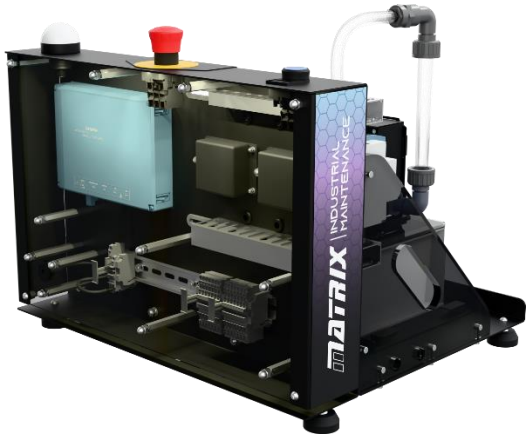
INDUSTRIAL MAINTENANCE

IM0004

PRODUCT SPECIFICATION



Name: Maintenance of Closed Loop Systems: Flow
Product Range: Industrial Maintenance
Product Code: IM0004
Curriculum Code: CP0539 & CP6773
Power Supply: 24V

Unit weight	**Packed Specifications**
Weight: TBC	Volume: TBC
Length: 52cm	Gross Weight: TBC
Width: 43.5cm	
Height: 46.1cm	

Product Description

The Industrial Maintenance Closed Loop PID Control System (Model IM0004) is a hands-on industrial training solution designed to teach fault diagnosis, system behaviour analysis, and component-level troubleshooting in a real-world flow control environment.

It includes a Siemens S7-1200 PLC, Unified Basic HMI, turbine flow sensor, proportional control valve, analogue flow gauge, IFM temperature sensor, float switches, and a proximity sensor, simulating industrial process equipment. Learners engage with hands-on experiments involving general system use and fault simulation, and sensor validation.

The system operates via a closed-loop feedback structure: the PLC adjusts both the valve and pump output using a PID algorithm to maintain a target flow rate, with real-time sensor feedback displayed on the HMI. The product includes a full curriculum of guided worksheets focused on closed-loop control theory, component diagnostics, and fault scenarios.

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Target Audience

This curriculum is designed for 16 to 18-year-old engineering students in further education colleges, as well as apprentices beginning careers in industrial maintenance, automation, and related engineering fields. It is ideally suited for learners pursuing T-Levels, BTECs, or similar vocational qualifications, and for those aiming to develop practical skills in diagnosing, maintaining, and troubleshooting real-world automated systems. Whether preparing for a role in manufacturing, utilities, or process industries, this program provides a strong foundation in industrial control systems and maintenance best practices.

Key Features

System Hardware & Design

- Siemens S7-1200 PLC with digital and analogue I/O
- Siemens Unified Basic HMI with real-time control and diagnostics
- Turbine-type flow sensor
- Proportional solenoid control valve and immersion pump
- IFM PT100 temperature sensor with transmitter
- Dual float switches (high/low) for level safety
- Inductive proximity switch on tank lid for safety interlock
- Modular, compact rig optimized for classroom or training bench use.
- CE/UL compliant components and wiring safety measures

Curriculum & Learning Outcomes

- Covers closed-loop system theory and PID control in real industrial context.
- Teaches sensor validation, feedback systems, and control loop dynamics.
- Builds skills in fault detection, diagnostics, and root cause analysis.
- Focuses on interpreting HMI/PLC data to guide decision making.
- Develops hands-on troubleshooting ability using multimeters and test routines.

Fault Simulation & Troubleshooting

- Built-in software-based faults (e.g. sensor offset, emergency stop errors)
- Hardware fault simulation via removable wiring (e.g. float switch failures)
- Faults include emergency stop, unreachable PID setpoint, temperature errors, and lid open detection.

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- Fault diagnosis via HMI IO screen, alarms, and status LEDs

Practical Exercises & Support

- 13+ guided worksheets covering each system component and fault type.
- “Over to You” sections to encourage independent problem-solving.
- Structured fault scenarios reflecting real-world industrial situations.
- IO diagnostics and LED indicators on PLC and field devices for live troubleshooting
- Full BOM, wire numbers, and test points included for in-depth exploration.

