Index

6R concept, 38–39

A
Abrasive cleaning, 297–298
Abrasive wear particles, 193
Accelerated aging results, 366
Achieved availability, definition, 224
Acrylonitrile Butadiene Styrene (ABS), 108
Active disassembly, 253
Active disassembly using smart materials (ADSM), 253
Active redundancy, definition, 163
Adaptation processes, 278
Adhesive wear particles, 194
Affinity diagram, 363–364
Aging behavior, 188
Air-blasting units, 297
Alkaline Ion Water Purifier (Matsushita), 21
Aluminum
fraction, 261
hot-roll line, example, 240–242, 243–244
products, total LCA (case study), 52–54
American Electronics Association, 69
American Society for Nondestructive Testing (ASNT), 293–294
American Society of Metals (ASM), 332
American Society of Testing of Materials (ASTM), 332
Analyze. See Define Measure Analyze Design Verification/validation phase, 364–366 tools, 364–366
AND gate, 173
Aqueous cleaning, 296
As-good-as-new condition, 231–232
Asymptotic mean integrated squared error (AMISE), 221
Authorized treatment facilities (ATFs), 32
AutoCAD, 141
Automobile shredder residue (ASR), 32
Automotive Industry Action Group (AIAG), 380
Automotive Parts Rebuilder’s Association, 289
Availability, analysis, 222–244
modeling availability, 237–242
definition, 163, 223
performance, 194
Backtracking manufacturing, 266
Barcodes, providing, 308–309
Bathtub hazard rate curve, 164–165
illustration, 164f
Battery-Free Remote Control, 20
Bell-shaped random variable, 202
Best linear unbiased estimator (BLUE), 276
Bill of materials (BOM), 192
Binomial distribution, 197–198
usage, 171
Biological cleaning, 296
Biweight function, 220–221
Board members, 5
Brainstorming, 366
Breaking, occurrence, 254
Burn-in period, 164
Business, motivation, 78
Cambridge Material Selection (CMS)
(Granta Design), 341
Capability index ($C_{pk}$), 375
Capilene® garments, 112
Carnegie Mellon Green Design Institute, 98
Cascades
appearance, 373
CATIA, 141
Cavities/orifices, number (reduction), 311
Certificate of Destruction (CoD), 31
Chemical cleaning, 296–297
Chemical Corrosion Expert System, 341

383
Ciba Specialty Chemicals, 107
Circle, 174
Clariant chemical corporation, 107
Cleaner Technologies Substitutes Assessment (CTSA), 98
Cleaning, ease, 307
Cleaning processes, 294–298
Climatex® Lifecycle™ fabric, creation, 107
Climatex® LifeguardFR™, 107
Closed-form expressions, 196
Closed-loop life-cycle system, open-loop life-cycle system (contrast), 38–39
Closed-loop product life-cycle system, 38
Coherent system structure/functions, 242–244
Co-kriging, 276
Common-cause failures, defining, 180
Common Threads Recycling Program, 112
Community, identification, 5
Competitors, identification, 5
Component age \( t \), reliability, 210
replacement, 189
Composite packaging, 261
Comprehensive evaluation/analysis, 194–195
Computer-aided design (CAD) data structures, 144
models, 153
packages, 323
software, 141–144
tools, 113
Computer-aided manufacturing (CAM), data structures, 144
Computer manufactured integrated systems (CMIS), 195
Concept reviews, 364
Conceptual design, 93, 95–96
DfLC tools, 95
environmental review, 14
Concurrent dynamism, 186
Concurrent engineering, concept, 186
Conditional failure rate, 210–211
Conditional probability of repair, 227
Conditional repair rate, 227
Condition-based monitoring (CBM) data, 270
Condition-based PM, 189
Condition base maintenance (CBM), 267 emphasis, 268–269
Confounded interactions, 369
Conjoint analysis, 93, 358
Consumer electronics product
new product scoring method, case study, 54–62
Contaminants, trapping, 311
Contingent valuation, 93
Continuous distributions, 202–207
Control charts, 195
Copper/lead fraction, 261
Corporate motivators, 78
Corporations, liability concerns (increase), 116
Corrective maintenance (CM), 188, 189, 222, 224
Corrosion/oxidation resistance, 348
Corrosive wear particles, 194
Counting process, 217–218
Cradle-to-cradle design, 71
Cradle-to-cradle life-cycle approach, 37–38
Cradle-to-cradle product development/assessment, 37, 40
Cradle to grave, 69
Critical to quality (CTQ), 359, 373
Cascade, 359, 373
flowdown, 375
Customers concerns, addressing, 7
demand, satisfaction, 4
identification, 5
inputs, 355
returns, 291–292
Cutter geometry/shaft design, 255–256
Cyber-Infrastructure-Based Engineering Repositories for Undergraduates (CIBER-U), 153
Cyclic principles, 26

