), 713-714, 714 (table). See also carbon dioxide (CO₂) emission; emission reduction; fugitive emissions; greenhouse gas (GHG) emission; nitrogen oxide (NO_v) emission; particulate emission; refineries, emissions of; sulfur oxide (SO_v) emission emulsion stability, 309 end point (EP). See final boiling point (FBP) energy balance, 551-552, 793. See also pipelines, flow equations and energy consumption, 601 (figure) current, 35-39, 36 (figure) 37 (figure), 38 (figure), 39 (figure), 40 (figure) biofuel, 66 (figure), 66 (table) chemical, 289 (figure) coal, 52-53, 54 (figure) crude oil, 53 (table), 56–57, 57 (figure), 177, 178 (figure) distillates and, 288 (figure) by fuel, 35, 37 (figure), 38 (table), 38-39 future, 39-41, 39 (figure), 40 (figure), 41 (figure) hydrogen, 203 natural gas, 72, 74 (figure), 787 (table) regional, 65 (figure) sources, 41 (figure) transportation fuel and, 61-67, 63 (figure), 64 (figure), 65 (figure) See also demand; energy consumption; specific countries; specific regions energy dependence, 38 (figure). See also energy balance; energy consumption energy efficiency, 39, 735 energy equivalency, 36 Energy Independence and Security Act (EISA), 748 Energy Information Administration (EIA), 617-619 energy monitoring, 218 (figure) energy-saving, 216 (table) energy sharing, 216-219, 218 (figure) energy supply, 3-6. See also energy balance EnerSea, 280 engineering management and, 745 process, 665-668 safety and, 724 environmental impact, 18 assessment, 709, 713 fluid catalytic cracking (FCC) and, 224-225 gasoline and, 91-92 heavy oil processing and, 181, 183, 185, 190 (table) transportation and, 159 See also desulfurization; emissions; environmental regulations; hydrosulfurization (HDS); sulfur content environmental impact assessment study, 709, 713 environmental issues, 407, 701-702 environmental legislation in the European Union, 288 (table), 748 sulfur content and, 227 Environmental Protection Agency (EPA), 62 diesel regulation and, 119-120 gasoline regulation and, 91 hazardous chemicals and, 722-723 risk management program of, 723-724 environmental regulation, 62-64, 71-72, 703, 714 (table), 776 air pollutants and, 703, 713-714. See also specific emissions aqueous effluents and, 703 biofuels and, 748 cost and, 701 European Union and, 71, 748 refineries and, 71-72 standards of, 750 sulfur and, 119 (table), 119-120, 464 transportation fuels and, 777 (figure) wastewater and, 709 (table) See also Environmental Protection Agency (EPA); greenhouse gas emission epoxy coating, 408 equations flow, 551-560, 554 (figure), 556 (figure), 558 (table), 559 (figure), 565-570, 571-573 velocity, 561-562, 563 equations of state (EOS), 653 equilibrium catalyst (e-cat), 152-153, 152 (table), 153 (figure), 153 (table), 153-155 equipment spacing, 726 equipment, 680 (table) design, 11, 13, 237, 366, 444 electrical, 402-406 hazardous area, 406 inspection, 411 (table) refinery, 399-400, 409-410; test, 467-468 troubleshooting and, 666 See also instrumentation error prediction, 463 estimation, 628-629 ethane, 21, 22, 26, 258 ethanol, 31, 55, 92 ether, 626 (table), 628 ethyl alcohol (EtOH), 751, 752 (table), 752, 754, 759 blends, 757-758 fuel properties of, 756 (table), 76-757 handling of, 758-759 Eureka process, 213–215, 312 (figure), 215 (figure) Europe crude oil reserves of, 43, 43 (figure), 45 (figure), 46 energy sources and, 770 (table) environmental regulations and, 288 (table) gasoline quality and, 92, 93 (table), 288 (table) natural gas reserves of, 48, 48 (figure), 50 (figure), 51 (figure) product imports and, 71, 774 (table) refining in, 70-71, 71 (figure), 103, 123, 609 (table), 610, 612 (table), 613 (table) safety incidents in, 717

European Biofuels Technology Platform, 750-751 European Commission, 95 exchange of futures for potential (EFP), 587 (table) exchangers, 326-329, 328 (table). See specific types existing gum, 462 (table) expected gross refinery margin (EGRM), 636, 640-641 explosion proofing, 725 explosions, 717-718 export-import parity, 590 ExSact[™] process, 213 extraction unit, 324 (figure), 325 (figure) extractive distillation (ED), 372-373, 374 (figure) ExxonMobil, 197, 623, 625 (table), 695 (table) hydrodesulfurization (HDS) and, 201-202 hydroisomerization and, 171-173 F facility siting, 726 failure analysis techniques, 396-397 failure mode effects analysis (FMEA), 396-397 failure mode effects and critical analysis (FMECA), 396-397 Fanning friction factor, 553-554 fatty acid composition, 757 (table), 760 (figure), 761-762 fault detection, 688, 689 FBATM process, 21, 212 (figure), 237 (table) alkalation and, 238 feed. See feedstock feed nozzle, 136-138, 137 (table), 138 (figure) feed plate heat exchanger, 413 feedstock, 3, 7 (table), 8 (table), 151 (figure), 661, 662 (table) agricultural, 752, 754-755, 759-760, 762 (table), 763 density, 132-133, 133 (figure) desulfurization and, 204 distillation and, 107-108 fluid catalytic cracking (FCC) and, 132 (table), 132-133, 133 (figure), 148

hydrodesulfurization (HDS) and, 203, 228–229, 229 (figure) oil and, 180–181, 228–229, 229 (figure)

petrochemical, 29, 224

quality, 617 (figure), 660, 777–780. See also crude oil, quality of
refining and, 72, 111–113, 613–614, 614 (figure), 637
residue, 198
selection, 737
testing of, 455, 659
ultra-heavy conversion, 224
See also biomass; cake feed; feed density
Fe-Powder test, 448
fibre reinforced plastic (FBR[™]), 280, 281 (figure)
50%/50% mixture method, 479–480

filtration, 351–352. *See also* distillation final boiling point (FBP), 79

financial reporting, 617–619

financial reporting, 617–619 financial risk management, 17, 633–634 (figure), 635 (figure), 636 (figure) finishing process, 102 (figure), 103, 119–120 fire suppression system, 725–726

fired heaters

control, 368–369, 370 (figure) inspection, 412, 422

first generation biofuels, 753, 765

fixed absolute pricing mechanism, 586 (table), 588-589 fixed-bed process, 186-189, 188 (figure), 189 (figure), 190 (table), 278 fixed differential pricing, 587 (table) fixed heaters, 331-336, 322 (figure) fixed lighting instillations, 404 fixed operational cost, 591 fixed price, 579 (table), 580 (table), 586 (table), 588-589 fixed roof tank, 499, 513 flame ionization detector (FID), 179 flammability, 85, 718 flange spreaders, 399 flash distillation, 107, 310 (figure), 474 flexicoking, 121 (table), 185 Flixborough, UK, 717 floating absolute pricing mechanism, 586-587, 587-588 (table) floating liquefied natural gas, 268 floating roof sinking, 515 floating roof tank, 499, 501 (figure), 513-514 flooding, 319 flow rate, 395, 585. See also pipelines, flow equations and fluid catalytic cracking (FCC), 6-7, 97, 111, 112 (figure), 121 (table), 610 additives and, 149 (figure), 149-152 applications of, 155-156 design and, 135-144, 135 (figure), 137 (table), 138 (figure), 139 (figure) development, 197-198 liquid petroleum gas (LPG) and, 127-128, 131, 135, 148 (figure) major reactions of, 128-132 operation control and, 372 (figure), 373 (figure) process of, 127-128, 128 (figure), 134-135, 134 (table), 155 products of, 198-202 reactor-regenerator, 371 (figure) technology and, 223-225 See also coke; desulfurization; fluid catalytic cracking (FCC) unit; fluid catalytic cracking pretreatment (FCC-PT); gasoline; hydrodesulfurization; specific parts fluid catalytic cracking (FCC) unit, 136, 137 (table), 138-140, 380-383, 384 (table) corrosion and, 447 innovation and, 197-198 optimization and, 679-682, 680 (table), 681 (figure), 681 (table) fluid catalytic cracking pretreatment (FCC-PT), 231-233, 232 fluid coking, 185, 186 (table) fluidized catalytic reactor control, 370-372, 371 (figure) foam, 345 FOC, 217-218 food price, 765 formal panel pricing, 588 (table) formula pricing, 587 (table) fouling factors, 329 4,6-dimethyldibenzothiophene (4,6-DMDBT), 228-229, 228 (table) Fourier-transform infared (FTIR) spectroscopy, 364 fractional distillation, 107