Educational Focus

- Aligned to UK T-Level & BTEC qualifications (Maintenance, Installation & Repair)
- Designed for Further Education students and apprentices aged 16–18.
- Teaches control system integration: sensors, PLC, HMI, actuators.
- Suitable for classroom teaching, self-guided labs, and assessment

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Learning Objectives

By the end of this curriculum, learners will be able to:

- **Explain the Function of Closed-Loop Systems**
  Demonstrate a clear understanding of how closed-loop control systems operate, including the role of feedback, setpoints, and automatic adjustments.
- **Identify and Describe Industrial Components**
  Accurately identify a wide range of electrical and mechanical components commonly used in industrial automation, such as sensors, actuators, PLCs, and HMIs.
- **Interpret System Behaviour and Diagnose Faults**
  Analyse system responses to identify abnormal conditions, isolate faults, and determine appropriate corrective actions using a structured fault-finding approach.
- **Understand Component Interaction within a System**
  Explain how individual components interact to maintain process stability and control, with a focus on flow regulation, safety interlocks, and sensor integration.
- **Apply Practical Maintenance and Troubleshooting Skills**
  Gain hands-on experience simulating real-world scenarios, using diagnostic tools, interpreting system feedback, and applying safe, effective maintenance practices.
- **Develop Confidence in Industrial Maintenance Tasks**
  Build competence and confidence in performing system inspections, interpreting visual indicators, and using HMIs and PLC I/O feedback to guide decision-making.

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Worksheets

CP0539

- Worksheet 1 – Closed-Loop Control Systems
- Worksheet 2 – Emergency Stops
- Worksheet 3 – Status LED
- Worksheet 4 – PLC
- Worksheet 5 – HMI
- Worksheet 6 – Pump
- Worksheet 7 – Valve
- Worksheet 8 – Float Switch
- Worksheet 9 – Proximity Switch
- Worksheet 10 – Flow Sensor
- Worksheet 11 – Temperature Sensor
- Worksheet 12 – Digital Sensors
- Worksheet 13 – Analogue Sensors
- Worksheet 14 – Faults

CP6773

- Fault Scenario 1: Titanium Forging
- Fault Scenario 2: Pharmaceutical Plant
- Fault Scenario 3: CNC Machines Factory Cooling
- Fault Scenario 4: Marketing
- Fault Scenario 5: Potash Mine
- Fault Scenario 6: First Day On The Job
- Fault Scenario 7: Why's It Always The Temperature?
- Fault Scenario 8: Settings

Packing List

Essentially the product will be sold as almost one complete tested unit.

Contents;

- IM0004: Base with PLC and tank installed.
- The variable flow indicator will be shipped unscrewed, for the customer to attach by hand upon delivery. No tools required.

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Curriculum(s)

This product comes with two curriculums;

CP0539 – Industrial Maintenance of Closed Loop Systems

CP6773 - Troubleshooting & Fault-Finding Closed Loop Systems

Click here to download curriculum from our Learning Centre

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Main Components

Main Module

PLC – Siemens S7-1200 (CPU 1214C)

- **Purpose:** Central controller for logic, PID control, safety interlocks, and I/O processing
- **Key Features:**
  - 14x Digital Inputs, 10x Digital Outputs (24VDC)
  - 2x Analog Inputs (0–10V)
  - Handles PID algorithm for flow regulation.
  - Interfaces with HMI for setpoint, alarms, and diagnostics

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AQ Module (Analog Output Module)

- **Purpose:** Provides analogue output signals (0–10V or PWM control) to actuators
- **Key Features:**
  - Controls proportional **valve** and **pump** via voltage or PWM
  - Enables smooth adjustment of flow rates.
  - Interfaces directly with field devices for closed-loop control

Unified HMI – Siemens Unified Basic Panel (MTP700)

- **Purpose:** Operator interface for real-time monitoring, fault display, and parameter input
- **Key Features:**
  - 7" touch screen for flow setpoint input and system feedback
  - Displays alarms, I/O status, PID values, and temperature cutoffs.
  - Setup page allows editing of temperature cutout limits and viewing system state

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Pump – COMET 24V Immersion Pump

- **Purpose:** Drives water through the flow circuit
- **Key Features:**
  - Controlled by analogue signal (via PWM)
  - Variable speed to match flow setpoint.
  - Monitored for conditions like dry running and flow blockage

Valve – Burkert Proportional Solenoid Valve

- **Purpose:** Fine-tunes water flow based on PID control
- **Key Features:**
  - Receives analogue or PWM signal from AQ module.
  - Works with pump to maintain target flow.
  - Includes "deadband" behaviour (opens above 10% demand)

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Tank – Water Reservoir with Integrated Safety Sensors

- **Purpose:** Holds system fluid and houses level and temperature sensors
- **Key Features:**
  - High and low float switches for overfill/dry run protection.
  - IFM PT100 RTD sensor for fluid temperature monitoring
  - Proximity switch on lid to detect open/closed state

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Frequently asked questions

What software is needed to run the system?

None. The system runs entirely self-contained using the onboard Siemens PLC and Unified HMI.

Optionally, Siemens TIA Portal (v20 and above recommended) can be used to modify or create your own PLC logic.

Does the kit come with curriculum materials?

Yes. A full curriculum is included, complete with guided student worksheets and detailed teacher notes, available through the Matrix Learning Centre.

What age group is this kit aimed at?

