

CONTENTS

Summary – Volume I	5
Preface to Volume I	6

VOLUME I PROCESS MEASUREMENT

Part I Introduction to the Measurement and Control of Technological Processes

1	An Introduction to Measurement and Control (<i>Karel Kadlec, Jiří Macháč</i>).....	18
1.1	Measurement and Control Tasks – Basic Terminology and Labelling	18
1.1.1	Measurement and Control Tasks	18
1.1.2	Basic Terms from Measurement and Control.....	19
1.1.3	Principles of Block Diagrams Drawing.....	20
1.1.4	Labelling of Measurement and Control Loops in Technological Diagrams	21
1.2	Process Measurement Instruments and Their Properties.....	28
1.2.1	Process Measurement Instruments	28
1.2.2	Classification of Sensors.....	30
1.2.3	Sensors, Transducers, Transmitters	31
1.2.4	Datalogger of Measured Values.....	32
1.2.5	Smart Sensors and Smart Transmitters.....	34
1.2.6	Wireless Sensors	38
1.2.7	Equipment for Explosive Atmospheres (ATEX).....	40
1.2.8	Virtual Instrumentation	41
1.2.9	Characteristic Properties of Measuring Instruments	43
1.3	Measurement Uncertainties	47
1.3.1	Basic Principles and Guidelines.....	47
1.3.2	Calculating Standard Uncertainties	49
1.3.2.1	Calculating Standard Uncertainties from Data Obtained by Direct Measurement Method.....	49
1.3.2.2	Standard Uncertainty Determination from a Single Quantity Indirect Measurement....	52
1.3.2.3	Determination of Expanded Uncertainties	54
1.3.2.4	General Guidelines How to Express Uncertainty	55
1.3.2.5	Supplementary Information about Uncertainties.....	55
1.4	Checking the Measurement and Calibration Sensors Accuracy	56
2	Measurement and Computer Data Acquisition (<i>Dušan Kopecký, Karel Kadlec</i>)	60
2.1	Internet of Things and Industry 4.0	61
2.2	Computers for Information and Industrial Networks.....	63
2.3	Communication in Industrial and Information Networks	65
2.3.1	ISO/OSI Reference Model.....	65
2.3.2	Bus Main Features.....	67
2.3.2.1	Bus Definition and Basic Terminology.....	67
2.3.2.2	Bus Wiring Scheme.....	68
2.3.2.3	Data Transfer Rate.....	69
2.3.2.4	Coding for Data Transmission	70
2.3.3	Buses in Personal Computers	70
2.3.3.1	Standard RS-232C (Serial Port)	71
2.3.3.2	Universal Serial Bus (USB).....	75
2.3.3.3	Peripheral Component Interconnect (PCI) Bus.....	78
2.3.3.4	Peripheral Component Interconnect Express (PCI Express) Bus	80
2.3.3.5	Ethernet	82
2.3.3.6	Wireless Standard IEEE 802.11 (Wi-Fi).....	84
2.3.3.7	Bluetooth Wireless Standard.....	86
2.3.4	Buses for Networks in Industrial Automation	86
2.3.4.1	RS-422, RS-423 and RS-485 Standards.....	86
2.3.4.2	Controller Area Network (CAN)	88
2.3.4.3	DeviceNet Network.....	89
2.3.4.4	General Purpose Interface Bus (GPIB).....	90
2.3.4.5	Meter-Bus (M-Bus).....	90
2.3.4.6	Process Field Bus (Profibus)	91
2.3.4.7	Wireless Meter-Bus (Wireless M-Bus)	93
2.3.4.8	Wireless Standard IEEE 802.15.4 and ZigBee.....	93
2.3.5	Industrial Ethernet.....	95
2.3.6	Current loop	97

2.3.7	HART Communication Protocol.....	98
2.3.8	IO-Link Communication Protocol.....	99
2.3.9	JUMO digiLine.....	100
2.3.10	Industrial Interface Converters.....	102
2.4	Multifunctional Data Acquisition Systems.....	102
2.4.1	Multifunctional Data Acquisition Cards and Boards.....	103
2.4.2	Modular Systems for Data Acquisition.....	104
2.5	Data Acquisition and Processing Software.....	105
2.5.1	Operating Systems.....	105
2.5.2	Drivers and Software.....	106
2.5.3	Integrated Development Environments.....	107
2.6	Conclusion.....	109