Fischer-Tropsch (FT) technology, 64, 787, 788-789

fractionation, 259–260, 260 (figure) fractions, 26-27, 27 (table) freeze point, 84, 462 (table) fresh fluid cracking catalyst, 152 (table) friction factor, 553-555; gas and, 557-560; liquids and, 555-557 front-end scheduling, 691 fuel, 27-29, 473-476, 476 (figure) additives, 476-477 quality, 457. See also quality control shortage, 197 specifications, 67, 91-93, 91 (table), 92 (table), 93 (table), 94 (table), 97 (table) See also diesel; gasoline; heating oil; jet fuel; liquid petroleum gas (LPG); petroleum coke; residual fuel oil; specific fuels fuel blending, 14, 15 (figure), 492 (figure), 493-496, 495 (figure), 496 (figure), 497 (figure) modes of, 473-477, 474 (table), 480 (figure) optimization of, 482-483 quality and, 478, 486-487, 487 (figure), 488 (figure) technology and, 475 (figure), 483-490, 484 (figure), 48 (table), 485 (figure), 486 (figure), 487 (figure), 488 (figure), 489 (figure), 490 (figure), 491 (figure) fuel cells, 793 fuel coke, 117 fuel system, 291 fuel volatility index (FVI), 83 fugitive emissions, 513-514 functionality, 518 fungibility, 753-754 furnace tubes, 452-453 futures, 580 (table), 587 (table) fuzzy logic, 391, 392 (figure)

G

gas absorption column, 322 (figure) gas chromatography (GC), 79 gas condensates, 24, 25 (figure) gas flow, 552-553, 557-560, 558 (table), 559 (figure). See also pipelines, flow equations and gas metering, 271 gas oil, 228–229, 228 (figure) gas plant, 387-388, 390 (figure), 390 (table) gas processing, 626 (table), 628 gases, 80 gasification, 291. See also regasification gasifier feed, 214 gasoline processing, 111-119, 130 (figure), 130-131, 225–227. See also alkylation; catalytic reforming; coking; fluid catalytic cracking (FCC); hydrocracking; isomerization; polymerization; thermal cracking; visbreaking gasoline, 27-28, 473-474, 476 (figure) additives, 476 catalyst supports and, 245 catalytically cracked (CCG), 198-202, 198 (table), 199 (table), 201 (figure) environmental protection standards and, 91-92 hydrodesulfurization (HDS) and, 201-202, 227-228 hydroisomerization and, 167, 171–172, 171 (figure), 172 (figure), 173 (figure) low sulfur, 198-200, 199 (figure)

octane boosting and, 167-171 price of, 67-68, (figure) quality of, 89-90, 461 specifications, 91-93, 92 (table), 93 (table) sulfur content and, 90 (figure), 149-150, 150 (table) See also gasoline processing gasoline sulfur reduction (GSR) additive, 149-150, 150 (table) gas-to-liquid (GLT), 274-275, 276 (figure) plants, 64-65, 277 technology, 787-788 transportation and, 550, 563, 565 gas-to-oil ratio, 24 GC-AED, 198, 199 (figure) gel permeation chromatography, 80 GEMMS, 695 (table) geographical distribution of biofuel, 53-55, 55 (figure) of coal, 52-53 of conventional oil, 42, 44 (figure), 45 (figure), 46 (figure) of crude oil, 51-52, 52 (figure), 53 (figure), 56 (figure), 56 (table), 61 (figure) of natural gas, 52, 53 (figure), 54 (figure), 56 (figure), 56 (table) reserves/production ratio and, 55-57, 56 (table), 57 (figure) of unconventional oils, 33, 46 Germany, 760 glands, 403 Go-finding, 207 (table) government regulation, 41, 62-64, 71. See also environmental regulation GPSA K value, 337 (table) gravity, 80, 618 (figure) green cokes, 98, 99 (table) green diesel, 795. See also biodiesel Green Paper, 748 greenhouse gas (GHG) emission, 65, 750-751, 751 (figure) reduction of, 751-752, 752 (table). See also emissions reduction refinery impacts on, 71-72; standards, 71 See also carbon dioxide (CO₂) emissions; emission standards; environmental regulation; specific emissions gross refinery margin (GRM), 631, 640. See also estimated gross refinery margin (EGRM) guard-bed catalyst, 230-231, 231 (table) gunite vessel, 412

н

H₂S, 225 (figure), 225 (table), 226 (figure), 226 (table),

438

H2S/NH3 inhibition, 210

hardness test, 409

Hardy Cross method, 567

Haverly Systems (HIS), 694 (table)

hazardous area equipment, 406

hazardous waste, 703

hazards. See safety issues, hazards and Hazen-Williams correlation, 55–557, 556 (table)

HDM, 235 (figure), 235–237

heat exchange, 240, 262. *See also* heat exchanger; heat exchanger network (HEN)

heat exchanger, 326-328, 328 (table), 330 (table), 368 inspection of, 410, 412-413, 414, 424 mathematical methods and, 534-535 heat exchanger network (HEN), 104-105, 106 (figure), 216, 536 (figure) heater tubes, 446 heating coils, 329-331 heating oil, 29, 96 heating value, 251 heavy crude, 26, 177, 178 (figure), 778. See also heavy oil heavy fraction (HCCG), 198, 199 (figure) heavy gas oil (HGA), 107 heavy oil, 2 (figure), 89, 380 challenges of, 9 molecular weight and, 25 (figure) processing of, 57-58, 60-61, 191 refining of, 6, 9 (figure) reserves, 33, 46, 46 (figure) residue and, 3 (table), 9 (figure) upgrading, 191 heavy residue, 3 (table), 6 heavy vacuum gas oil (HVGO), 107, 445, 451-452 heavy-oil, 177-179, 178 (figure) characteristics of, 187 (table), 188 (table) upgrading, 181-193, 183 (table), 184 (figure), 185 (table), 186 (figure) See also asphaltene heptane, 162-164 heteroatom compounds, 9, 119 heteroatom removal, 9. See also hydrotreating heterogeneously catalyzed hydrodesulfurization (HDS), 120 heteropoly acid, 163 HETP, 320-321 HEXSORB, 168, 169 high-pressure liquid chromatography (HPLC), 82, 179. See also liquid chromatography (LC) high-pressure separator (HPS), 127-128 high-temperature hydrogen attack, 445–446, 446 (figure) high-temperature sulfide corrosion, 443-444 Honeywell Process Solutions, 694 (table) human resources, 746. See also workforce hybrid systems, 295, 296 (figure), 297 (figure) HYCON, 190, 191 (figure) hydrates, 2 hydraulic nut splitter, 399-400 hydraulic torque wrenches, 399 hydraulics planning, 691 hydrocarbon characteristics of, 1, 2, 7 (table), 21 resource classification, 41–42, 42 (figure) See also aromatics; olefins; paraffins; naphthenes hydrocarbon conductivity, 309 hydrocarbon group analysis, 179 Hydrocarbon Processing, 621 hydrocracking, 60, 103, 116, 117 (figure), 121 (table), 159 heavy crude and, 186-190, 189 (figure), 189 (table), 190 (table), 191 (table) pretreater, 233 unit, 385-386, 387 (figure), 388 (table), 795 hydrodealkylation (HDA), 208, 210 hydrodemetallation (HDM), 187-190, 245-246 hydrodenitrogenation (HDN), 120, 208, 210

