



Technology Training that Works

Practical Instrumentation for Automation and Process Control

Contents

Preface xi

1	Introduction	1
1.1	Basic measurements and control concepts	1
1.2	Basic measurement performance terms and specifications	2
1.3	Advanced measurement performance terms and specifications	3
1.4	Definition of terminology	5
1.5	P&ID (Process and Instrumentation Diagram) symbols	8
1.6	Effects of selection criteria	13
1.7	Measuring instruments and control valves as part of the overall control system	23
1.8	Typical applications	24
<hr/>		
2	Pressure Management	25
2.1	Principles of pressure management	25
2.2	Pressure sources	26
2.3	Pressure transducers and elements – mechanical	28
2.4	Pressure transducers and elements – electrical	38
2.5	Installation considerations	44
2.6	Impact on the overall control loop	49
2.7	Selection tables	50
2.8	Future technologies	52
<hr/>		
3	Level Measurement	53
3.1	Principles of level measurement	53
3.2	Simple sight glasses and gauging rods	54
3.3	Buoyancy type	56
3.4	Hydrostatic pressure	58
3.5	Ultrasonic measurement	66
3.6	Radar measurement	70
3.7	Vibration switches	71
3.8	Radiation measurement	73
3.9	Electrical measurement	78
3.10	Density measurement	86
3.11	Installation considerations	88



Technology Training that Works

3.12	Impact on the overall control loop	89
3.13	Selection tables	90
3.14	Future technologies	92
4	Temperature Measurement	93
4.1	Principles of temperature measurement	93
4.2	Thermocouples	94
4.3	Resistance Temperature Detectors	106
4.4	Thermistors	113
4.5	Liquid-in-glass, filled, bimetallic	117
4.6	Non contact pyrometers	124
4.7	Humidity	126
4.8	Installation considerations	129
4.9	Impact on the overall control loop	130
4.10	Selection tables	130
4.11	Future technologies	132
5	Flow Measurement	135
5.1	Principles of flow measurement	135
5.2	Differential pressure flowmeters	139
5.3	Open channel flow measurement	153
5.4	Variable area flowmeters	156
5.5	Oscillatory flow measurement	158
5.6	Magnetic flowmeters	169
5.7	Positive displacement	174
5.8	Ultrasonic flow measurement	177
5.9	Mass flow meters	179
5.10	Installation considerations	186
5.11	Impact on overall control loop	186
5.12	Selection tables	188
5.13	Future technologies	188
6	Control Valves	191
6.1	Principles of control valves	191
6.2	Sliding stem valves	193
6.3	Rotary valves	206
6.4	Control valve selection and sizing	210
6.5	Control valve characteristics/trim	214
6.6	Control valve noise and cavitation	219
6.7	Actuators and positioners operation	222
6.8	Valve benchset and stroking	225
6.9	Impact on the overall control loop	226
6.10	Selection tables	227
6.11	Future technologies	227



Technology Training that Works

7	Other Process Considerations	229
7.1	The new smart instrument and field bus	229
7.2	Noise and earthing considerations	234
7.3	Materials of construction	243
7.4	Linearisation	243
8	Integration of the System	247
8.1	Calculation of individual instruments and total error for the system	247
8.2	Selection considerations	250
8.3	Testing and commissioning of the subsystems	252
9	Weightometers	255
9.1	Introduction	255
9.2	Weightometers	262
9.3	Calibrating and testing weightometers	267
9.4	Operator checks	271
9.5	Other types of weightometers and weighing systems	271
9.6	Electrical disturbances for weighing systems	281
Appendix A	Thermocouple Tables	283
Appendix B	Process Instrumentation Practical Exercises	369
Appendix C	Ultrasonic Level Measurement	389
Appendix D	Multiple Choice Questions	423
Appendix E	Practical Exercises for Equipment Kit A	429
Appendix F	Practical Exercises for Equipment Kit B	469
Appendix G	Instruction Sheet: Connecting to Remote Labs within Electromeet	491
Appendix H	Remote Labs Instrumentation Practical: Span and Zero Configuration using an Ultrasonic Level Detector	495
Appendix I	Remote Labs Instrumentation Practical: Temperature Measurement Influences Using a Datalogger	503