**D**
DaimlerChrysler, 128
Damage-resistant designs, attempt, 302
Data segregation, Pareto analysis, 207–208
Decreasing failure rate (DFR), 206
Define Measure Analyze Design Verification/validation (DMADV), 355
Define Measure Analyze Improve Control (DMAIC) process, 352–353
Define phase, tools, 356–357
Degrees of freedom, 373
Design. See Define Measure Analyze Design Verification/validation decision support tools, 313–315 failures, reasons, 163 maintainability, 194 phase, 366–374
process, DfE incorporation, 10–11
reviews, usage, 377
tolerance window, increase, 376
tools, 91–92
Designers, liability concerns (increase), 116
Design for assembly (DFA), 2, 186
guidelines, 310
Design for Disassembly (DfD), 252–253, 313
Design for Environment (DfE), 2–5
approach, application, 10
components, 323
creation, 68
emphasis, 185
explanation, 2–3
innovations, examples, 19–22
process, implementation, 12–15
program, 6
understanding, 11–12
tools
guidelines/checklist document, 15–16
usage, 15–19
usage, 70
Design for maintainability, 185–195
Design for manufacturability (DFM), 367
Design for manufacture (DFM), 186
Design for manufacturing (DFM), 2
Design for product assurance (DFPA), 186
Design for production (DFP), 2
Design for remanufacture (DfR), 186
Design for remanufacturing
conflicts, 313
processes, 284
Design for sustainability (DfS), 37
Design for the life cycle (DfLC), 68
concepts, development, 69
definitions, 69–71
development, historical influences, 68–69
future, 113–117
implementation, 88, 105–107
examples, 107–117
process, 105–106
incorporation, industrializing nations (impact), 116
information, localization, 117
motivations, 72–78
paradigm changes, 113–115
principles, 78–86, 106
additions, 85–86
sharing, 115
sustainability, 117
uncertainty, 114
Design for X (DfX), 69, 186
requirements, 71
Design of Experiment (DOE/ANOVA), 194
Design of experiments (DoE), 367–368
development, 371
Design Repository (University of Missouri-Rolla // UMR), 152
Detail design, 96
methods, application, 90–91
Detailed design environmental review, 14
Disassembly
ease, 307
embedded design, 252
guidelines, 309–310
processes, conceptual modeling, 252
time, 9
trees, 98
Discrete distributions, 197–202
Distributions, intensity functions (usage), 213–214
Dofasco, Inc., 129
Dow Jones Sustainability Group Index, 35
Downtime, definition, 162
Drum magnetic separator, 258–259
Ductility, 348
Dutch Promise Manual, 98