Part II Measurement of Process Variables

3	Temperature Measurement (Karel Kadlec).....	112
3.1	Contact Temperature Sensors.....	113
3.1.1	Thermal Expansion Thermometers.....	114
3.1.2	Thermocouples.....	116
3.1.2.1	Measuring Circuits in Thermocouples.....	119
3.1.3	Resistance Temperature Detectors (RTDs).....	122
3.1.3.1	Metal Resistance Temperature Detectors.....	122
3.1.3.2	Semiconductor Temperature Sensors.....	126
3.1.3.3	Measurement Circuits for Signal Evaluation in Resistance Thermometers.....	127
3.1.4	Signal Processing in Electrical Thermometers.....	129
3.1.5	Installing Contact Thermometers.....	135
3.1.6	Calibration of Contact Thermometers.....	137
3.2	Special Thermometers.....	139
3.3	Non-Contact Thermometers.....	140
3.3.1	Basic Theoretical Principles of Non-Contact Thermometry.....	141
3.3.2	Arrangement of IR Thermometers and IR Cameras.....	146
3.3.2.1	Non-Contact Thermometers.....	147
3.3.2.2	Optical System in Non-Contact Thermometers.....	149
3.3.2.3	Influences Affecting the Measurement with Non-Contact Thermometers.....	150
3.3.3	Thermal Imaging Cameras and Infrared Thermography.....	152
3.3.3.1	Thermal Imaging Cameras.....	152
3.3.3.2	Thermographic Measurement.....	156
3.3.3.3	Thermogram and Its Evaluation.....	158
3.3.4	Calibration of Non-Contact Thermometers.....	160
3.3.5	Applications of Non-Contact Thermometers.....	161
4	Pressure Measurement (Karel Kadlec).....	167
4.1	Hydrostatic Manometers.....	170
4.2	Piston Pressure Gauges, Deadweight Testers.....	171
4.3	Mechanical Pressure Gauges with Flexible Elements.....	172
4.4	Electronic Pressure Transmitters.....	175
4.4.1	Conversion of the Mechanical Quantity (Displacement) into an Electrical Signal.....	175
4.4.2	Potentiometric and Inductive Displacement Sensors.....	176
4.4.3	Capacitive Pressure Sensors.....	176
4.4.3.1	Principle of the Capacitive Pressure Sensor.....	176
4.4.3.2	Ceramic Diaphragm.....	178
4.4.3.3	Transmitters with Capacitive Sensors.....	179
4.4.4	Pressure Transducers with Resistance Strain Gauges.....	181
4.4.4.1	Principle of Resistance Strain Gauges.....	181
4.4.4.2	Transmitters with Semiconductor Strain Gauges.....	183
4.4.4.3	Process Transmitters with Piezoresistors.....	186
4.4.5	Piezoelectric Pressure Sensors.....	189
4.4.5.1	Piezoelectric Effect.....	189
4.4.5.2	Piezoelectric Pressure Sensor Construction.....	191
4.4.6	Resonant Pressure Sensors.....	191
4.4.6.1	The Principle of Resonant Pressure Sensors.....	191
4.4.6.2	Micromechanical Resonant Pressure Sensor.....	193
4.4.7	Smart Pressure Transmitters.....	194
4.4.8	Electronic High Pressure and Vacuum Gauges.....	196
4.5	Installation of Process Pressure Gauges.....	197

