

Index

- Accelerated life tests (ALT) 133, 134, 184, 248, 250, 251, 254–266
- Accelerated stress testing (AST) 250, 255, 261, 265, 270, 331, 336
- Active redundancy 376, 381, 392, 402
- Assignable cause 297–300, 308, 313, 325
- Average outgoing quality 182, 317–321
- Bathtub curve 26, 56, 419
- Bayesian network 422, 430
- Bayesian reliability analysis 445, 446
- Bernoulli trials 46, 50, 51
- Binomial coefficients 50
- Binomial distribution 27, 46, 47, 50, 51, 249, 283
- Binomial expansion 46, 47
- Binomial variable 312
- Block diagram, *see* Reliability block diagram
- Burn-in process 26, 248, 249, 285, 331–336, 439
- c chart 302, 304, 312, 314–316
- Canary 131, 418–420
- Cascade failure 358, 359
- Cause-and-effect diagram 344, 346, 352–354, 356
- Censored data 267, 268, 287, 289
- Chance (or common) cause(s) 179, 181, 182, 295, 297, 299, 300, 316, 319, 323
- Chi-square distribution 461–465, 467
- Coefficient of kurtosis 37, 38, 53
- Coefficient of skewness 37, 53
- Coefficient of variation 36–38, 213, 214, 220
- Coherent structures 396
- Common cause failure 355, 356, 358–361
- Common mode failure(s) 355, 356, 359, 361, 362, 364, 366, 369, 372, 393
- Conditional probability 29, 357, 395
- Conditional reliability 19, 31–33, 39, 55, 62, 82
- Confidence interval 65, 249, 276–283, 291
 - on the mean, variance known 279
 - on the mean, variance unknown 280
 - on parameter for exponential distribution 287–291
 - for reliability for success-failure testing 283
- Continuous random variable 51, 73
- Control chart 96, 98, 180, 279, 295–297, 299–325
- Control limits 297, 300, 301, 304, 306–308, 311–315
- Correlation 239, 254, 306, 323, 325, 424, 430
- Critical-to-quality (CTQ) 92–93, 98, 105, 106
- Cumulative distribution function 24, 45, 78, 210, 455
- Customer satisfaction 2, 6, 10, 95, 105–107, 175, 188, 409
- Cut sets 120, 121, 127, 128
- Deductive method 116, 117, 119, 347
- Deductive vs. inductive methods 116, 117, 119, 347
- Degrees of freedom 280, 281, 284, 291, 457, 461, 467–472
- Derating 128–130, 172, 223–245
- Design review 106, 131, 132, 341, 348, 373
- Design for six sigma (DFSS) 10, 89–108
- Discrete random variable 45, 46
- DMAICT or DMAIC process 92, 97–99, 104, 105, 107, 108
- Dynamic system reliability models
 - parallel model 390, 399
 - series model 306, 325
 - shared-load parallel model 357, 390, 391
 - standby redundant system 381, 385, 402
- Expected value 27, 35, 36, 100, 179, 217, 401, 413
 - of a continuous random variable 35, 36
 - (mean) of a discrete random variable 46
 - of a function of random variables 100
- Exponential distribution 32, 51, 55, 57, 61–64, 66, 76, 287–291, 377, 386–390, 442, 444, 446, 448
- F-distribution 285, 467
- Factor of safety 209, 211–214, 219
- Failure models 79, 128–131, 173, 174, 183, 195–199, 202, 204, 206, 239, 252, 256, 258, 260, 261, 347, 413, 443
- Failure precursors 415, 418, 420–430
- Failure rate 26, 27, 29, 32, 34, 39, 54, 57, 60–62, 67, 71, 72, 74, 76, 77, 203, 204, 233, 335, 347, 376–379, 383–389, 412, 413, 435, 439, 443, 446 *see also* hazard rate

- Failure mode and effect analysis (FMEA) 95, 97, 118, 193–195, 205, 206, 248, 341, 364, 366, 369, 373
- Failure mode, effect and criticality analysis (FMECA) 91, 93, 98, 117–119, 193–195
- Failure mode, mechanism and effect analysis (FMMEA) 193–206, 219, 342, 343, 345, 417, 425
- Failure modes 117, 118, 123, 193–206
- Failure truncated test 65, 290
- False alarm on a control chart 325, 415, 422
- Fault tree analysis (FTA) 91, 117, 119–128, 195, 341, 342, 343, 347, 360