hydrodesulfurization (HDS), 121 (table), 187, 189-190 active site and, 226 catalysts and, 245. See also specific catalysts; zeolite catalytically cracked gasoline and, 201-202, 226-227 deep, 227-228 units, 203-207, 204 (figure), 209 (figure) See also desulfurization; hydroprocessing; VGO hydrotreating hydrofluoric acid, 114 hydrogen, 7 (table), 302, 793 balance, 287 -to-carbon ratio, 2, 5, 10 coal and, 5 consumption, 203 crude oil and, 2-3 management of, 10-11 network targeting and, 296-300 petroleum refineries and, 10-11 plant, 13 (figure), 300-302 production, 13 (figure), 103, 288-292, 290 (figure), 291 (figure) purification, 292-295 surplus, 299 (figure) transportation, 295-296 See also hydrogen plants; hydroisomerization hydrogen addition, 9. See also catalytic hydrogenation; hydrocracking hydrogen attack, 445-446, 446 (figure) hydrogen blister, 439 hydrogen composite curves, 297, 298 (figure) hydrogen induced-cracking (HIC), 439 hydrogen pinch concept, 296-300 hydrogen plants, 289-291, 290 (figure), 291 (figure), 293 (figure), 294 (figure), 296 (figure), 297 (figure), 301 (figure), 302 (figure). See also pressure swing adsorption hydrogen sulfide, 23 hydrogen surplus curve, 297, 300 (figure) hydrogen transfer (HT), 150 hydrogenated vegetable oils (HVOs), 752, 762 (table), 763 hydrogenation, 121 (table) hydroisomerization, 9, 12 (figure), 159-166, 161 (figure), 164 (table), 166 (table), 170 (figure), 171 (figure), 171-174, 172 (figure), 173 (figure) base oil and, 171-173 catalysts and, 160-167, 162 (table), 164 (table), 166 (table), 167 (table), 167 (table), 168 (figure), 168 (table), 174 gasoline and, 167-171 thermodynamics and, 159-160 See also catalyst chemistry; thermodynamics hydroprocessing, 64, 452 units, 442 vacuum gas oil (VGO) and, 207 (table) 207-210, 207. See also hydrodesulfurization "hydroskimming" refineries, 613 hydrostatic testing, 409, 412-413 hydrosulfurization (HDS), 198-202, 199 (table), 201 (figure) diesel fuel and, 202-206 See also sulfur content; sulfur removal hydrotreater, 369-370

hydrotreating, 119–120, 133–134, 134 (table), 627 capacity and, 610, 611 cost of, 626 (table) particulates and, 230 HYSOMER process, 168

I

import terminal, 269 (figure), 272 (figure) impurities, 21, 25 natural gas and, 74. See also natural gas, processing of See also acids; alcohols; aromatics; detergents; polymers in situ metallography, 409 incident prevention, 738 India consumption and, 776 gasoline and, 92-93, 93 (table) refining in, 71 safety incidents in, 717-718 induction heater, 400 industry reporting, 41 inert gas, 256-257 inerting, 725 information technology (IT), 685, 698, 741. See also computer-aided process operation; computer systems; software infrared (IR) thermography, 395 Ingenious, Inc., 695 (table) inhibitor sweetening, 121 (table) inlet device, 344-351 inline blenders, 475 (figure), 495 (figure) inline gasoline batch blender, 475 (figure) input streams, 612-613 inspection. See refinery inspection Institute François du Petrol (IFP), 792 instrumentation, 355 advances in, 366, 368 for automation, 696-698 blending and, 485, 486 (figure) maintenance, 406-407, 435 reliability and, 366-368, 396, 466-467 See also equipment; measuring instruments, refinery; process control insulation, 407 insulation resistance test, 403 integrated gasification combined cycle (IGCC), 795 integrity audits, 738 interaction coefficient values, 480 intermediate fluid vaporizer (IFV), 270 intermediate precision, 461 intermediate streams, 107 intermittent compressor, 345. See also compressor International Energy Agency (IEA), 749, 750 International Organization for Standardization (ISO), 88 Invensys Production Management, 695 (table) inventory calculation, 507–510, 508 (figure), 509 (figure) inventory policy, 679, 681, 682 inverters, 405 investment, 619, 621 IPSORB, 168, 169 isobutane, 210-211 isobutene, 113, 114, 115 ISOCRACKING, 207 (table), 208, 210 ISODEWAXING®, 172, 173 (figure)

isomer, 21, 22
isomerization, 103, 115–116, 116 (figure), 121 (table), 159, 171 (table), 628

cost and, 626 (table)
light naphtha and, 160–165, 168 (table)
long chain paraffins and, 165–171 *See also* hydroisomerization

isoolefin HG active site, 226
ISOP catalyst, 239–241, 240 (figure), 240 (table), 241 (table)
isoparaffins, 21, 86 (figure), 113
isothermal flow, 570–571
IsTerming, 207 (table), 208

J

Japan, 216–219 jet fuel, 94 J-T expansion, 258

Κ

KBR FCC configuration, 136 (figure) Kellogg OrthoflowTM, 141–142 kerosene, 28–29, 101, 107, 651 (figure) Ketjenfine 757, 231 Ketjenfine 848, 232, 233 (figure) Ketjenfine KF 542-9R/-5R, 230 Ketjenfine KF 647, 231 Ketjenfine KG 6, 231 Ketjenfine KG 6, 231 Ketjenfine KG-55, 230 key performance indicators (KPIs), 466, 734–736 kinematic viscosity, 84 kinetic reactor model, 655, 661, 662 Knutsen CNG ship, 281 (figure)

L

L/D ratios, 340 (table) labor cost, 593 (table) labor safety, 721. See also refineries, safety and laboratories cost and, 511 (figure) operations of, 744 testing and, 463-464 See also laboratory information management system (LIMS) laboratory information management system (LIMS), 465, 466 landfill, 796 laser beam alignment, 399 (figure) lead, 712 (table) leadership, 729-730 leak test. 409 leaks, 515 licensors, 181, 183, 185 life cycle assessment (LCA), 713, 751 light crude oil (LCO), 25 (figure), 116 light distillates, 116, 288 (figure). See also specific distillates light gas oil (LGA), 107 light vacuum gas oil (LVGO), 107 linear model, 658 linear programming, 532, 657, 659-664, 692 Linear Theory method, 567-568

INDEX 811

line-up errors, 515 liquefaction, 261-267, 262 (figure), 263 (figure), 264 (figure), 265 (figure), 26 (figure) liquefaction plants, 72-73, 259, 262 (figure), 277 (table) Liquefin[™] process, 264–265, 265 (figure) liquid chromatography (LC), 82, 177-179 liquid flow, 552, 555-557, 556 (figure), 557 (table) liquid hold-up, 338 (table) liquid hydrocarbons: measurement of, 80. See also specific hydrocarbons liquid-liquid extraction, 323. See also separators liquid natural gas. See natural gas liquids (NGL) liquid petroleum gas (LPG), 27, 31, 91 (table), 119, 127-128, 131, 156 liquid-ring compressor, 346 LNG Smart®, 268 long-chained molecules, 370. See also fluidized catalytic reactor control long-term contracts, 578 (table) Louisiana, 623, 625 (table) "Low Carbon Fuel Standard" (LCFS), 748-749 low-temperature operability, 474 low-temperature separation, 257-258 low temperature shift (LTS) catalyst, 242 LPG. See liquid petroleum gas lube oil, 160, 173 (figure), 525, 544 lubricating oil, 29, 109, 394-395, 626 (table), 628 lubricity, 462 (table), 477 lumped bias, 479, 480 (figure) lumping methodologies, 650-652