4.6	Calibration of Process Pressure Gauges	199
4.7	Selection of a Suitable Pressure Sensor	201
5	Level Measurement (Karel Kadlec)	205
5.1	Mechanical Level Sensor	207
5.1.1	Simple Mechanical Level Gauges	207
5.1.2	Weight-Based Level Measurements	208
5.1.3	Float Level Indicators	208
5.1.3.1	Float Switches	209
5.1.3.2	Floats with Guide Tube	210
5.1.3.3	Tilting Float Level Switch	211
5.1.3.4	Floats with Magnetostrictive Transmitters	212
5.1.3.5	Bypass Level Indicator	213
5.1.3.6	Applications of Level Transmitters and Level Switches	214
5.1.4	Displacer-Type Level Gauge	214
5.1.5	Electromechanical Level Transmitters	215
5.1.6	Vibrating Level Switches	215
5.1.6.1	Principle and Design of Vibrating Level Switches	215
5.1.6.2	Applications of Vibrating Level Switches	217
5.1.6.3	Installation of Vibrating Level Sensors	217
5.1.7	Paddle Level Switches	218
5.2	Hydrostatic Level Transmitters	219
5.2.1	Connection of Hydrostatic Pressure Transmitters	221
5.2.1.1	Level Measurement in Open Vessels	222
5.2.1.2	Level Measurement in Closed Vessels	222
5.2.1.3	Measurement with Diaphragm Seals	224
5.2.1.4	Measurement with Submersible Probe	225
5.2.1.5	Bubbler Level Measurement	226
5.2.2	Properties and Applications of Hydrostatic Level Transmitters	228
5.3	Electrical Level Gauges	229
5.3.1	Conductivity Level Sensors and Switches	229
5.3.2	Capacitive Level Transmitters and Switches	230
5.3.2.1	Principle of Capacitive Level Sensor	230
5.3.2.2	Properties of the Process Medium	232
5.3.2.3	Electrodes of Capacitive Sensors	233
5.3.2.4	Placement of Electrodes in the Technological Apparatuses	236
5.3.2.5	Evaluation Electronic Circuits	239
5.3.2.6	Applications of Capacitive Level Transmitters and Level Switches	240
5.4	Thermal Level Switches	240
5.5	Optical Level Sensors	241
5.5.1	Transmission-Type Detectors	241
5.5.2	Reflection-Type Detectors	242
5.5.3	Refraction-Type Detectors	242
5.6	Ultrasonic Level Measurement	243
5.6.1	Properties of Ultrasound	243
5.6.2	Principles of Ultrasonic Level Gauges	244
5.6.2.1	Continuous Ultrasonic Level Transmitters	244
5.6.2.2	Ultrasonic Level Switches	247
5.6.3	Installation of Ultrasonic Level Gauges	247
5.6.4	Applications of Ultrasonic Level Gauges	249
5.6.5	3D Solids Scanner	249
5.7	Radar Level Gauges	251
5.7.1	Permittivity and Microwave Radiation	251
5.7.2	Non-Contact Radar Level Gauges	252
5.7.2.1	Pulse Radar	252
5.7.2.2	Radar with Frequency Modulated Carrier Wave (FMCW)	253
5.7.2.3	Antenna Designs	253
5.7.2.4	Installation of Radar Level Gauges	257
5.7.3	Guided Wave Radar Level Gauges	259
5.7.4	Applications of Radar Level Gauges	262
5.8	Radiation Level Gauges	262
5.8.1	Radioactive Sources and Radiation Detectors	263
5.8.2	Applications of the Radiation Level Gauges	264
5.9	Selection of the Level Sensor	264

