

# How Control Loops Operate

## Course 282: How Control Loops Operate

Covers definition of control loop terms and characteristics. Includes specific examples of operation of control loops of many kinds. Discusses proportional, integral, and derivative modes in detail. Describes advanced control methods by means of four strategies with specific examples. Examines the effects of loop dynamics on system stability. ISA and SAMA instrumentation symbols and interpretation and use of process drawings and diagrams are covered.

TPC Training is accredited by IACET to offer **0.7 CEU** for this program.



### Lesson 1: Fundamentals of Control Loops

#### Topics

Control Loops; Control Loop Definitions; Process Sensors; Sensor Characteristics; Controllers; Recorders; Signal Conditioners; Final Control Elements; Control Loop Applications

#### Objectives

- Explain the difference between an open loop and a closed loop.
- Define error, feedback, disturbance, and feedforward control.
- List several kinds of process sensors and describe the operation of each.
- Explain how accuracy, resolution, sensitivity, linearity, and step response affect sensor operation.
- Describe the functions of process controllers, recorders, signal conditioners, and final control elements.
- Explain the basic operation of a typical control loop.

### Lesson 2: Control Loop Characteristics

#### Topics

Classification of Control Modes; Two-Position Control; Floating Control; Continuous Control Modes; Proportional Mode; Integral Mode (Reset); Derivative Mode (Rate); PID Mode; Digital Control Systems; Supervisory Control; Direct Digital Control (DDC); Distributed Control System (DCS)

#### Objectives

- Describe the difference between continuous and discontinuous control modes and give an example of each.
- Describe the action of the various continuous control modes.
- Define proportional band, reset time, and rate time.
- Discuss the advantages of each of the combination control modes.
- Name several advantages of digital controllers.
- Discuss the differences between supervisory control, direct digital control, and distributed control systems.

### Lesson 3: Advanced Control Methods

#### Topics

Advanced Control; Cascade Control System; Feedforward Control; Ratio Control System; Ratio Control in a Secondary Loop; Multivariable Control System; Multivariable Loop Example

#### Objectives

- Describe how a cascade control system works.
- Identify the primary and secondary variables in a cascade loop.
- Compare feedforward and feedback control.
- Identify dependent and independent variables in ratio control.
- Explain the advantage of having a secondary control loop in ratio control.
- Describe how a multivariable control system works and define interaction.

### Lesson 4: Loop Dynamics

#### Topics

Loop Dynamics; Effects of Process Time Lag; Compensating for Dead Time; Higher-Order Delay Lags; System Stability and Transient Response; Controller Tuning for Stability; Gain and Phase Shift

#### Objectives

- Describe two kinds of process time lags and give an example of each.
- Discuss the effects of capacitance and resistance on loop dynamics.
- State the three main objectives of a well-designed process control system.
- Describe how PI, PD, and PID controllers are adjusted to achieve optimum response.
- Discuss the effects of system gain and phase shift on system stability.

### Lesson 5: Loop Protection

#### Topics

Loop Protection in Hazardous Areas; Explosion-Proof Enclosures; Intrinsically Safe Instrument Systems; Additional Loop Protection; Fail-Safe Mechanisms; Hard and Soft Constraints; Alarms and Annunciators; Interlocks

#### Objectives

- Discuss the classification of hazardous locations as identified in the NEC Handbook.
- Define volatility and flash point, and explain the purpose of a purged enclosure.
- Describe two kinds of explosion-proof enclosures.
- Discuss ways of making a system intrinsically safe.
- Describe examples of fail-safe mechanisms, and differentiate between hard and soft constraints.
- Compare latching and nonlatching alarm systems, and explain the function of annunciators.
- Discuss the purpose and operation of interlocked and sequential control.

### Lesson 6: Process Control Symbols and Drawings

#### Topics

Instrument Identification; Symbols Used in Process Control; Symbol Recognition; Piping and Instrument Drawing; Location Drawing; Loop Diagram; Installation Drawing; Wiring Diagram; Other Kinds of Symbols

#### Objectives

- Recognize standard symbols used in process control diagrams.
- Describe a process control system through the use of instrument symbols.
- Recognize and use four kinds of process control diagrams.
- Analyze a process control drawing for the elements, signal flow, and process flow.

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## Lesson 7: Flowcharts and Electrical Diagrams

### Topics

Sequence of Operation; Flowchart; Switches; Relays; Motor Starters;  
Electrical Elementary Diagram; Pump System Schematic Diagram;  
Programmable Controller Diagram; Electronic Symbols

### Objectives

- Convert sequence-of-operation text to a flowchart.
- Read electrical and electronic control diagrams and drawings.
- Recognize symbols used on electrical and electronic diagrams, including those for PLCs and SAMA logic.
- Convert electrical diagrams to PLC diagrams.
- Discuss the role of computers in process control.