Μ

magnetic particle testing, 408-409 main-bed hydrotreating, 231-233 maintenance. See refinery maintenance; instrumentation, maintenance and; specific forms of maintenance maintenance costs. See refinery maintenance, cost and management information system (MIS), 542. See also refinery management management of change, 736-737 management strategy, 730 (figure), 730-732, 731-732 (table), 740. See also refinery management Manager for Interactive Modeling Interface (MIMI), 695 (table) Manning correlation, 556 (table), 557 marine diesel fuel, 96, 96 (table) marine terminal, 523 marker crude oil, 580 (table), 581 (table) markets, 17, 774-775 analysis of, 776 crude oil trading and, 577-580, 578 (table) drivers of, 774-777 gas-to-liquid process and, 275 pricing and, 580 (table), 580-581, 582-583 (table), 583 (figure), 584 (table), 585 (table), 586 (table), 587-588 (table), 585-589 products and, 589, 614 See also products, pricing of; pricing Markov decision process, 635-636 marshaled energy, 720 mass spectrometry (MS), 82 MAT/FST unit, 153 mathematical methods, 532-538

algorithms and, 483, 537, 678-682 flow equations and, 551-560, 554 (figure), 556 (figure), 558 (table), 559 (figure), 565-570, 571-573 scheduling and, 542-543 See also equations Maya heavy crude, 188 (table), 781 (figure), 782 (figure) mean time between failure (MTBF), 397 mean time to repair (MTTR), 397 measurement, 79-81. See also specific types of measurement measuring instruments, 358-360 (table), 364-366 mechanical puller, 400 melting point, 84 membrane separation, 74-75, 75 (figure), 292-293, 294 (figure), 295 mercury, 256 Merox process, 119 mesoporous material, 166-167 (table) metal deactivators, 476 metal salt, 163 metallic constituents, 82-83 metals, 160, 394 (table), 778. See also specific metals methane, 10, 26, 72-73, 249 coal-bed, 42 natural gas hydrate and, 282 (figure) See also natural gas methanol, 764 methanol-to-gasoline process, 789 Mexico, 612 (table) MFC Linde process, 266–267, 267 (figure) middle distillates, 6, 9, 116 consumption of, 288 (figure) demand for, 62, 64, 64 (figure) See also specific distillates Middle East crude oil reserves and, 33, 34 (figure), 43, 43 (figure), 44 (figure), 46 natural gas reserves and, 48 (figure), 49 (figure), 51 (figure) refining in, 69, 69 (figure), 609 (table), 612 (table), 613 (table) See also specific countries milling, 754-755 minimum number calculation, 313 minimum reflux, 313 mixed refrigerant processes, 266-268. See also specific processes mixed silica-alumina (MSA), 163 mixed-flow compressor, 346 Mizushima, 217 Mo03, 163-164 Mochida, 210, 211 (figure) model calibration, 655 model development, 648-649. See also refinery modeling; simulation model modeling trends, 669-670 molecular simulation, 670 molecular weight, 80-81 molybdenum, 163-164 monitoring points, 410 monoaromatic hydrocarbons, 23 mono-olefins, 22 Monte Carlo simulation, 675-678, 679

Moody friction factor, 554, 555, 556 (table), 557 MoS₂, 232–233 motor current monitoring, 395-396 motor fuel, 237-239 MSDWTM, 172 mud wash, 309 Multi State Mixed Refrigerant process (LiMuM), 268 multifunction gauging system, 505 (figure), 506 (table), 506-507 multiheader crude blending, 526 (figure) multiheader distillate run-down blender, 457 (figure) multiphase flow, 563-565, 564 (figure), 569 multiple operator interfaces, 515 multiplexed sampling system, 487 multiunit refinery model, 666-667 multivariable control (MVC), 375, 376 (table) multivariable predictive control (MVPC) technology, 375-377, 376 (figure), 377 (figure), 378 (figure), 380 atmospheric processing and, 381 (figure), 381 (table) catalytic processing and, 383 (figure), 385 (figure), 386 (table) crude vacuum processing and, 382 (table) delayed coking and, 389 (figure), 389 (table) fluid catalytic cracking (FCC) and, 383 (figure), 384 (table) gas plant and, 387-388, 390 (figure), 390 (table) hydrocracking and, 387 (figure), 388 (table) variables, 381 (figure), 381 (table), 382 (table), 384 (table), 386 (table), 388 (table), 389 (table), 390 (table) Murphree efficiency, 315 Muse, Stancil, & Co., 620 (figure) Ν nanoparticles, 243-244, 246 naphtha complex, 667 naphtha, 29, 107 blending, 525-528, 528 (figure), 529 (figure) isomerization and, 160-165 sulfur and, 119 naphthenes, 22, 174 naphthenic acid corrosion, 444-445, 447, 449, 451-452 National Institute of Occupational Safety and Health (NIOSH), 724 natural gas, 72-73, 763, 776 (table), 785 (table) applications of, 78 (figure) conditioning and, 251-257, 253 (figure), 255 (figure), 256 (table), 257 (figure) consumption of, 31, 72, 74 (figure), 787 (table) conventional, reserves of, 33, 46-48, 48 (figure), 49 (figure), 50 (figure), 55–56, 56 (figure), 249, 250 (figure) definition of, 1-2, 2 (figure), 9, 10 demand for, 5-6, 9, 75-76 fraction and, 259-260, 260 (figure) hydrates, 281 gas-to-liquids (GLT) and, 284, 282 (figure), 283 (figure), 786-787 liquefaction of, 251 (figure), 261-267, 262 (figure, 263

(figure), 264 (figure), 265 (figure), 266 (figure) molecular weight and, 25 (figure)

- pricing and, 787 (figure)
- processing of, 9–10, 11–13, 11 (figure), 12 (figure), 19, 72–75, 74 (figure), 784, 785–786, 788 (figure)

properties of, 23, 42, 249-251, 250 (table), 251 (table), 258 (figure) production of, 3, 13 (figure), 257-259 refineries, 252 (figure), 253 (figure) regasification and, 268-270 regional realities of, 73 (figure) storage of, 273-274, 274 (figure), 275 (figure) technology and, 786 (figure) thermodynamic properties and, 250 transportation, 249, 260-261, 269 (figure), 279-281, 288 (figure), 549-550 as transportation fuel, 66-67, 7 (figure) unconventional, reserves of, 42, 48-51, 51 (figure). See also coal-bed methane (CBM) See also Natural gas hydrates (NGH); natural gas liquids (NGL); natural gas processing Natural gas hydrates (NGH), 270-273, 281. See also compressed natural gas (CNG); gas-to-liquids (GLT); natural gas liquids (NGL); natural gas processing natural gas liquids (NGL), 9, 10, 31, 73-74 process of, 261-267, 262 (figure), 263 (figure), 264 (figure), 265 (figure), 266 (figure) regasification and, 268-270 storage and, 273-274, 273 (table), 274 (figure), 274 (table), 275 (figure), 275 (table). See also tank transportation of, 549 vaporization and, 270-273 See also gas-to-liquids (GLT); natural gas natural gas processing, 11-14, 784, 784, 788 (figure), 789. See also natural gas, processing of; refineries natural gas vehicles, 67 (figure) near infrared spectroscopy (NIS), 82, 364-366 Nebula technology, 233 Nelson-Farrar, 624 (table) net positive suction head (NPSH), 348, 350-351 network targeting, 296-300 New Zealand, 94 (table) Newton-Raphson method, 567, 568 nickel, 154-155, 230-231 nickle-based alloy, 442 NIR spectroscopy, 697-698 nitrogen, 229, 781 (figure) nitrogen oxide (NO_x) emission, 225, 336, 703, 712 (table), 751 nitrogen reduction, 336 NLP-based optimization, 532-536 noble-metal-based water-gas shift (WGS) catalyst, 242-243 nodes, 566 noise, 395 noise pollution, 706, 708-709 noncatalytic POX, 277 (figure) noncooling process, 258 noncritical equipment, 396 nondestructive examination, 414 nonfuel products, 29-31, 30 (figure). See also asphalt; lubricating oil; naphthas; petrochemical feedstock; petroleum coke; solvent; waxes nonhydrocarbons, 291-292 nonlinear model, 477-478, 660-665 normal boiling point. See boiling point North America conventional natural gas reserves of, 48 (figure), 49 (figure), 51 (figure)

crude oil reserves of, 43 (figure), 44 (figure), 46 energy sources and, 770 (table) refining in, 69–70, 70 (figure), 609 (table), 612 (table), 613 (table) *See also specific countries* NOx reduction additive, 151–152, 151 (figure) NYMEX, 585