6	Flow Measurement (Karel Kadlec)	269
6.1	Terms and Definitions	269
6.2	Classification of Flow Sensors	271
6.3	Positive Displacement Meters	274
6.4	Velocity Flowmeters	276
6.4.1	Differential Pressure Flowmeters	276
6.4.1.1	Speed Probes	276
6.4.1.2	Differential Pressure Flowmeters with Primary Elements	277
6.4.1.3	Capillary (Laminar) Flowmeter	281
6.4.2	Variable Area Flowmeters – Rotameters	282
6.4.2.1	Principle of Operation	283
6.4.2.2	Dependence on Density and Viscosity	284
6.4.2.3	The Design of the Flowmeter	285
6.4.2.4	Installation of Variable-Area Flowmeters	286
6.4.2.5	Features of Variable Area Flowmeters	288
6.4.2.6	Application of Variable-Area Flowmeters	288
6.4.3	Spring-Loaded Variable Area Flowmeters and Target (Paddle) Flowmeters	289
6.4.4	Turbine and Paddlewheel Flowmeters	291
6.4.5	Electromagnetic Flowmeters	293
6.4.5.1	Principle of Electromagnetic Flowmeter	293
6.4.5.2	Design of Electromagnetic Flowmeter	295
6.4.5.3	Influence of the Medium on the Measurement Results	299
6.4.5.4	Properties of Electromagnetic Flowmeter	300
6.4.5.5	Application of Electromagnetic Flowmeters	302
6.4.6	Ultrasonic Flowmeters	303
6.4.6.1	Classification of Ultrasonic Flowmeters	303
6.4.6.2	Transit-Time Ultrasonic Flowmeters	303
6.4.6.3	Doppler Ultrasonic Flowmeters	306
6.4.6.4	Flowmeters with In-Line and Clamp-on Ultrasonic Transducers	306
6.4.6.5	Ultrasonic Multi-Beam Flowmeters	307
6.4.6.6	Properties of Ultrasonic Flowmeters	309
6.4.6.7	Applications of Ultrasonic Flowmeters	310
6.4.7	Vortex Flowmeters	312
6.4.7.1	Principle of Vortex Flowmeter	313
6.4.7.2	Design of Vortex Flowmeters	314
6.4.7.3	Properties of Vortex Flowmeters	317
6.4.7.4	Application of Vortex Flowmeters	322
6.5	Open Channel Flow Measurement	323
6.5.1	Weirs in Flow Measurement	324
6.5.2	Parshall Flume	326
6.5.3	Alternative Sensors for Flow Rate Measurement in Open Channels	327
6.6	Mass Flowmeters	328
6.6.1	Mass Flow Measurement Methods	328
6.6.2	Coriolis Mass Flowmeters	329
6.6.2.1	Principle of Coriolis Flowmeter	329
6.6.2.2	Measuring Tubes	331
6.6.2.3	Electronic Control and Evaluation Circuits	332
6.6.2.4	Properties and Applications of Coriolis Flowmeters	333
6.6.3	Thermal Mass Flowmeters	336
6.6.3.1	Dispersion Mass Flowmeters (Thermal Anemometer)	336
6.6.3.2	Calorimetric Thermal Mass Flowmeter	339
6.7	Calibration of Flowmeters	340
6.8	Selection of a Suitable Flowmeter	341
7	Heat Measurement (Karel Kadlec)	348
7.1	Principle of Heat Meters	348
7.2	Measurement of Heat Transferred by Liquid Medium	348
7.3	Measurement of Heat Transferred by Steam	352
7.4	Application of Heat Meters	354
8	Measurement of Weight – Industrial Scales (Michal Mikulec, Karel Kadlec)	356
8.1	Weighing Accuracy	357
8.2	Load Cells	357
8.3	Discontinuous Scales	358
8.3.1	Platform Scales	359

8.3.2	Tank and Hopper Scales	360
8.3.3	Roller Conveyer Scales	362
8.3.4	Vehicle Weighing Scales (Weighbridges)	362
8.3.4.1	Road Vehicle Scales	362
8.3.4.2	Rail Scales and Weighbridges.....	364
8.3.4.3	Electronic Evaluation Units in Scales.....	364
8.3.4.4	Software for Vehicle Weighing Scales.....	364
8.4	Continuous Scales	366
8.4.1	Belt Scales	366
8.4.2	Solids Flowmeters with Deflection Chute or Impact Plate	368
8.4.3	Coriolis Type Solids Flowmeters.....	369
8.4.4	Evaluation Units for Continuous Weighing	370
8.5	Continuous Dosing	371
8.5.1	Weigh Belt Feeders.....	372
8.5.2	Differential Dosing Scales – Loss in Weight Feeders	373
8.5.3	Evaluation and Control Systems for Dosing Scales.....	374
9	Humidity and Moisture Measurement (Dušan Kopecký, Karel Kadlec)	377
9.1	Humidity Parameters	377
9.2	Humidity Measurement in Gases	379
9.2.1	Psychrometric Hygrometers	379
9.2.2	Sorption Hygrometers.....	381
9.2.2.1	Mechanical Hygrometers.....	381
9.2.2.2	Resistive Hygrometers	381
9.2.2.3	Capacitive Hygrometers.....	382
9.2.2.4	Piezoelectric Hygrometers.....	386
9.2.3	Dew-Point Hygrometers (Chilled-Mirror Hygrometers).....	387
9.2.4	Coulometric Electrolytic Hygrometer	388
9.2.5	Infrared and Microwave Hygrometers	389
9.3	Moisture Measurement in Solids	390
9.3.1	Chemical Methods	390
9.3.2	Gravimetric Methods	391
9.3.3	Methods Using a Measurement of Electrical Quantities	394
9.3.3.1	Resistive (Impedance) Techniques	394
9.3.3.2	Capacitance (Dielectric) Techniques	395
9.3.4	Spectrometric Methods.....	395
9.3.4.1	Infrared Absorption and Reflection	395
9.3.4.2	Microwave Moisture Analyser	398
9.3.5	Nuclear Magnetic Resonance	401
9.3.6	Fast Neutron Moderation	403
9.3.7	Time-Domain Reflectometry.....	403
9.4	Application of Moisture and Humidity Analysers	404
10	Composition Measurement (Tomáš Bartovský, Karel Kadlec, Pavel Kadlec)	407
10.1	Introduction into Analysers	407
10.1.1	Functional Principles of Automatic Analysers	407
10.1.2	Characteristic Properties of Automatic Analysers	408
10.2	Measurement of Liquid Mixtures Composition.....	410
10.2.1	Sensors of Liquid Density.....	410
10.2.1.1	Hydrostatic Density Meters	410
10.2.1.2	Ultrasonic Density Meters	411
10.2.1.3	Vibration Density Meters.....	414
10.2.1.4	Combined Density and Sound Velocity Sensors	420
10.2.1.5	Radiation Density Meters	421
10.2.1.6	Microwave Density Meters	423
10.2.1.7	Density Meters Based on Other Principles	426
10.2.1.8	Applicability of Density Meters	427
10.2.2	Optical Sensors	428
10.2.2.1	Refractometer Sensors	428
10.2.2.2	Turbidimeters and Nephelometers.....	434
10.2.2.3	Polarimeters	440
10.2.2.4	Dissolved Oxygen Optical Sensor	445
10.2.3	Infrared Liquid Analysers.....	448
10.2.3.1	Fourier Transform Near-Infrared Spectrometers.....	449
10.2.3.2	Instruments Based on Attenuated Total Reflectance Infrared Spectroscopy.....	451

