

Basic principles

11

Technical documentation

117

Machine elements

213

Production technology

297

Measurement and testing technology

415

Fluid technology

459

Automation technology

497

Occupational and environmental protection, maintenance

581

Materials engineering

611

Interdisciplinary skills

711

Contents

Basic principles	11
Physical quantities and units	11
Formula symbols and units	13
Mathematical characters/symbols	15
Numbering systems	16
Converting numbers between numbering systems	17
Codes	18
Basic mathematical principles	22
Rule of three, percentage calculations, power calculations	22
Pythagorean theorem	24
Trigonometric functions	24
Formula conversion	25
Area calculation	26
Right-angled triangle	29
Lengths	30
Volume calculation, surface area calculation	31
Density of materials	35
Centre of gravity	36
Force, motion	37
Friction	40
Lever, torque	41
Roller, pulley block, winch	42
Work	44
Power	47
Efficiency	48
Fluid technology	48
Heat	54
Types of stress	60
Strength of materials	61
Basic drives	68
Electrical engineering formulae	68
DC technology	68
Electrical field	72
Magnetic field	74
AC technology	76
3-phase AC technology	82
Electrical resistors	83
Non-linear resistors	86
Capacitors	88
Semiconductor components	91
Electrical engineering symbols	97
Metal technology symbols	107
Technical Documentation	117
Technical drawing, fundamentals	117
Projections	118
Dimensioning	120
Tolerances	130
Fits	139
Standard hole system	142
Standard shaft system	144
Limit deviations for holes and shafts	146
Surface specifications	148
Welding and soldering	155
Representation of welding seams	155
Joint and seam types	157
Identification numbers for welding and soldering methods	159
Welding positions	160
General tolerances for welding construction	160
Thread	161
Holes, screws, rivet	163

Counterbores	169
Centre holes	169
Knurl	170
Hatching	171
Workpiece edges	171
Gear wheels	175
Gearing diagrams	175
Sealing elements	176
Roller bearing	178
Springs	180
Thread run-outs, thread undercuts	181
Undercuts, centre holes	182
Counterbores	184
Identification of circuit diagrams	188
Conductors and conductor connections	188
Identification of electrical equipment	188
Circuit diagrams	191
Equipment connections	193
Cable connections, clamp connections	194
Contact tables	196
Connection chart (terminal diagram)	200
Location diagram	200
Program workflow	201
Elementary program structures	201
Basic geometrical constructions	203
Pre-printed forms for technical drawings	207
Paper formats	207
Title block	208
Scales	208
Line types, line groups	209
Standard number ranges and preferred numbers	210
Rounding radius	210

Machine elements 213

Thread	213
Metric ISO thread	216
fine thread	216
Pipe thread	217
Metric ISO trapezoidal thread	218
Thread run-outs and thread undercuts	218
Identification of threads	219
Screws	219
Designation of screws	222
Strength classes of steel screws	222
Minimum depths of engagement	223
Through-holes for screws	223
Mechanical properties of rust-proof screws and nuts	223
Identification codes on steel screws and nuts	224
Screw head types	224
Thread types and bolt ends	224
Screws	224
Forces in a screw connection	230
Pretensioning forces and tightening torques	231
Selection of shaft screws	232
Thread	232
Metric ISO thread and tolerances	232
Determining the lengths of thread engagement	233
Limits for male and female thread	233
Pins, lengths of thread engagement, screw-in groups	234
Nuts	234
Designation of nuts	234
Strength classes of nuts with regular thread	234
Identification for nuts with strength classes	235
Combination of nuts and screws	235
Resistance of nuts to stripping out	235