0

objective function, 482-483, 483 (figure), 682 (table) objective value, 678 (figure) OCR, 189 OCR/UFR-RDS process, 234 (table) octane blending, 167-171, 756-757. See also blending octane number, 85, 86 (table), 103, 113, 473 offline optimization, 489 offloading, 269 offset misalignment, 398 (figure) offshore import terminal, 273 offsite operations, 473, 622, 743-744. See also fuel blending offsite piping, 414 oil, 178 (table). See also specific types Oil and Gas Journal, 621 oil field variability, 21 oil-gas separator, 24 oil imports, 774 (table). See also specific countries oil movement, 514-521, 515 (table), 516 (table), 518 (table), 520 (figure), 521 (figure) control levels, 518-519, 519 (figure) See also pipelines oil price, 40 (figure), 67-68, 68 (figure), 770, 785 (figure) energy consumption and, 39-40 future considerations and, 796 oil shale, 25 (figure) olefin, 22, 210, 225, 474 boiling point and, 86 (figure) fluid catalytic cracking (FCC) and, 198, 200 plant optimizer, 668 Olefin HG active site, 227 OmniSuite, 694 (table) 1-octene, 225, 226, 227 online analysis, 696-698 blending and, 486-487 tank farms and, 511-512, 512 (figure) online analyzers, 650 on-shift process optimization, 658 onsite and offsite operations, 14 (figure), 15 (figure), 743-744 on-stream inspection, 410 (table), 429-434 open rack vaporizer (ORV), 270 (figure) operate environmental units, 744 operate utilities, 744 operational efficiency (OE), 397 operations management, 742 operator training simulators, 669 operations support, 744 opportunity value (OV), 635, 641 (table), 642 (table), 643 (table) OPTI, 192-193, 193 (figure) optimization, 482-483, 531, 536-537, 543, 643-644, 667 algorithms, 483 challenges of, 538 lend control and, 488-491, 489 (figure), 490 (figure)

maintenance and, 678 methods, 538-539, 664 (figure) offline, 489, 490 (figure) planning tools and, 658-665. See also simulation tools; specific tools real-time, 689-691, 691 (table) scheduling and, 691 software and, 690, 691 (table) variables, 531 See also refineries, scheduling and Optimized Cascade process, 263-264, 264 (figure) Organization of Petroleum Exporting Countries (OPEC), 33 Orinoco Oil Belt, 193 (table) OSHA, 720, 721, 722 overall process effectiveness, (OPE), 397 overhead corrosion, 437-438 oxidation, 206, 277, 288, 462 (table) oxidation inhibitors, 476 ozone, 712 (table)

Ρ

packed columns, 320-321, 321 (figure) packed towers, 319 packing, 319 PAD district, 607, 608 (table) paints, 408 pall rings, 318 (figure) panhandle equations, 557, 558, 559 paper markets, 578-580, 579 (table), 580 (table) paraffins, 21-22, 22 (figure) fluid catalytic cracking (FCC) and, 198 hydroisomerization and, 159-160, 163 isomerization and, 165-167 RON of, 160 parallel mixed refrigerant (PMR), 266 Par-Isom process, 115–116, 116 (figure), 169, 170 (figure) particle size distribution (PSD), 153 particulate emission, 225, 712 (table) peak oil, 52-53, 53 (figure) PEFCs, 243 performance monitoring, 397, 737-738 permeability, 294 (table) permit-to-work system, 721-722 PETRO LP, 695 (table) petrol. See gasoline petroleum definition of, 1, 2 (figure) formation process, 1-2, 21 history of, 1, 8 (table), 772-774 refining of, 6-9, 8 (table), 10 (figure), 19-20. See also refineries See also crude oil; products; specific types; specific products petroleum coke, 29, 30 fluid catalytic cracking and, 130, 131, 147-148 production of, 117-119 properties of, 97-98, 117 (figure) quality of, 118, 118 (table) See also specific types petroleum cuts, 27. See also products petroleum fractions, 81-82, 98-99 petroleum products. See products Petroleum Resources Management System (PRMS), 42

petroleum streams, 649 photovoltaic energy, 793 physical markets, 577-578 **PINA**, 81 pinch technology, 216-219 pipeline terminal, 523 pipelines ASME specifications and, 550, 551 cost and, 563, 561 design, 560-563 flow considerations, 563-565, 564 (figure) flow equations and, 551-560, 554 (figure), 556 (figure), 558 (table), 559 (figure), 565-570, 571-573 hydrogen and, 295 natural gas and, 260-261 networks, 565-570, 566 (figure), 568 (figure) inspection of, 428 standards of, 550 (table), 550-551 temperature profiles and, 570-573 terminals and, 523 pipelines-to-tanks crude blending, 526 (figure) piping, 410, 725 pitch, 213, 214 (table) planned inspection, 410 planning headquarters (HQ), 664 planning, 16 (figure), 16-17, 539, 540, 657 (table), 657-658,664 plants. See baseload plants; biorefineries; gas plant; gasto-liquid plants; hydrogen plants; liquefaction plants; natural gas processing plants; refineries; refinery economics; tank farm plate exchangers, 326 PLATOFORM, 695 (table) platts, 585 PLEX technology, 208 Poiseuille's law, 554, 556 (table) polyaromatic aromatic hydrocarbons (PAHs), 23, 81, 99, 203 polymer electrolyte fuel cells (PEFCs), 241 polymerization process, 103, 114-115, 115 (figure), 121 (table) polypropylene, 193, 193 (table). See also catalyst, commercial polythionic acid stress corrosion cracking (PTA SCC), 441, 451 positive displacement pump, 348, 350-351 pour point, 84, 85 (table), 203 power transformers, 403 precision, 461, 470 precoat filter, 351-352 predictive control, 362 predictive maintenance, 394 preheat exchange control, 369 (figure) pressure, 395, 506 pressure drop, 329 (table), 553 pressure swing adsorption (SPA), 289-291, 290 (figure), 292, 295, 297 (figure) pressured natural gas (PNG®), 281 pretreatment, 226-227, 227 (figure), 231 preventative maintenance, 393, 416, 675. See also refinery maintenance prevention methods. See corrosion, prevention and price reporting journals, 585 price variation, 67-68

pricing, 3, 581-585 agreements, 585 crude oil and, 580 (table), 580, 581, 582-583 (table), 583 (figure), 584 (table), 585 (table), 585-589, 586 (table), 587-588 (table) differentials, 587-588 (table), 588-589 information sources for, 585, 590-591 mechanisms, 585-589, 586-587 (table), 589 (table) models, 637-641, 638 (table), 639 (table), 640 (figure) products and, 589-591, 590 (table), 614-615, 615 (figure), 636, 637-638, 639 (figure). See also markets; refinery economics PRICO®, 268 process alarm management, 366 process automation, 686, 687-688 instrumentation and, 686, 696-698 offsite, 691 process control, 355-364, 375-377, 376 (table), 388-391, 668-669, 688-689 case studies, 368-373 distributed, 698 planning and, 691-696, 694-695 (table) real-time optimization (RTO) and, 689-691 reliability and, 366-368 See also computer-aided process operations; process automation; process control process modeling, 693-698, 694-695 (table) process parameters, 395 process safety, 722-723 process simulation. See simulation model processing technologies, 621-623, 622 (table) processing capacity, 58-60, 62 (figure) cost of, 625-628, 626 (table), 627 (figure) See also refinery economics production control, 665 products, 3, 4 (figure), 4 (table), 5, 7 (table), 15 (figure), 16 (figure), 17, 124, 772 (table), 778 (figure) Alaskan crude oil and, 28 (figure) analysis of, 14, 457-465, 462 (table) atmospheric distillation and, 4 (figure), 61 (figure), 6 bio-based, 18-19 distribution of, 61-72, 605 (table), 606 (figure), 606 (table), 607, 611 (table) future of, 796 import-export of, 63 mixed, 10 natural gas and, 31 pricing of, 584 (table), 589-591, 590 (table), 614-615, 615 (figure), 636, 637-638, 639 (figure). See also pricing, products and; refinery economics quality of, 89-91, 132-134, 133 (figure), 134 (figure). See also quality control regional consumption of, 65 (figure). See also consumption specifications, 458, 460 supply and demand for, 598-599, 599 (figure), 560 (figure). See also demand; supply test methods, 457, 458-459 (table), 460-463, 462 (table) upgrading, 267. See also upgrading yield, 134 (table), 135 (table), 602 (table) See also blending; byproducts; fuel products; nonfuel products; products; specific products

proficiency test, 468 programmable logic controller (PLC), 489, 686-687, 687-688 programming, 631, 633,662-663, 663 (figure), 664 (figure) propane, 21, 258 propene, 22, 114 ProPlan, 695 (table) proportional integral derivative (PID), 375, 376 (table), 380 propylene, 31, 158, 198 ProSched, 695 (table) PSA cycle, 293 (figure) Pt, 242, 243 Pt/alumina, 164-165, 164 (table), 166 (table) Pt/CeO₂, 242, 243 Pt/TiO₂, 242, 243 pump, 348-351, 349 (figure), 351 (table), 569 pump around heat exchanger, 368 pump curve, 349 pump inspection, 417 pumpout system, 269 pure vegetable oils (PVOs), 752, 765 (figure) purging, 725 purification process, 292-295. See also distillation purifiers, 300 purity tradeoff, 297-298