- Frequency histogram 21
- Function of random variable 215–218
- Fuses 130, 131, 261, 418–420, 431
- Gamma distribution 75–77, 288
- Gamma function 56, 76, 451, 453, 454
- Gaussian distribution, *see* Normal distribution
- Geometric distribution 50, 51
- Hazard rate 19, 22, 26–34, 36, 39, 45, 54–57, 62–64, 69, 72, 74, 79, 376, 378, 383–385, 390, 392, 436; *see also* Failure rate
- Health monitoring 137, 195, 409–431
- Histogram 21, 23–25, 30, 83, 98, 427
- Human factors 115–117, 131, 132, 160
- Hypothesis testing 95
- Imperfect switching 387–390
- Independence 325, 442
- Inductive methods 117, 119
- Infant mortality 26, 56, 57, 82, 136, 249, 334
- Instantaneous failure rate 27, *see also* Hazard rate
- Interpretation of the confidence interval 277, 278
- Key reliability practices 114, 170–175
- Kurtosis 37, 38
- Lack of memory property, exponential distribution 51
- Legal liability 15
- Life cycle conditions 4, 5, 8, 19, 111, 113, 131, 141, 149–166, 173, 177, 183, 184, 190, 198, 262, 347, 417
- Life cycle cost 10, 106, 143, 414, 441, 446
- Life cycle environment 156, 198, 250, 254, 412
- Life cycle profile 111, 149, 150, 167, 198, 206, 353, 373, 413, 424
- Lognormal distribution 45, 73–75, 79, 84, 210, 404, 446
- Maintainability 2, 5, 8, 12, 37, 45, 73, 106, 112, 115, 116, 131, 132, 138, 143, 145, 160, 375, 401
- Mean
 - of continuous distribution 62
 - of a continuous random variable 35, 51, 62
 - of a discrete random variable 46
 - of random variable 35, *see also* Expected value
- Mean time between failures (MTBF) 36, 62–67, 77, 288–291, 378, 385, 386, 388–390, 392, 404
- Mean time to failure (MTTF) 36, 39, 58, 61, 62, 67, 74, 75, 379, 384, 391, 440, 443
- Median 34, 37, 56, 59, 60, 62, 68, 69, 74, 75, 78, 79, 277, 302–304
- Minimum cut set (MCS) 120, 121, 127, 128, 396, 397, 399, 400
- Minimum (minimal) path set 396, 397, 399, 400
- Minimum variance unbiased estimator 65, 284, 287
- Mode, of a random variable 56, 62, 68, 74
- Moments, of a random variable 36
- Moving range chart 303, 308, 309
- np*-chart 302, 304, 312–314
- No-fault found (NFF) 351–373, 436
- Normal distribution 38, 67–71, 73, 75, 89, 90, 180, 212–214, 279–282, 284, 318, 321, 322, 325, 455–457, 461
- Occurrence rating 199, 200, 204, 205
- p*-chart for proportion 300, 302–304, 312
- Parallel system 381–385, 391
- Parameter estimation 74, 242
- Part assessment process 114, 115, 177–185, 190
- Patterns, on control charts 324, 326
- Percentiles 19, 33–35, 39, 42, 61, 68
- Physics of failure (PoF) 111, 128, 129, 138, 239–264, 268, 270, 275, 276, 412, 413, 415, 417, 418, 420, 428, 430
- Point estimator 65, 66, 90, 94, 290
- Poisson distribution 45, 50, 314
- Probabilistic design 98, 207–220
- Probability density function (pdf) 19, 23–25, 36, 37, 39, 51–58, 60, 61, 63, 67, 68, 73–75, 136, 208, 209, 215, 260, 299, 383–385, 392, 455, 457, 461, 467
- Probability distribution 34, 46, 55, 68, 74, 79, 101, 121, 226, 249, 277, 412, 440
- Probability mass function 45, 57
- Probability plot 77–83
- Process capability index 90, 94, 179, 180–182, 322, 323
- Process mean 89, 90, 95, 179, 180, 299, 306, 317, 324
- Product failure(s) 12, 14, 15, 23, 137, 138, 193, 195, 254, 339–341, 352, 355, 373, 409
- Product qualification 132, 250–276, 353
- Product screening 12, 248, 249, 295, 331–336
- Prognostics 131, 206, 260, 261, 409–431
- Prognostics and health management (PHM) 260, 261, 413–424, 429, 430
- Qualification 111, 113, 115, 132–138, 145, 150, 173, 178, 183, 184, 186, 189, 190, 194, 195, 206, 227, 245, 248, 250–276, 331, 336, 353, 414, 420