10.2.4	Viscosity Sensors	452
10.2.4.1	Viscosity – The Internal Friction in Fluids	452
10.2.4.2	Viscometers	456
10.2.5	Electrolytic Conductivity Sensors of Liquids	466
10.2.5.1	Theoretical Background	466
10.2.5.2	The Cell Constant	468
10.2.5.3	Measurement Methods and Design of Conductivity Sensors	468
10.2.5.4	Applicability of Inductive Conductivity Sensors	472
10.2.6	Electrochemical Sensors	474
10.2.6.1	Amperometric Sensors	474
10.2.6.2	Potentiometric Sensors	476
10.2.6.3	Semiconductor pH Sensors	481
10.2.6.4	Oxidation-Reduction Potential (ORP) Sensors	483
10.3	Measurement of Gas Mixtures Composition	484
10.3.1	Thermal Conductivity Analysers	484
10.3.1.1	Thermal Conductivity	484
10.3.1.2	Thermal Conductivity of Gas Mixtures	486
10.3.1.3	Measuring Method	487
10.3.1.4	Electrical Connection and Influence of Supply Current	489
10.3.1.5	Sample Replacement	489
10.3.1.6	Examples of Thermal Conductivity Analysers	490
10.3.2	Analysers with Catalytic Combustion Sensors	491
10.3.2.1	Function Principle	491
10.3.2.2	Pellistor Sensors	491
10.3.2.3	Examples of Pellistor Sensor Analysers	494
10.3.2.4	Applications of Pellistor Sensor Analysers	495
10.3.3	Analysers with Semiconductor Sensors	496
10.3.3.1	Principle of Semiconductor Sensors	496
10.3.3.2	Sensor Design	497
10.3.3.3	Applications of Semiconductor Sensors	498
10.3.4	Photometric Analysers	498
10.3.4.1	Principles of Photometric Analysers	498
10.3.4.2	UV Absorption Analysers	500
10.3.4.3	Infrared Analysers	503
10.3.4.4	Fluorescence Analysers	512
10.3.4.5	Chemiluminescence Analysers	514
10.3.5	Magnetic Analysers	516
10.3.5.1	Magnetic Properties of Materials	516
10.3.5.2	Methods of Measurements	519
10.3.5.3	Applications of Magnetic Analysers	523
10.3.6	Analysers with a Photoionization Detector (PID)	523
10.3.7	Electrochemical Gas Sensors	525
10.3.7.1	Amperometric Sensors	525
10.3.7.2	Potentiometric Sensors	527
10.3.8	Process Gas Chromatographs	530
10.3.8.1	Measurement Principle and Basic Components of Chromatographs	531
10.3.8.2	Chromatographic Column	532
10.3.8.3	Detectors	534
10.3.8.4	Sample Injection	539
10.3.8.5	Oven	540
10.3.8.6	Carrier Gas	540
10.3.8.7	Analysis Evaluation	540
10.3.8.8	Examples of Process Chromatographs	541
10.4	Sampling and Sample Treatment for Automatic Analysers	545
10.4.1	Sampling and Gas Sample Treatment	545
10.4.1.1	Gas Sampling	545
10.4.1.2	Gas Sample Transport	545
10.4.1.3	Removal of Mechanical Impurities from Gas	547
10.4.1.4	Gas Sample Treatment	547
10.4.1.5	Disposal of Gas Samples	549
10.4.2	Sampling and Treatment of Liquids	549
10.4.2.1	Liquid Sampling	549
10.4.2.2	Liquid Sample Transport	549
10.4.2.3	Removal of Mechanical Impurities from Liquids	550