Q

quality audit, 469–470
quality control, 14, 19, 455–457, 465 (figure), 465–470, 468 (figure), 470 (table), 471 (table)
blending and, 486–487, 487 (figure), 488 (figure)
planning and, 658
process units and, 697 (table)
quality cost, 469, 471
quality giveaway, 455–456, 471 (table)
quality measuring instruments, 364–366

R

radiography, 409 rag formation, 309 rag processing, 309 railcar terminal, 523 rare earth, 154, 224 reaction network, 652 (figure) reactor desulfurization, 204-206, 209 (figure) fluid catalytic cracking (FCC) and, 371 (figure), 371-372 residua thermal cracking, 214 reactor effluent air cooler (REAC), 440 reactor model, 655 (figure), 655-656 reactor-regenerator, 371 (figure), 372 real-time optimization (RTO), 689-692, 691 (table) reciprocating pump, 350-351, 350 (table) reduction additive, 149-150, 151-152 reference pricing, 580-581 refineries, 8 (table), 17-18, 59 (figure), 59 (table), 46 (figure), 638 (figure) automation and, 687-688, 696-698 configuration and, 122-123, 502 (figure), 503 (table) distribution of, 68-71. See also specific regions emissions and environmental issues of, 18, 71-72, 292 (table), 513-514, 616, 706 (table). See also refinery pollutants

energy consumption in, 17, 616, 619 (figure) equipment and, 358-360 (table), 364-366, 399-400, 409-410 future of, 9, 10 (figure) management and, 17-18 margins and, 57, 469, 471. See also refinery economics material problems and, 451-453 natural gas, 252 (figure), 253 (figure) offsite operations of, 14 (figure), 15 (figure), 15-16 planning and scheduling for, 16-17, 657 (table), 657-658, 677, 691–696 products, 4 (figure), 4 (table), 7 (table), 103. See also products safety and, 14, 467-468, 513-514, 677, 687, 696-698, 746. See also safety issues scheduling and, 531-544, 541 (figure), 541 (table), 544 (table), 677. See also scheduling technology, 9 (figure), 598 (table), 621-623, 780-784, 790, 792 See also baseload plants; biorefineries; gas-to-liquid plants; gas plant; hydrogen plants; liquefaction plants; natural gas processing plants; refineries; quality control; refinery capacity; refinery inspection; refinery maintenance; refinery management; refinery modeling; refinery planning; refinery economics; refining industry; refining processes; tank; tank farm Refinery and Petrochemical Modeling System (RPMS), 694 (table) refinery capacity, 58-60, 58 (figure), 59 (figure), 59 (table), 60 (figure), 60 (table), 61 (figure), 62 (figure), 64, 68 global, 609–611, 611 (figure), 611 (table), 612 (figure) regional statistics and, 607-608, 609 (table), 610 (figure) in the United States, 600-604, 603 (figure), 604 (figure) refinery economics, 17, 67-68, 614, 617-621, 636, 774 blending and, 494, 495 (figure) biofuels and, 746-766, 765 (figure) capital cost, 592, 594 (table) cost control and, 739 environmental regulation and, 701 financial risk management and, 632-633, 641 (table) labor cost, 593 (table) loss and, 679-680 margins and profits and, 592-593, 594 (figure), 595 (table), 619, 620 (figure), 620 (table). See also refining planning operating and, 124, 591 (table), 589, 591 (figure), 591 (table), 591-592, 593 (table), 594 (figure), 595 (table), 611, 615, 612, 621 (figure) pipelines and, 563 process cost function and, 625-628, 626 (table), 627 (figure) supply and, 591 (figure), 592 (figure) tank operation and, 516 See also oil price; products, price of; price variation; pricing refinery inspection, 13-14, 402-406, 408-415, 410 (table), 411 (table), 413 (table), 447 criteria, 410-411 documentation, 414-415, 433 tools, 411 (table) See also quality control

refinery maintenance, 13, 16 (figure), 17, 393-401, 675-676 cost and, 594 (table), 676-677 civil, 407-408 electrical systems and, 401-401. See also electrical systems instrumentation and, 406-407, 435 (table), 340 maintenance and, 736 (table), 739 (table) management and, 736 (table), 739 (table), 742-746 performance measurement and, 733 (figure), 733 (table), 733-736, 734 (figure), 735 (figure) personnel and, 729-730, 741-742 strategy and, 730 (figure), 730-732, 731-732 (table), 735 (figure), 736-737 support aspects and, 737-742 See also instrumentation, maintenance and; specific forms of maintenance refinery modeling, 649 (figure), 656-658, 660 (figure), 669-670 design and, 665-666 development and, 649, 653-654 model components, 652-653, 645-656, 63 (figure), 655 (figure), 656 (figure), 669-670 software and, 658 (table), 658-669 technology and, 649-652 See also process engineering refinery planning computerized, 692-696, 694-695 (table) management and, 737 (figure), 737-738 risk management and, 632-633, 633-636, 738 supply chain and, 631-632 refinery pollutants, 702 (table), 702-706, 706 (table) air, 703, 710-711 (table), 712, 713 (table), 713-714, 714 (table) noise, 706, 708-709 water, 702 (table), 702-703, 704-705 (table), 708 (figure) refining companies, 605 (table), 606 (table), 772 (figure). See also specific companies refining industry, 60, 612-616, 629, 769-71 challenges of, 33-34, 60-61, 794-796 configuration, 612-613 (table) history of, 61 (figure), 73, 101, 121-123, 772-774 regional, 63 (figure) structure, 604-607. See also geographical distribution See also markets; refineries; refinery capacity; refinery economics; refining processes; specific industry aspects refining processes, 378-387, 388, 390 (figure), 390 (table), 522 (figure), 597-598, 610-611 automated, 724-725 complexity and, 623, 659 (figure) control schemes and, 378-386, 379 (table), 690 (figure) gas and, 38 See also optimization; refinery capacity; refinery economics, process cost function and; specific processes reflux ratio, 311 RefOpt, 695 (table) reformed gas shifting, 290-291 reformer, 277-278, 277 (figure), 278 (figure). See also specific reformers reformer reactor model, 667 reformulated gasoline (RFG), 28, 92 refractive index, 81 refractivity intercept, 87

refractory lined vessel, 412 refrigeration, 279 RefSim, 695 (table) regasification, 268-270, 282, 283 (figure) regenerator, 137 (table), 141-142, 142 (figure), 151 (figure), 153 (figure), 371 (figure), 372 regenerator heat balance, 15 regional production, 607 (figure), 607 (table), 607-608, 608 (table), 609 (table), 610 (figure), 610-611, 612 (table), 796 regulatory blend control, 489 Reid vapor pressure (RVP), 83, 473 reliability, 366-368, 369, 401 Reliance refinery, 58 remote-impounding, 726 repeatability, 462 reproducibility, 462-463 reserves regional, 35 (table) conventional crude oil and, 35 (table), 42-45, 43 (figure), 44 (figure), 45 (figure), 46 (figure) conventional natural gas and, 46-51, 48 (figure), 49 (figure), 50 (figure), 51 (figure), 786 (figure) heavy crude and, 177, 178 (figure) unconventional crude oil and, 46, 46 (figure), 47 (figure) unconventional natural gas and, 48-51, 51 (figure) See also regional distribution; specific products; specific regions reserves-to-production ratio (R/P), 55-57, 56 (table), 57 (figure) reservoir fluids, 23-24, 24 (table), 25 (table) residua thermal cracking, 213-215 residual fuel oil, 29 residual hydrocracking, 121 (table) residue upgrading, 213-215, 215 (figure), 780-790, 784 (table), 785 (table) residuum desulfurization (RDS), 234-237, 234 (table), 237 (figure) resin, 777, 778 (table) resource classification, 41-42, 42 (figure) resource constraint, 675, 678 (figure) reverse rim alignment, 398-399 Reynolds number, 331, 337, 339, 342, 344, 553-554 rigorous model, 661, 662 (figure), 664, 667 rim and face alignment, 398 (figure) riser heat balance, 155 Riser Separation System (RSTM), 138, 140 riser termination device, 138–140, 139 (figure) riser-reactor, 127, 151 (figure) risk curve, 634 (figure), 636 (figure), 640 (figure), 641 (figure) roads, 407 ROK-Finer process flow, 202 (figure) RONs, 113, 160 (table), 163, 168, 169 (table), 478 root mean square error prediction, 463 rotary compressor, 345-346 rotary displacement pump, 351 rotary equipment, 409 rotating electrical machines, 404 rotating equipment alignment, 397-399 roughness coefficient (C_{HW}), 555–557, 559 round-robin evaluation, 468 rudimentary control, 356 Russia, 612 (table)