E
Eco-Compass, 93
development, 98
Ecodesign, 69, 70
Ecodesign checklists, 98
Eco-indicator, calculation, 328–329
Eco-indicator 95, creation, 101
Eco-innovation, 113
Eco-labeling programs, participation, 4
Ecological footprint, 100
Economic dependency, 190
Economic drivers, 34–35
Economic Input Output Analysis
Life-cycle Assessment (EIO-LCA), 98
Eco-point, 101
Eddy current, 261
Electrochemical machining (ECM), 349
Embodied energy, 100
Embodiment
design, 96
methods, application, 90–91
Empirical data, usage, 216–217, 240
Empirical performance history, 194
Employee skills reliance, automation (contrast), 299
End of life (EOL), reaching, 266
specification, 52–53  
End-of-pipe efforts, 73  
End-of-pipe legislation, 73  
Energy consumption, 9  
Energy efficiency, 54, 56  
Enhanced bill of materials (EBOM), 152  
Environmental/chemical degradation, 301  
Environmental clean-up, participation, 114  
Environmental cost accounting tools, 101–105  
Environmental effect analysis (EEA), 16–19  
Environmental effects, 54, 57, 72–73  
Environmental impact, 41  
responsibility, 72  
Environmental impact statement (EIS), 323  
Environmental issues, 330–332  
back-burner status, 4  
Environmentally conscious design, 69, 71  
Environmentally conscious design, impact, 354  
Environmental objectives, 4–5  
creation, 6–8  
Environmental performance, 4  
reporting, 8  
Environmental priority number (EPN), 17  
Environmental priority system (EPS), 101  
Environmental Protection Agency (EPA), regulation, 7  
Environmental regulations, compliance, 7  
Environmental Review Process, 12  
Environmental risks, mitigation, 8  
Environmental stewardship, practice, 6–7  
Environment program, design (creation), 5–12  
Epanechnikov function, 220–221  
Ethical behavior, 4  
Ethical responsibility, 54, 57  
European Commission, proposal adoption, 31  
European Parliament/Council, legislation (adoption), 31  
European Union (EU), Battery Directive (91/157/EEC), 7  
Exchange coefficient, 346  
Expected replacement rate (ERR), 191  
Experimental designs, types, 369–374  
Expert system, necessity, 340–341  
Exponential distribution, 204–205, 213  
Exponential life, 234–235  
Facility-level remanufacturing process, 292–293, 300  
Factory refurbished resale, 292  
Failure  
conditional probability, 238  
data sources, 181–182  
definition, 162, 190–191  
density function, 165–166  
intensity/reliability functions, relationship, 211  
number, 222  
probability, 209, 222  
process modeling, 217–222  
reference, usage, 268  
Failure mode, effects and criticality analysis (FMECA), 171  
Failure Modes and Effect Analysis (FMEA), 16–17, 171–172  
Fashion obsolescence, avoidance, 301–302  
Fasteners, reduction, 310  
Fatigue analysis, 269–270  
Fatigue wear particles, 194  
Fault tree analysis, 173–175  
Fault tree probability evaluation, 174–175  
Federation of Swedish Industries, 101  
Feedback loop, 15  
Ferrous metal fraction, 261  
Final environmental review, 14  
Financial liability, reduction, 8  
Flagged material, use, 9  
Fluid analysis/tribology, 193–194  
Food and Drug Administration (FDA), regulation, 330  
Forever Flashlight, 19–20  
Fractional factorial experiment, 369–374  
Fracture toughness, 348  
Fragmentizers, 253  
Free Play Energy, 112–113  
Frequency amplitudes, knowledge, 269  
Froth flotation, 262–263  
Full cost accounting (FCA), 105  
Full factorial experiment, 369  
Functionality, 41  
G  
Gage bias, 378  
Gage repeatability and reproducibility (GR&R) assessments, 377  
Gamma distribution, 214  
Gantt chart, 357  
Gaussian function, 220–221  
Gears, positioning, 35
General Electric, remanufacturers, 290
GeoMagic Studio 6 software, 145
Geometric distribution, 199
Geometry, occlusion, 144–145
German Packaging Ordinance of 1991, 73
Global Reporting Initiative Work, 5
Goals, statement, 356
Government organizations, 5. See also Non-government organizations
Grabbing, 255
Granulator, 256–257
Green design
  life cycle, 320f
  materials selection, 319–321
  factors, 326–332
  necessity, 321–322
  process, 322–326
Green Design Tool, 96
Green engineering/design, 71
Green integrated technology (GRINTECH), 359
Green products, 27
GR-NF415GX Refrigerator (Toshiba), 20–21