Designs of nuts	236
Nuts	237
Lock washers for locknuts	240
Locknuts for anti-friction bearing	240
Lock washers for locknuts of anti-friction bearings	241
Across-flats dimensions	241
Squares of parallel shanks	242
Washer, circlips, serrated lock washers	242
Pins, grooved pins with round heads, blind rivets	246
Bolts, cotter pins	252
Retaining elements, fit washers and support disks	253
Screw locking elements	254
Sealing elements	255
Featherkeys, spring washers, grooves	257
Saddle keys, gib-head saddle keys, grooves	258
Shaft ends, splined shaft connections	259
Tool taper	260
Roller bearing	261
Designation of anti-friction bearings	261
Dimension series of anti-friction bearings	262
Selection and use of anti-friction bearings	263
Tolerance classes of anti-friction bearings	264
Designation and identification of anti-friction bearings	264
Examples of designations for anti-friction bearings	267
Roller bearing	268
Slide bearing	271
Lubricating nipples, grease cups	273
Springs	275
Flange couplings	278
Muff couplings	279
Standard parts for jig-and-fixture manufacturing	279
Gear drive	289
Worm drive	290
Belt drive	291
Roller chains	294

Production technology 297

Manufacturing processes	297
Main groups	297
Machining terms	297
Tool applications groups	299
Cutting materials	299
Cooling lubricants	301
Speed diagram	302
Application guidelines	303
Specific cutting force	304
Drilling	304
Thread cutting	311
Turning	312
Taper turning	317
Classification and application of hard cutting materials	318
Indexable inserts	319
Planing and slotting	323
Milling	324
Indexing with the indexing head	329
Grinding	330
Bending	335
Plastic cutting	337
Production scheduling	338
Determination of the allowed time according to REFA	338
Cost calculation	340
Main usage time	341
Drilling, reaming, counterboring, thread tapping	341
Planing, slotting	341
Turning	342
Thread cutting	342

Milling	343
Grinding.....	345
Welding and soldering	346
Colour coding for gas cylinders	350
Gas consumption when welding steel	352
Gas cylinders	353
Welding rods	353
Electric arc fusion welding	353
Gas-shielded welding	356
TIG welding	358
MAG welding	358
MIG welding	359
Flame cutting	359
Autogenous gas cutting	359
Plasma arc cutting	360
Laser cutting	360
Soldering.....	361
Gluing.....	365
Plastics welding	367
Lubricants.....	368
CNC machine tools	374
Block diagram of a CNC control system	374
Coordinate axes and directions of motion	374
Reference point.....	374
Structure of CNC programs	375
Address letters, special characters	376
Preparatory functions.....	377
Additional functions.....	378
Command codes according to DIN.....	380
Tool path corrections	380
Command codes for PAL-CNC lathes	381
Command codes for PAL-CNC milling machines.....	390
Programming process	402
Flexible manufacturing systems	404

Measurement and testing technology 415

Dimensional metrology	415
Glossary.....	415
Metrological terms	418
Basic principles of dimensional metrology and measuring instruments	421
Vernier callipers	423
Micrometers	424
Dial gauges.....	429
Angular position encoders	431
Parallel block gauges	433
Gauging.....	435
Surface inspection technology	442
Quality management	444

Fluid technology 459

Ideal gas equation	459
Normal state	459
Generating compressed air	459
Branching and maintenance unit	460
Treating compressed air	460
Pipe routing	461
Pneumatic cylinders	462
Air consumption	462
Piston force	463
Piston speed	464
Pneumatic valves	465
Directional valves	465

Identification and connection designation	465
Delay valves	465
Pressure valves	466
Compressed air motors	467
Pumps	468
Logical operations with pneumatic elements	468
Identifying circuit-diagram components in fluid technology	469
Basic pneumatic controls	470
Path-dependent control systems	470
Pressure-dependent control systems	471
Time-dependent control systems	471
Speed controls	471
Functional diagrams	472
Path-dependent sequence controls	474
Electro-pneumatic control systems	475
Solenoid valves	475
Basic circuits for electro-pneumatics	476
Hydraulics	478
Hydraulic oils	478
Flame-resistant hydraulic fluids	479
Calculating hydraulic systems	480
Components in a hydraulic system	482
Single-cylinder control	482
Hydraulic cylinder	483
Hydraulic valves	484
Hydraulic-valve circuits	485
Pressure valves	486
Flow-control valves, throttle valves	488
Shut-off valves	488
Hydraulic accumulator	489
Hoses and pipes	489
Hydraulic control systems	490
Proportional valve	495