S "saccharification," 754-755 safety, hazard, and operability analysis (HAZOP), 676 safety assurance, 696-697. See also refineries, safety and safety devices, 414 safety issues, 17, 18, 717 gasoline and, 91-92; 718 hazards and, 718-720 management and, 721-726 standards, 720-721 See also refineries, safety and salt, 103-104, 307. See also desalting sand filter, 351 sand pipes, 137 (table), 141, 144 (figure) sanitation, 407 saturate, aromatic, resin, and sphaltene (SARA), 81, 178-179, 179 (figure), 777-780. See also specific components SCANfinding process, 201-202, 227 (table) scheduling time horizon, 540-541 scheduling, 16-17, 531, 539-542, 691, 692 (figure) blending and, 490 computerized, 692-696, 694-695 (table) industrial applications and, 543-544 maintenance and, 677 management and, 737-738 mathematical tools and, 542-543 offsite, 541 (figure) short term, 539-540, 541 tools, 543, 544 See also refineries, scheduling and second generation biofuels, 753, 765 security disclosures, 41 Selas-Linde GmbH, 270 (figure) semicritical equipment, 396 sensitization, 41 separation assistance device, 344-351. See also compressor; pump separation process, 102-103, 102 (figure), 102-110, 105 (figure, 105 (table), 106 (figure), 106 (table), 109 (figure), 110 (figure). See also desalting; distillation; specific processes separation units. See heat transfer equipment; specific units; three-phase separators; two-phase separators sequential systems, 687-688 settling regime, 337 Seveso, Italy, 717 Shaw/Axen's feed injectors, 138 Shell, 189, 266, 695 (table) shipment execution, 737 shock pulse monitoring, 395 shot coke, 117 shutdown maintenance, 400-401 sieve tray distillation column, 316 (figure), 318 (figure) sigma phase, 447 silica, 246 silicoaluminophosphate (SAPO) molecular sieves, 165-166 simple deflection box, 344-345 simple refineries, 613 SimSci-Esscor's ROMeo, 690 simulated annealing (SA), 536, 537 (figure), 537 (table), 537-538, 538 (figure), 538 (table) simulated distillation (SD), 79

simulation model, 17-18, 200-201, 447, 543, 646-648, 663-664, 69. See also refinery modeling simulation tools, 648 (figure). See also optimization, planning tools and; process modeling; specific tools single-phase gases, 552-553. See also gas flow single-phase liquids, 552. See also liquid flow Site Source Sink Profile (SSSP), 216-217, 217 (figure), 218 (figure) site steering committees, 741 skill level. 742 slack variables, 482 sliding vane compressor, 346 sludge, 702 (table), 703 slurry bubble column reactors (SBCRs), 278 slurry water-based hydrate process, 238-284 smog formers, 712 (table) smoke point, 87, 462 (table) SO₂, 336 soda ash neutralization, 441 Sodegaura Refinery, 215 sodium (Na), 154 software applications, 658 (table), 658-665 commercial, 641-643 for process engineering, 665-668 real-time optimization (RTO) and, 691 (table) scheduling and, 692 (figure), 692-696, 694-695 (table) solid acid catalyst, 237-239 solid alkylation process, 210-213, 211 (table). See also alkylate process solid waste, 702 (table) solvent, 18, 29, 81, 108, 121 (table), 325 (figure) sour oil, 26 source and sink location, 296-297, 298 (figure) South Africa, 64-65, 95 South and Central America, 609 (table), 612 (table), 613 (table) crude oil reserves of, 43, 43 (figure), 44 (figure), 46 energy sources and, 770 (table), 774 (table) natural gas reserves of, 48 (figure), 49 (figure), 51 (figure) refining in, 70 (figure) See also specific countries SOX reduction additive, 150, 151 (figure) spares philosophy, 407 specific gravity (SG), 80 spectroscopy, 82, 242, 364 spectrum-based blending indices, 480 spherical tank, 499 spiral exchangers, 326 Spit MR[™], 263 spot contracts, 578 (table) stainless steel, 441, 442, 444, 447 standard deviation, 463 standard error prediction, 463 standard methods, 88-89, 89 (table). See also specific organizations Standard Oil of New Jersey, 197. See also Exxon Mobile starters, 402 static devices, 405 static electricity controls, 726 static equipment, 409 steady-state model, 653-656, 665, 693, 696

steam generator system, 291 steam methane reformer, 277 (figure) steam reforming, 289-290 steam reforming catalysts, 239-243 stochastic model, 638-641, 639 (table), 640 (figure), 641 (figure), 641 (table), 643 (figure) stochastic optimization, 536 stochastic programming, 633 stock quality, 486-487 stock tank, 487 storage tank. See tank storage tank inventory. See tank inventory straight-edge alignment, 398 straight-run products, 107 strainer, 351 Strategic Research Agenda, 750-751 stream identification, 533 (table) stream pooling, 485 stress corrosion cracking (SCC), 441-443 stress-related failure, 414 stripper, 137 (table), 140 (figure), 140-141, 151 (figure), 323 (figure) stripping, 108. See also stripping structure-oriented lumping (SOL), 652 sugar cane, 754 sulfur, 23, 462 (table) additives, 150 corrosion and, 443-444 fluid catalytic cracking (FCC) and, 150 (figure), 151 (figure) fuel and, 94-95, 474, 476. See also specific fuels grades of, 94-95 measurement of, 465 recovery of, 120-121, 254-255, 626 (table), 628 refining and, 612-613 removal of, 62-64, 149-150, 150 (table). See also desulfurization See also sulfur content; ultralow sulfur diesel (ULSD) sulfur content, 82 in crude oil, 119, 616, 618, 781 (figure) in diesel fuel, 119 (table), 202-203, 203 (figure), 205 (figure) in diesel oil, 229 environmental legislation and, 227, 464-465. See also environmental regulation in gasoline, 89, 90 (figure), 149-150, 150 (table), 198-200, 199 (figure) See also desulfurization; hydrodesulfurization (HDS) sulfur oxide (SO_v) emission, 224–225, 703 sulfur reduction additive, 149–150, 150 (table) Sumitomo Chemical Company (SCC), 217-218 Sumitomo Precision Products, 270 (figure) SUNCOR, 191, 192 (figure) Super Type-II Active Reaction Sites (STARS[™]), 232 (figure) supercritical equipment, 396 supply cost, 591-592 supporting process, 102 (figure), 103, 120-121 surface production operations, 24-25 sustainability, 749–752 Sweden, 63 sweet crude, 444. See also sweetening sweetening, 121 (table), 252-254. See also pretreatment switchgear, 402-403

Syn Technology, 207 (table), 210 Syncrude process, 192 (figure) SynSat process, 204 (figure) SynTechnology, 64 synthesis gas technology, 275, 277, 278 synthetic catalysts, 223 synthetic fuel (BLT), 752, 762 (table), 763–764 S-Zorb process, 205, 206 (figure)