10.4.2.4	Removal of Gases from Liquids.....	550
10.4.2.5	Adjustment of Pressure and Temperature.....	550
10.4.2.6	Disposal of Liquid Samples.....	550
10.5	Measurement of Solids in Gas.....	551
10.5.1	Gravimetric Methods and Beta-Attenuation Particulate Monitoring.....	551
10.5.2	Optical Methods.....	552
10.5.3	Sampling.....	554
10.6	Colour Measurement.....	555
10.6.1	Principles of Colour Theory.....	555
10.6.2	Basic Quantities and Equations Used in Spectrophotometry.....	556
10.6.3	Colour Detection and LED Analysers.....	557
10.6.3.1	Inline Colour Measurement System <i>ColorCONTROL ACS7000</i>	558
10.6.3.2	Universal Colour Sensors with Optical Fibre.....	560
10.6.3.3	Sensors with Integrated Optics for Special Surfaces.....	560
10.6.4	Water Colour Measurement with the SIGRIST <i>ColorPlus</i> Absorption Photometer.....	561
10.6.5	Food Colour Fast Control.....	562
10.6.6	Real-Time Colour Measurement in Food Applications.....	564
10.6.7	Real-Time Measurement of Sugar Colour.....	565
11	Sizing of Particles, Pores and Porous Materials (<i>Jiří Štětina, Evžen Šárka, Tereza Uhlířová, Eva Gregorová, Willi Pabst, Zdeněk Bubník</i>).....	572
11.1	Particle Size Measurement.....	572
11.1.1	Laser Diffraction Particle Sizing.....	576
11.2	Measurement of Porosity and Pore Sizes in Materials.....	579
11.3	Image Analysis.....	580
11.3.1	Principle of Image Analysis.....	580
11.3.2	Image Analysis in Particle Size Distribution Measurements.....	582
11.3.3	Application of Image Analysis for Assessment of Porosity and Pore Size of Materials.....	585
	List of Abbreviations.....	591
	Subject Index – Volume I.....	600

VOLUME II PROCESS CONTROL

Summary – Volume II

Preface to Volume II

Part III Process Control

12 Short Review of Selected Terms (*Miloš Kmínek*)

- 12.1 The System and Its Description
- 12.2 Variables
- 12.3 Basic Relations

13 Mathematical Models (*Miloš Kmínek*)

- 13.1 Inductive Mathematical Models in General
- 13.2 Deductive Mathematical Models in General
- 13.3 Deductive Model Creation Based on Balances

14 Simulating the Solution to Mathematical Model Equations (*Miloš Kmínek*)

- 14.1 Principle of Stepping Methods of Solution to Ordinary Differential Equations
- 14.2 Solution to Sample Tasks

15 Introduction to Production Process Control (*Miloš Kmínek*)

- 15.1 Basic Concepts
- 15.2 Controlled System
- 15.3 Measuring Element
- 15.4 Actuator
- 15.5 Continuous Control
- 15.6 Two-Position and Three-Position Controls
- 15.7 Digital Control

16 Logic Control (*Iva Nachtigalová, Miloš Kmínek*)

- 16.1 Mathematical Principles of Logic Control
- 16.2 Logic Control Types
- 16.3 Logic Control Implementation

17 Batch Process Control in Industrial Practice (*Vlastimil Braun*)

- 17.1 Introduction to Batch Production
- 17.2 Standards for Batch Production Control