- Quality
 - and customer satisfaction 6
 - definition 1–2
- Quality control 2, 11, 26, 132, 182, 288, 295, 299, 306, 312, 316, 317, 345, 348, 440, 444
- Quality function deployment 2, 91, 97, 98
- R chart 300, 303, 305–307
- Redundancy 76, 121, 131, 182, 355, 359–361, 381, 392, 393, 401, 402
- Reliability
 - definition 2–5
 - of system 9, 32, 76, 84, 169, 247, 347, 375–402
 - and warranty 437–439
- Reliability assessment 21, 45, 114, 115, 178, 182–184, 260, 415, 416, 425

- Reliability block diagram (RBD) 117, 125, 219, 375, 376, 382, 383, 389, 391, 397, 398, 401
k-out-of-n system 391
parallel system 382
series system 376
series-parallel system 383
- Reliability capability 16, 114, 169–175
Reliability estimation 21, 64, 81, 247–291
Reliability function 19, 24, 25, 31, 32, 34, 36, 39, 55, 57, 60, 83, 84, 380, 383, 386, 387, 390–39
Reliability improvement 105, 171, 174, 175, 438
Reliability management 137, 172, 175, 448
Reliability testing 55, 107, 115, 169, 171–174, 288, 331
Requalification 415, 420
Risk management 137, 188–190
Root cause(s) 13, 91, 95, 96, 98, 108, 112, 137, 252, 339–351, 359, 362, 364, 373, 436
Root cause analysis 95, 97, 137, 172–174, 184, 185, 194, 195, 201, 206, 339–350, 353, 373, 424, 435
Rules, for out-of-control 301, 305, 308
- S chart 303, 306, 307, 311
Safety factor 128, 207, 214
Sample mean 276, 279–282, 300
Sample range (R chart) 300, 306, 308
Sample size 279, 280
Sample standard deviation 276, 306
Sample variance 280, 461
Series system 376–382, 401, 402
Series-parallel systems 383
Severity rating 200, 205
Six sigma process 10, 89–108
Skewness 37, 53
Sources of variability 95, 297
SPC, *see* Statistical process control
Special (assignable) cause 96, 179, 296–300, 305, 308, 313, 325
Stable process 179, 318
Standard deviation 36–38, 52, 53, 56, 59, 62, 67–70, 73, 89, 90, 94, 134, 180, 181, 210–213, 217, 276, 277, 280–282, 299, 300, 302, 304, 306, 311, 318, 322, 324
of a continuous random variable 36–38, 52
Standard normal random variable 68, 69, 455
Standby redundant systems 385
Standby systems 387
- Statistical process control (SPC) 11, 91, 97, 104, 241, 295, 299, 325, 336
Statistical tolerances 216
Stress–strength interference models 209–212
Supply chain 16, 111, 112, 114, 137, 142, 143, 169, 171, 173, 175, 177, 185, 188, 190, 252, 428, 430, 436
System effectiveness 6, 115, 116
System reliability 9, 32, 76, 84, 169, 247, 347, 375–402
- t*-distribution 280, 281, 457–459
Time-truncated test 65
Total time on test 65–67, 287, 289, 291
- U-chart, for defects per unit 302–304, 312, 314, 315
Unbiased estimator 65, 284, 287, 306
Unreliability function 19, 39, 76, 79
Uprating 179, 239–245
- Variance
of a continuous random variable 51
of a discrete random variable 46
Variance transmission equation 95, 98, 100, 101
Virtual qualification 184, 194, 195, 206, 245, 250, 260, 261, 262, 274
Virtual testing 250, 260, 262, 270
- Warranty, and reliability 437–439
Warranty analysis 433–449
Warranty cost 435, 437, 439–449
Wearout 26, 56, 57, 69, 82, 83, 130, 133, 134, 136, 157, 197, 199, 202–204, 258, 266, 270, 356, 365, 418, 435
Wearout failures 133, 157, 197, 199
Weibull distribution 45, 55–59, 61, 63, 79–84, 210, 249, 446, 448
mean 56
probability paper 81
reliability function 57
scale parameter 56
shape parameter 56
standard deviation 56
- \bar{X} control chart 305–308
 \bar{X} and R control chart 302–308
 \bar{X} and S control chart 304, 305, 311
- Zone rules for control charts 300, 301