H
Hazard function, 210–211
Hazardous materials/substances, 305
Hazard rate
  definition, 162
  function, 167
Heat treatability, 348–349
Heat treatment, 349
Henkel Corporation, 129
Hex shaft, 256f
Highly accelerated life testing, 366
Homogenous Poisson Process (HPP), 217
Hooke’s law, usage, 343
House of Environmental Quality, 96
House of quality (HOQ), 361
HOWs, 360–363
Human reliability, common-cause failures, 179–180
Hybrid method, 179
Hypergeometric distribution, 200–201

I
IdeMat software, 69, 95–96
Imperfect maintenance, 235–237
Increasing failure rate (IFR), 188, 206
Independent remanufacturers, 289
Indicators, usage, 98–101
Industrial ecology, 71
Industrial life-cycle design methods, 107
Influence method, factors, 178–179
Information/agreement, representation, 356
Infrared optical sorting, 264
Infrared thermography, 193
Inherent availability, definition, 224
Initial environmental review, 13–14
Innovation statement, 10
Inspection, ease, 307
Integrated Environmental Management Systems (EPA), 106
Integrated environmental management systems (IEMS), 105
Integration factor (IF), method (usage), 239
Intensity function, 210–211
  estimation, binomial distribution approach (usage), 211
Inter-arrival rate, 218
Intrinsic availability, 222
definition, 223
Inverse manufacturing, 266
Investor Responsibility Research Center (IRRC), 8, 35
Iowa State, research, 153–154
ISO 14000 standards, 105
Item reliability, 177

K
Kano analysis, 358–359
Kano technique, 93
Kodak
  2004 Annual Report, 131–132
  Design Structure Matrix, 136
  Fling perception, 131
  one-time-use cameras, 131f, 132–133, 265
  observations, 145–152
  recycling/remanufacturing/reuse efforts, 131
  Water & Sport one-time-use camera, 134
  BOM, 135–136
  internal housing, assembly drawing, 144
Kriging, 276

L
Label advisors, 335
Land bioproductivity, 100
Learning-by-doing activities, 129
Legislation, compliance, 4
Legislative drivers, 28–34
Liability, avoidance, 4
Life-cycle analysis (LCA), 4, 19, 185–186
Life-cycle assessment (LCA), 98, 249
Life-cycle costing (LCC), 101, 105
Life-cycle design, 67, 69. See also Design for the life cycle methods, 86–91
Life-cycle Design Strategies (LiDS) Wheel, 98
Life-cycle Design Strategy Wheel, 93
Life-cycle factor, 54, 56
Life-cycle influences, future design, 115–117
Life-cycle inventory (LCI), completion, 328–329
Life-cycle spectrum, 27
Life-cycle tools, design, 91–105
Life Cycle Unit, 270, 273–274
Life Stage, 16
Lifetime
data analysis, 274–277
data recording/collection, 270–274
monitoring, 270–277
Likelihood function, 215–216
Lognormal distribution, 214
Log normal distribution, 214
Long-run expected replacement rate, 187

