

Introduction to Instrumentation and Control

Introduction to Instrumentation and Control (I&C) – Operator-Focused Overview

Operator

1. What Is Instrumentation & Control?

Term	Definition	Why It Matters to the Operator
Instrumentation	Devices that measure, record, or display process variables (e.g., temperature, pressure, flow).	Gives you real-time data to decide if the process is within limits.
Control	Systems that adjust process conditions automatically (or manually) to keep variables at set points.	Allows you to maintain product quality, safety, and efficiency with minimal manual effort.
I&C System	Integrated network of sensors, transmitters, controllers, actuators, and Human-Machine Interfaces (HMIs).	The “brain+body” you interact with from the control room.

2. Core Components of an I&C System

Component	Function	Typical Operator Interaction
Sensors / Transducers	Convert a physical quantity (temp, pressure, level) into an electrical signal.	View raw measurements on HMI; verify sensor health via diagnostics.
Transmitters	Condition and send the sensor signal (4-20mA, 0-10V, HART, Foundation Fieldbus).	Check signal quality, alarm on loss of signal.
Controllers (PID, PLC, DCS)	Compare measured value to set-point, calculate corrective action.	Set/adjust set-points, tune PID parameters, view controller status.
Actuators (valves, motors, dampers)	Execute the controller's command (open/close, speed up/down).	Observe actuator position, manually override if needed.
Human-Machine Interface (HMI) / SCADA	Graphical display, alarm handling, trend logging, command entry.	Primary workstation for monitoring, alarming, and control actions.

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Component	Function	Typical Operator Interaction
Safety Instrumented System (SIS)	Dedicated hardware and software for protecting personnel/equipment (IEC 61511).	Respond to safety alarms, initiate safe shutdowns, perform periodic proof tests.

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3. Basic Control Strategies

Strategy	How It Works	Typical Use Cases
On/Off (Binary) Control	Switches actuator fully on or off based on a threshold.	Simple temperature or level control where precision isn't critical.
Proportional (P)	Output varies proportionally to the error (setpoint – measurement).	Fast response, limited overshoot; e.g., flow control.
Proportional+Integral+Derivative (PID)	Adds I (integral) to eliminate steady-state error and D (derivative) to dampen oscillations.	Most common for temperature, pressure, level, and flow loops.
Feedforward	Anticipates disturbance by adding a corrective term before the error appears.	Boiler feedwater control, where steam demand is known in advance.
Cascade	Primary controller sets the setpoint of a secondary controller.	Boiler drum level control (primary) / feedwater valve (secondary).
Advanced (Model Predictive, Adaptive)	Uses process models or real-time parameter updates.	Complex petrochemical reactors, high-value batch processes.

4. Typical Operator Workflow

1. Start-up / Warm-up

- Verify all critical alarms are cleared.
- Check instrument health (communication, sensor diagnostics).
- Bring controllers to **Auto** mode and set initial setpoint.