Т

tabu search, 537 tail gas, 292, 293 (figure) tank, 273, 513-514 cleaning, 408 costs and, 516 environmental concerns and, 704 (table), 710 (table) inspection, 408, 413 (table), 413-414, 425, 426 quality measurement and, 487, 488 (figure) types, 499-502, 500 (figure), 501 (figure) See also tank farm tank farm, 14, 15 (figure), 16, 484-485, 499, 504 (table) capacity of, 502 (figure), 503 (figure), 503-504, 504 (figure) design of, 499-504, 500 (figure), 501 (figure), 502 (figure), 502 (table), 503 (table), 507 (figure) inventory, 504-510, 505 (figure), 506 (table), 508 (figure), 509 (figure), 510 (figure) oil movement in, 514-521, 515 (table), 516 (table), 518 (table), 520 (figure), 521 (figure) qualities, 510-514 See also tank tank inventory, 504-510, 505 (figure), 506 (table), 508 (figure), 509 (figure), 510 (figure) tank inventory calculations, 507-510, 508 (figure), 509 (figure) tank lube inline blending, 527 (figure) tank quality estimation, 512-513, 513 (figure) tank quality measurement, 487, 488 (figure), 513 (figure) tar sand, 25 (figure). See also Canadian tar sands task status monitoring, 521 TEAL process, 268 technical management systems, 686 technology, emerging, 790, 791 (table) temperature distillation, 782 (figure), 783 (figure) fluid catalytic cracking (FCC) and, 155, 201 hydrogen processing, 294-295 measurement, 506, 534 pipe flow and, 570-573 refining maintenance and, 395 reformers and, 240-241, 241 (figure) Ten-lump kinetic model, 131 (figure) terminal operations, 521–523, 523 (figure), 524 (figure) terminals, 403. See also terminal operations test method. See product, test method test productivity, 463-464 thermal conversion technologies, 103, 182-185, 183 (figure), 626 (table). See also thermal cracking thermal cracking, 103, 116-117, 121 (table), 626 (table) thermal reforming, 121 (table) thermodynamic models, 652-653 thermodynamics, 159, 161 (figure), 250, 409. See also

hydroisomerization

thermolysis of water, 291-292 thin layer chromatography (TLC), 179 thiol formation, 200 (figure) thiophene hydrodesulfurization, 226 (figure) three stage separator, 311 (figure) TLC/FID analysis, 181 (figure) total acid numbers (TANs), 393, 448 total isomerization process (TIP), 168, 170 (figure) toxicity, 719 trade. See crude oil, trading; fuel oil, pricing; markets training, 669, 696, 742 training simulator, 696 transesterification, 31 transportation fuel, 18, 752 demand for, 61-67, 63 (figure), 64 (figure) regional consumption and, 61-62, 65 (figure) See also biodiesel; biofuel; diesel; gasoline; natural gas, as transportation fuel; specific fuels transportation, 16, 549-550, 608 (table) acids and, 114 cost and, 549 heavy crude and, 191 (figure) hydrogen and, 295-296 modeling and, 565-570 natural gas and, 9-10, 279-281, 288, 549-550, 550 (figure), 563, 568 (figure) See also pipelines; gas transport modules (GTMTM) tray columns, 319-320, 320 (figure) trays, 317, 318 (figure) truck terminal, 523, 524 true boiling points (TBPs), 79 trueness, 463 tube plugging, 413 tungstate-promoted zirconia, 166-167 tungsten oxycarbide, 163-164 turboexpander extraction, 259, 268 twin laser reverse indication alignment, 399 (figure) TwisterTM, 258 two-phase separators horizontal, 340 (table), 340-342, 341 (figure) vertical, 339 (figure), 339-340 two-stage desalter, 308 (figure) two-tier blending, 490 (figure)

U

U.S. Clean Air Act (CAA), 703 UFR/OCR process, 236 ultra-heavy feedstock conversion, 224 ultralow sulfur diesel (ULSD), 62-64, 464, 792 ultrasonic analysis, 395, 409 unconventional hydrocarbon. See specific products unconventional oil, 33, 42 (figure), 46 unconventional reserves. See crude oil, unconventional, reserves; natural gas, unconventional, reserves Unionfinding/APCU, 207 (table) unit programming modeling (UPM), 662–663, 663 (figure), 664 (figure) unit shutdown, 410, 411 (table) unit troubleshooting, 666 United States biofuel and, 756 crude oil and, 288 (table) demand in, 598-599, 599 (figure), 560 (figure)

diesel fuel and, 95 (table), 103 environmental regulations and, 714 (table) gasoline and, 91–92 industry structure and, 604-607 refining in, 103, 123, 123 (figure), 599-604, 602 (figure), 602 (table), 603 (figure), 604 (figure), 216 (table), 613 (table), 615 refining companies in, 605 (figure), 605 (table), 606 (figure), 606 (table), 606-607, 608 (table) regional specialization in, 607-608 Universal Oil Products (UOP), 109, 110 (figure), 112 (figure), 114-115, 117, 119. See also UOP FCC process; **UOP/FWUSA** solvent deasphalting UOP CCR, 112, 112 (figure) UOP FCC process, 111, 112 (figure) UOP/FWUSA solvent deasphalting, 109-110, 110 (figure) upgrading bottom-of-the-barrel, 233-237 crude oil, 780-790, 790 (figure), 791 (table), 780-785 heavy-oil, 181-193, 183 (table), 184 (figure), 185 (table), 186 (figure) residue, 213-215, 215 (figure), 780-790, 784 (table), 785 (table) technology and, 791 (table) upside potential (UP), 635 urea electrolysis, 292 utilization, 601, 605 (figure). See also demand

V

vacuum distillation, 4 (figure), 6, 7 (table), 8 (table), 10 (figure), 26, 61 (figure), 121 (table). See also vacuum distillation unit vacuum distillation unit, 380, 438, 451-452 vacuum gas oil (VGO) hydrotreating, 207 (table) 207-210, 207catalyst technology and, 230-231, 231 (table) heat exchanger network (HEN) and, 537-538 vacuum residue (VR), 233. See also bottom-of-the-barrel vacuum tower, 107 Valero, 606 value at risk (VaR), 634-635, 635 (figure) valve actuators, 405-406 vanadium, 23, 148, 154-155, 230-231 vane-type device, 345 vapor liquid contact, 316 (figure) vapor pressure, 81, 83, 462 (table), 757 (figure) vapor product, 107 vaporization, 270-273, 271 (table) vapor-liquid equilibrium (VLE), 309-310 vapor-to-liquid (V/L) ratio, 83 variable costs, 591 variance. 463 velocity equations, 561-562, 563. See also pipelines, flow equations Venezuela, 46, 70, 187 (table), 193 (table) ventilation, 725 vessel inspection, 412, 423 vibration monitoring, 394, 418, 419-421 videoscopic inspection, 409 visbreaking, 117, 111, 112 (figure), 182-184, 183 (figure) viscosity, 84, 462 (table). See also viscosity index viscosity gravity constant (VGC), 87-88 viscosity index, 29, 88

volatile oils, 24 volatile organic compounds (VOC), 712 (table) volatility, 758 volatility index. *See* fuel volatility index (FVI) volatility models, 651–652 Vortex Separation System (VSSTM), 138, 140 VOTRANSTM, 280

W

warehouse management, 744-745 wastewater, 702, 703, 707 (table), 709 (table), 711 (table) water-gas shift (WGS) catalyst, 241, 242 water pollution, 702 (table), 702-703, 704-705 (table), 708 (figure) water washing, 450 Watson (UOP) characterization factor, 87 wavelength-dispersive X-ray fluorescence (WDXRF), 465 waxes, 29 wear metal, 394 (table) wet gas, 24 wet H₂S corrosion, 438, 440 Weymouth equation, 557, 558-559 wobbee index (WI), 251 workforce, 682 (table), 729-730, 741-742, 746 World Energy Outlook, 774-775

Х

X-ray absorption fine structure (XAFS), 243

Y

yield estimation, 152 YPF La Plata Refinery, 252 (figure)

Ζ

zeolite, 127, 129, 130, 133, 14 active matrix and, 146-147 alkylation and, 237-23 fluid catalytic cracking (FCC) and, 223-224 hydrodesulfurization and, 212 hydroisomerization and, 161-163, 165, 162 (table), 164 (table) innovation and, 197 synthesis of, 144–146, 146 (figure) See also thermal cracking; zeolite Y; ZSM-5 zeolite-to-matrix ratio, 224 zeolite Y, 145-146 zeolitic catalysts. See zeolite ZSM-5, 130-131, 149 (figure), 162, 224 ZSM-12, 162 ZSM-22 (TON), 165 ZSM-23 (MTT), 165