M
Magnetic pulley, 258
Magnetic resonance imaging (MRI), 206
Magnetic separation, 257–261
Maintainability, 187–191, 222. See also Design for maintainability
definition, 223
modeling, 226–231
terms/definitions, 187–188
Maintenance, 188, 233
downtime, 188
frequency, 114
policies, classes, 188–189
Maintenance free operating period (MFOP), 270
Maintenance free operating period survivability (MFOPS), 270
Manufacturability, 41–43
Manufacturing issues, 330
process, 349
flagged material generation, 9
Material stage, 37. See also Premanufacturing
Markets, localization, 117
Markov method, 175–177
usage, 176–177
Material data, sources, 332
design considerations, 81
determination, 333–334
eo-indicator, 327–328
energy content, 327
evaluation, 339–340
interaction, 326f
properties, 326–329, 348–349
ranking, 333
recycling, 285
screening, 333
strength, 348
utilization, 54, 56
Material cycle, Energy use, and Toxic emissions (MET) matrix, 95–96
Material Declaration Statement (MDS), 14
Material input per service (MIPS) unit, 99
Materials and Process Design Advisor (Rockwell International), 341
Material selection
cost/property analysis, 335–337
expert system, 340–341
methods, 334–347
process, steps, 333–334
Materials-Energy-Chemicals-Other (MECO) matrix, 96
Maximum likelihood estimate (MLE), 219
ME 99 Mechanical Dissection, 129
Mean time between failure (MTBF), 212–213, 219, 222–229
alternative, 270
determination, 266, 377–378
target, 355
Mean time between maintenance (MTBM), 188, 222, 224–229
Mean time to failure (MTTF), 167–168, 188, 194, 212–213
concept, 274
determination, 266
exponential distribution, definition, 162
usage, 222, 224–229, 268
Mean time to repair (MTTR), 162, 194
Measure. See Define Measure Analyze
Design Verification/validation phase, 357–364
tools, 358–364
Measurement systems analysis (MSA), 360, 378
Medium producers, life-cycle design help (necessity), 117
Merit index method, 338
Metal detector, 259–261
components, 260f
Metric selection, 8–10
MID Commercial Furniture, 108
Mind Maps, 93
Minnesota Technical Assistance Program (MnTAP), 16
Minolta Vivid 910 3D Scanner software, 145
Mission time, definition, 162
Mobility 2001 report, 32
Modeling availability, 237–242
m-out-of-n network, 170–171
Multi-generation plan (MGP), 356
Multi-generation product plan (MGPP), 356
Multi-life-cycle approach, 27
Multiple life-cycle stage concern, 108–112
Multiple linear regression, 275–276
Multiple lives, product design, 115
Multiple-parameters indicators, 100–101

N
National Association of Corrosion Engineers (NACE), 341
National Centre for Design (RMIT University), 107–108
National Design Repository (Drexel University), 152, 153
National Emission Standard for Hazardous Air Pollutants (NESHAPS), 330
National Institute of Standards and Technology (NIST), 152, 380
Core Product Model, 152
Negative binomial distribution, 198–199
New product development decision making, 3
design decisions, 3
management decisions, 3
Nondestructive testing (NDT) methods, 294
Nonferrous metal fraction, 261
Nonferrous metal separation, 261–262
Non-government organizations, 5
Nonhomogeneous Poisson Process (NHPP), 217–219
Nonlinear equations, system, 215
Nonmetallic material fraction, 261
Nonparametric kernel density estimate, 220–222
Nonquantitative property, scaling, 338
Nonthreaded joints, disassembly, 252
Normal distribution, 202–203

O
Object registration, performing, 144
Observation research, 361
Oil point method (OPM), 100
One-factor-at-a-time (OFAAT) approach, 367–368
Open systems, attempt, 301
Operating condition, 191
Operating time, 222
Operational readiness (OR), 222
definition, 223
Opportunistic maintenance (OM), 189
OR gate, 173
Original Equipment Manufacturers (OEM)
core collection, 303–304
cost-reduction ideas, 129
direct mail returns, usage, 289
integrated strategy, 303–304
internalized remanufacturing, 300
parts supply, 287
remanufacturing, 290–291
driver, 291–292
societal commitment, 57
Outcome, 195
Overband separators, 257
Overhauling, 265

