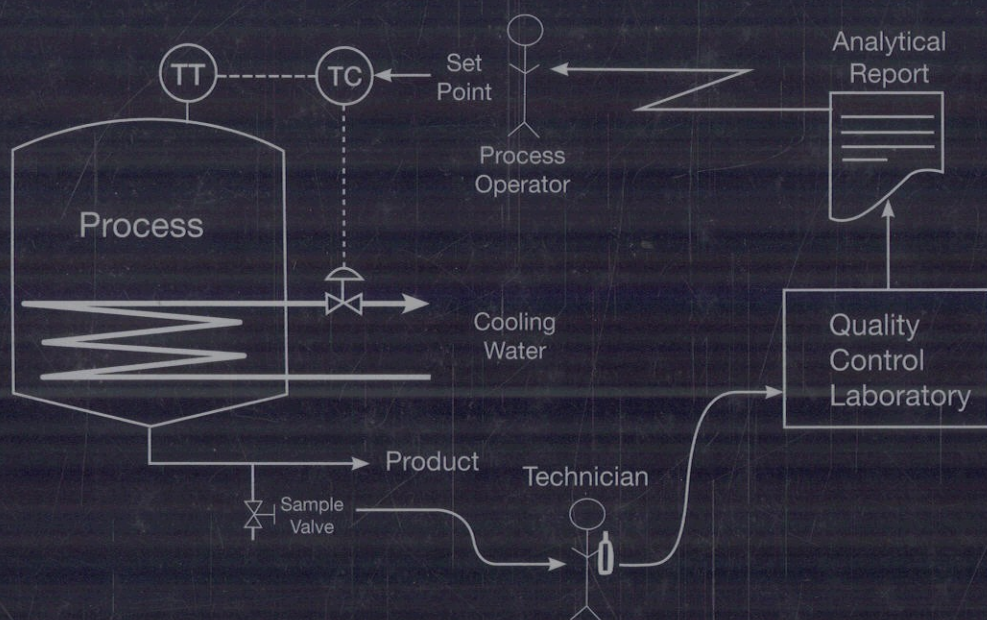


Basic Process Measurements

Cecil L. Smith



Preface	vii
1. Basic Concepts	1
1.1. Continuous vs. Discrete Measurement	2
1.2. Continuous vs. Sampled Measurement	8
1.3. In-Line, On-Line, and Off-Line	8
1.4. Signals and Resolution	12
1.5. Zero, Span, and Range	17
1.6. Turndown Ratio and Rangeability	22
1.7. Accuracy	24
1.8. Repeatability	27
1.9. Measurement Uncertainty	31
1.10. Measurement Decision Risk	36
1.11. Calibration	45
1.12. Measurement Device Components	48
1.13. Current Loop	50
1.14. Power Supply and Wiring	55
1.15. Serial Communications	56
1.16. Smart Transmitters	60
1.17. Environmental Issues	64
1.18. Explosive Atmospheres	68
1.19. Measurement Device Dynamics	75
1.20. Filtering and Smoothing	82
2. Temperature	88
2.1. Heat and Temperature	88
2.2. Temperature Scales	90
2.3. Thermowells	94
2.4. Bimetallic Thermometers	104
2.5. Thermocouples	106
2.6. Resistance Temperature Detectors	121
2.7. Thermistors	133
2.8. Temperature Transmitters	137
2.9. Pyrometers	142
2.10. Others	153

3. Pressure	158
3.1. Force and Pressure	159
3.2. Measures of Pressure	162
3.3. Pressure-Sensing Elements	167
3.4. Indicators and Switches	170
3.5. Pressure Sensor	171
3.6. Strain Gauge Pressure Sensors	173
3.7. Capacitance Pressure Sensors	176
3.8. Resonant Frequency	180
3.9. Installation	182
3.10. Differential Pressure	187
4. Level and Density	196
4.1. Level, Volume, and Weight	197
4.2. Pressure Transmitter	202
4.3. Differential Pressure Transmitter	210
4.4. Capacitance and Radio Frequency	216
4.5. Ultrasonic	223
4.6. Noncontact Radar	227
4.7. Guided Wave Radar	233
4.8. Nuclear	236
4.9. A Few Others	240
4.10. Level Switches	244
4.11. Interface	249
4.12. Density	255
5. Flow	260
5.1. Mass Flow, Volumetric Flow, and Velocity	261
5.2. Static Pressure and Fluid Velocity	264
5.3. Flashing and Cavitation	267
5.4. Fluid Dynamics	270
5.5. Flow Meter Application Data	276
5.6. Orifice Meter	279
5.7. Head Meters	285
5.8. Coriolis Meters	291
5.9. Magnetic Flow Meter	304
5.10. Vortex-Shedding Meter	309
5.11. Transit-Time Ultrasonic Flow Meter	312
5.12. Doppler Ultrasonic Flow Meter	318
5.13. Thermal Flow Meters	324
5.14. Turbine Meter	330
5.15. Other Flow Meters	334
5.16. Flow Switches	337