Automation technology 497

Logic operations	497
NAND and NOR circuit technology	500
Bistable multivibrators	500
Boolean algebra.....	503
Circuit families	504
Work table	505
Truth table	505
Level.....	505
Basic terms used in measurement technology	506
Displaying measurands	507
Accuracy classes	507
Graphical symbols for labelling measuring instruments	507
Pointer instruments	508
Digital multimeter	509
Measuring circuits	510
Power measurement	510
Sensors	512
Measuring chain	512
Temperature sensors	514
Resistance sensors	514
Thermocouples	515
Path and angular measurement	516
Rotary speed measurement	518
Strain gauge	520
Pressure sensors	523
Inductive proximity switch	525
Capacitive proximity switches	527
Ultrasonic sensors	527
Optoelectronic sensors.....	528
Fluid level measurement.....	530

Flow measurement	530
Control technology.....	531
Contactors.....	533
Relays	535
Protective circuits.....	537
Command and signalling devices	538
Programmable logic controllers	540
Structure of a PLC	540
Binary logic operations	540
Control instructions.....	541
Programming languages IL, FBD, LAD	542
Marker, brackets	544
Querying NC contacts	544
Memory	545
Time functions.....	546
Counter.....	547
Program jump	548
Edge evaluation	548
Sequential control, step-by-step control	549
Commands, actions	550
Linear sequencer	552
Selection branch	553
Simultaneous branch	553
Program jump.....	553
Program loop.....	553
GRAFCET	553
Structured programming.....	555
Arithmetic functions	561
Comparison functions.....	561
Analogue value processing	561
Compact controller.....	562
Closed-loop control technology.....	564
Control loop.....	564
Elements of a controlled system.....	565
Time response of setpoints	565
Time response of control loop elements	566
Continuous controlling systems.....	566
Control processes.....	570
Time response of control processes	571
Setting controllers.....	572
On-off control systems	573
Machine safety	574
Safety categories	575
Risk assessment.....	576
Emergency control device	577
PLC circuit	578

Occupational and environmental protection, maintenance 581

Protective measures – protection against electric shock.....	581
Identification of pipes	591
Protection against hazardous substances at the workplace	592
Noise protection	592
Waste disposal	593
Packaging regulations	594
Information plates relevant to occupational safety	596
Designation of special risks (R statements)	601
Safety advice (S statements)	602
GHS/CLP	603
Actions in emergencies	605
Maintenance.....	606
Total Productive Maintenance	608

Materials engineering 611

Periodic table of the elements, material values of chemical elements	611
Material values of important materials and auxiliary materials	614

Chemical substances and formulae	615
Designation for steels	616
Material numbers	624
Products of non-alloy structural steel	627
Key steel grades	628
Tool steels	635
High-speed steels	636
Cast iron materials	637
Form and dimension standards of steel products	641
Material symbols and material numbers	652
Changing material properties of steel	653
Heat treatment processes	653
Steels for quenching and tempering	656
Stainless steels	656
Case-hardened steels	657
Steels for pressure purposes	658
Nitriding steels	658
Tool steels	659
Freecutting steels	662
Spring steel	663
Non-ferrous metals	664
European material numbering system for copper and copper alloys	665
Designations for aluminium and wrought aluminium alloys	666
Profiles made of aluminium, wrought aluminium alloys	674
Wrought magnesium alloys	677
Magnesium and titanium alloys	677
Composite materials	678
Lead die-casting alloys	678
Lead alloys for general use	678
Plain bearing materials	679
Sintered materials	680
Cutting materials	681
Cooling lubricants	683
Corrosion and corrosion protection	685
Plastics	690
Composite materials	697
Material testing	699

Interdisciplinary skills	711
Production factors	711
Enterprise and company	711
Employment contract, working hours, certificate of employment, occupational health and safety	713
Advanced training	715
Resignation and protection against dismissal	716
Insurance types, insurance principles	717
Statutory social security	717
Salary and wage statement	719
Employment tribunal, social welfare court	719
Collective bargaining law, collective bargaining, types of collective agreement	720
Works council, youth and trainee representation	721
Legal transactions	722
Possession and ownership	722
Legal capacity, contractual capability	723
Financial figures	723
Pricing	724
Sales contract	727
Depreciation	727
Legal forms of companies	728
Index	731
Index of standards	749
shortregister	769