P
Packaging, 54, 57
design principles, 80
Parallel network, 169–170
Pareto rule (80/20 rule), 207
Partnership for a New Generation of Vehicles (PNGV), 52–53
Parts
corrosion/dirt protection, 311
count method, 172–173
damage, 309
proliferation/standardization, contrast, 304–305
replacement, ease, 307
variety, reduction, 308
Pascal distributions, 199
Performance index, 343
method, 342–347
Personal Computer DfE tools, 96
Pert chart, 357
Petri Nets, theory, 252
Piezo effect, 20
Planning horizon, 187
Platform designs, attempt, 301
PlyFOLD container, 107
Poisson distribution, 201–202
Poisson process, 219
  events occurrence, 204
Polyurethane (PU), 253
Postlaunch review, 14–15
Postuse stage, 37
Powder consolidation, 349
Power spectral density (PSD), 269–270
Pré Consultants, 101
Predictive maintenance, 231
Premanufacturing stage, 37
Preserve™ products, 110
Press-fits, number (reduction), 310
Preventive maintenance (PM), 188–189, 222, 224
  automation, 195
  CM, contrast, 231
  cost, 189
  implementation, 192–195
  ineffectiveness, 218
  strategy, 191–192
Probability variables, review, 195–208
Process
  capability analysis, 374
  control plan, 373
  eco-indicator, 327–328
  improvement, 376
  material minimization, 334
Producer responsibility legislation, 73
Product
  architecture design guidelines, 300–302
  conceptual design, methods (application), 90
  data, capture, 134–141
  definition, 92–98
  methods, application, 90
digitization, 141–145
  dissection, 133–134
distribution design principles, 83
  end-of-life activities, 38
  end-of-life design principles, 85
  end-user repair, design, 115
  initiation document, 12–13
  life cycle, concerns, 112–113
  life-cycle activities, 73
  life-cycle stages, 37–40
  maintenance/repair guidelines, 303
  manufacturing design principles, 81
  material minimization, 334
  reliability, design process aspects, 164
  selling, 277–279
  service design principles, 84–85
  service systems, 116
tear-down, 15
total life cycle, 47–52
  use design principles, 83–84
  variety, reduction, 308
Product/component remanufacture, 200
Product design. See Sustainability matrix, 16
Product-development organizations, environmental awareness initiatives, 11–12
Product-development process, 15
Product Ideas Tree (PIT) diagram, 93
Production, localization, 117
Product sustainability
  assessment, 40–41
  case studies, 52–62
  drivers, 27–37
Product sustainability index (PSI), 41–44
  development effort, 45–46
  evaluation, methodology, 47–52
  influencing factors, identification, 47
  scores, determination, 47–52
Product/system failures, reasons, 163
Pro/Engineer, 141
Profitability, enhancement, 4
Project
  charter, 356
  creep, 356
  plan, 357
Proprietary technology, intentional use, 306
PT908 (PredicTech), 192
Pugh Decision matrix method, 337
Pugh Matrix, 364
Push-out capability, 310
Q
Quality
  definitions, 353–354
  department, usage, 351
  loss function, 371
Quality function deployment (QFD), 359, 361
  consideration, 363
  HOQ, 362
  matrices, 362
R
Radio-frequency identification (RFID), 309
Randomization, 371
Random variables, 195–197
  occurrence, 196
Index 391

Rapid application development, 358
Rare earth roll separator, 258–259
Readable labels, providing, 308–309
Real valued random variables, $n$-tuple, 196
Reassembly
design, 310
ease, 307
Rebuilding, 265, 266
Rebuilt, differences, 285
RECHARGE, 7
Rechargeable Battery Recycling Corporation (RBRC), 7
Reconditioned, contrast, 285
Reconditioning, 265, 312
Recopol™ mold, 108
Rectangle, 174
Recyclability, 54, 57
Recyclability/disassembly rating, 9
Recyclability/ remanufacturability, 41
Recycle (category), 356
Recycled-PET fabric, 108
Recycle, products, 108
Recycling technologies, 249–264
disassembly, 251–253
economical aspects, 250
process overview, 250–251
product design guidelines, 250
Re-Define furniture, 107–108
Reduce (category), 355
Reduce reuse and recycle (3Rs), 38
Redundancy, definition, 162
Refurbishing, 265
processes, 298–299
Regulatory motivators, 73–75
Reliability, 54, 57, 161–162. See also
Product
allocation methods, 178–179
bathtub curve, 377
configurations, 168–171
definition, 162
design, 161
evaluation methods, 171–178
function, 166
growth, 218
idealized maintenance, relationship,
231–235
models, 208–213
standards, 181–182
terms/definitions, 162–163
testing, 365, 377
Reliability-related formulas, 165–168
Remanufactured, contrast, 285
Remanufacturing, 266, 284–287
benefits, 285–286
business
practice, 287–292
scenarios, 288
cleaning, 310–312
conflicts, design, 313
consumer cores, 289
consumer demand, 287
definitions, 284–285
design decision support tools, 313–315
design principles/strategies, 300–306
disassembly guidelines, 309–310
employee skills reliance/automation,
contrast, 299
facility processes, 292–299
cleaning processes, 294–298
inspection/testing processes,
293–294
hardware design guidelines, 306–313
sources/overviews, 307
industry size, 286–287
inherent uncertainties, 306
inspection/testing, 312–313
operations, cost, 293f
processes, design, 284
raw material, 289
refurbishing processes, 298–299
replacement/reconditioning/repair, 312
sorting guidelines, 308–309
Remove (category), 355
Renewal process (RP), 217
Repairability, 222
definition, 223
Repairable systems
availability analysis, 222–244
modeling availability, 237–242
Repair rate
definition, 162
failure rate, relationship, 226
Repeatability, 378. See also Gage
repeatability and reproducibility
Replacement, 312
Reproducibility, 378. See also Gage
repeatability and reproducibility
Research Institute for Sustainability Engineering (RISE)
involvement, 41–42
study, 53
Resilience (disorder resistance), 113
Resource utilization/economy, 41
Restriction of Hazardous Substances (RoHS) Directive (2002/95/EC),
28–30
Reusable components, 307
Reuse (category), 355
Reuse strategy, 265–267
Reuse technologies, 249, 265–279
hazardous materials/substances, 305
Reuse technologies, (Continued)
lifetime monitoring, 270–277
maintenance, data/analysis, 267–270
parts proliferation/standardization,
contrast, 304–305
principles/strategies, 300–306
product maintenance/repair guidelines,
303
proprietary technology, intentional use,
306
Reverse engineering
fundamentals/applications, 127–130
future, 152–156
motivation, 128–129
needs/benefits, 130
principles, 154
process, example, 130–152
Reverse logistics, 292
design, 303–304
RMS, 192
Röhner Textil, 107
Root sum of squares (RSS), 372
Runge-Kutta-Gill methods, 191
Runge-Kutta methods, 191

S
Safe principles, 26
Safety Review Process, 12
Sample sizes, 216–217
Scope tool, 357
Selection, maps, 345
Selection of Strategic Environmental
Challenges (STRETCH)
methodology, 107
Selling-service approach, 278
Separation techniques, 257–264
Series network, 168–169
Service
durability, 54, 57
life, 54, 57
gemetric features, minimization,
311
material minimization, 334
Serviceability, definition, 223
Services, selling, 277–279
Shape memory alloy (SMA), 253
Shape memory polymer (SMP), 253
Shearing, involvement, 254
Sheppard, Sherri, 129
Shot peening, 349
Shredding, 253–256
principle, 254
Simple Iterative Procedure (SIP), 216
Single life-cycle stage concerns, 107–108
Single-parameters indicators, 99–100
Six Sigma process, 351, 353
approach, 375
Small producers, life-cycle design help
(necessity), 117
Socially responsible investors, 5
Societal drivers, 35
Societal impact, 41
Society of Environmental Toxicity and
Chemistry (SETAC), 45, 101, 323
Soft aluminum fraction, 261
Solar principles, 26
SolidWorks, 141
Solvent-based chemical cleaning,
295–296
Stakeholders
analysis, 356
identification/understanding, 5–6
Standardized normal distribution, 213
Statistical pattern analysis, 267–268
Statistical process control (SPC), 367,
380
chart, usage, 376
methodologies/tools, 194
Statistical testing, 371–372
Steady state, transient state (contrast),
192
Stochastic dependency, 190
Strength probability density function, 177
Strength random variable, 177
Stress probability density function, 177
Stress random variable, 177
Stress-strength modeling method,
177–178
Structural fatigue, 300
Subelement terminologies, definitions,
56–57
Subject matter expert (SME), 369
Substitute quality characteristic, 362–363
Substitute technologies/compounds, 106
Subtract-and-Operate Procedure (SOP),
development, 134
Success, metrics, 360
Supplier Innovation Challenge
(Whirlpool Corporation), 128–129
Supply chain, product information
sharing, 116
Surfaces, corrosion/dirt protection, 311
Suspended magnet design, 257
Sustainability
background, 26–27
definition, 25
drivers, interrelationship, 35–37
increase, 266
Mobility project, 32–33
product design, 26–27, 40–52
Sustainable multiple product life-cycle system, perpetual material flow, 35–37
Sustainable Process Index, 101
Swedish Environmental Research Institute, 101
Swiss eco-point (SEP) measures, 101
Synthesis Coalition, 129
System operation monitoring, 192–194
System reliability/availability, review, 208–222
Systems effectiveness measures, definition, 223–225
Systems reliability allocation method, 178
System structures function/availability, 242–244

T
Teardown Operations, 128
Tearing, involvement, 254
Theory of inventive problem solving (TRIZ), 366
Thermal cleaning, 295, 297
Thermal shock resistance, 349
Third-party remanufacturing, 289–290
Threaded joints, disassembly, 251
Three-dimensional (3D)
digitization technologies, 143
laser scanning/stereovision, 143
Three-parameter Weibull probability distribution, 214–216
Ticona Corporation, 129
Time element, 190
Time-space problems, 201
TM101 (solid-state vibration switch), 192–193
Total cost accounting (TCA), 101
Total product/packaging mass, 9
Total quality management/Six Sigma (TQM/SS), 354
approach, 355–380
Total quality management (TQM) definition, 351–354
resources, 380–381
Triweight function, 220–221
Truly sustainable products, 27
r-test, usage, 372

U
UNEP Ecodesign Manual, 98
Uniform function, 220–221
Unit, 189–190
Upgradeability, 54, 57
U.S. Clean Air Act, 330
Useful life, definition, 162
Useful-life period, 164
Use stage, 37

V
Valdez Principles, 325–326
Validation. See Define Measure Analyze Design Verification/validation studies, 374
Vapormatt, 297
VDI 2243 (German Engineering Standard), 284–285, 307
Vehicle Assessment and Benchmarking Activity center (General Motors), 128
Verification/validation. See Define Measure Analyze Design Verification/validation phase, 374–380
tools, 374–380
Vibration analysis, 192–193, 268–269
Vibration measurement, 192–193
Voice of the business (VOB), 362–363
Voice of the customer (VOC), 357–358
research, 359, 360–361
substitutes, 362
Volatile organic compounds (VOCs), 295–296
VS101 (solid-state vibration switch), 192–193

W
Waste Electrical and Electronic Equipment (WEEE), 73
EU directives, 7
Waste equals food, concept, 71
Watchdog Agent™, 271–273
Weibull analysis, usage, 365
Weibull distribution, 205–207, 214, 377.
See also Three-parameter Weibull probability distribution manipulation, 378
Weibull life, 235
Weibull pattern analysis, 267–268
Weibull process, 219
Weight factors, 337–340
Weld material, addition, 298–299
Wet-blasting, usage, 297
WHATs, 360–363
Work breakdown structure (WBS), 357
Work streams, identification, 33
Index

World Business Council for Sustainable Development (WBCSD), 32
World Commission on Environment and Development, 68–69
World Summit on Sustainable Development (2002), 69

X
Xerox Corporation
photocopier reuse, 265
remanufacturer, 290–291

X-ray optical sorting, 263f, 264

Y
Young’s modulus, maximization, 343

Z
Z-statistic, formation, 372
Z-test, usage, 372