It's designed for further and higher education students aged 16–20 studying engineering, automation, or maintenance.

How many students can use the kit at once?

It's ideal for 1 or 2 students working collaboratively. Two learners can comfortably work side-by-side during practical sessions.

How is the system powered?

The system uses a 24V DC power supply and comes with UK, EU, and US adapters. No mains wiring is required.

Does the system need mains water or drainage?

No. The system operates using a closed-loop water circuit with a built-in tank, no external plumbing is required.

To run the system, simply fill the tank with clean water up to the marked minimum level.

Can other fluids be used in the system instead of water?

No. The system is designed specifically for use with clean water only. Using other fluids may damage internal components, affect sensor readings, or void the warranty.

Is post-use maintenance required?

Very little. Just check water level and clarity occasionally.

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Can I reprogram the PLC?

Yes. You may load your own program using TIA Portal. The system is delivered with default training code, which is editable.

Does the system simulate faults?

Yes. It includes both software-based and hardware-inserted faults to simulate real-world troubleshooting scenarios.

How is the system stored?

The entire kit, including all cables and accessories, can be stored safely on a shelf or under a workbench. For short-term storage, we recommend disconnecting the variable flow indicator to prevent damage, as it extends above the rear panel. For long-term storage or transport, the kit can be placed back into its original shipping box for added protection.

Is the system portable?

Yes. The system is manageable by one person and designed for easy transport between classrooms or benches.

Do I need a PC to operate it?

No PC is needed for normal operation. The HMI provides all necessary control and diagnostics.

Is technical training required to use the kit?

No prior experience is needed. The worksheets walk students through system operation, faults, and diagnostics step-by-step.

What is the warranty or support included?

The product includes a standard 12-month warranty with full technical support from Matrix TSL.

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Tender Specification

Matrix Technology Solutions Ltd shall supply the **Industrial Maintenance Closed Loop PID Control System (Model IM0004)** with the following features, capabilities, and performance assurances:

Hardware Specification

- The system shall include an **integrated closed-loop water tank** with a capacity of approximately 3.5–4.5 litres, suitable for desk-based educational environments.
- The system shall be constructed using a **powder-coated steel frame** with corrosion-resistant plumbing and transparent acrylic flow and level indicators.
- The system shall feature **quick-release mounting points** and push-in connectors to allow easy maintenance and compact storage.
- The system shall include a **24V DC immersion pump** with variable speed control via PWM or analogue voltage.
- The system shall include a **Burkert proportional solenoid valve**, compatible with 0–10V control signals.
- The system shall include the following sensor set:
    - A turbine-type flow sensor providing pulse or PWM output
    - An IFM PT100 RTD temperature sensor with a 4–20mA transmitter
    - Dual float switches for high- and low-level detection to prevent overfill and dry-run conditions
    - An inductive proximity switch for tank lid position detection
- The system shall incorporate a **simulated dual-channel emergency stop**, reset button, and multicolour status LEDs (green, amber, red) for system state indication.

Control & Communication Features

- The system shall include a **Siemens S7-1200 CPU 1214C PLC**, providing 14 digital inputs, 10 digital outputs, 2 analogue inputs, and integrated PID control capabilities.

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- The system shall include a **Siemens Unified Basic HMI (MTP700)** with a 7" capacitive touchscreen to allow real-time interaction with system parameters, faults, and alarms.
- The system shall support the following communication interfaces:
    - **Ethernet** for PLC-HMI communication and TIA Portal programming
    - **USB** for HMI firmware updates using Siemens tools
    - **Optional LAN expansion** via user programming for SCADA or remote diagnostics
- The system shall operate from a **24V DC power supply**, provided with global plug adapters for UK, EU, and US regions.

Performance Expectations

- The system shall dynamically regulate flow using PID algorithms based on live sensor input and user-defined setpoints.
- The system shall display **real-time flow readings** on the HMI and control pump and valve outputs proportionally to meet setpoint demands.
- The system shall support **eight software-injected faults** and a range of **hardware faults via wire removal**, to simulate real-world diagnostic challenges.
- The system shall issue **instantaneous alarms and visual fault indicators** via the HMI and status LED stack.

Software & Curriculum

- The system shall be delivered with **preloaded Siemens PLC and HMI programs** for immediate training use.
- The system shall allow users to edit and expand system logic via **Siemens TIA Portal** (project files available on request).
- The system shall be accompanied by **13+ guided worksheets**, aligned with UK T-Level and BTEC qualifications, covering:
    - Closed-loop control
    - Emergency stop simulation
    - Status LED interpretation

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  - Flow and valve regulation
  - Temperature monitoring
  - Float switch logic
  - Pump and valve fault diagnostics
- The system shall include detailed **teacher notes** with expected learner outcomes, troubleshooting hints, and wiring schematics.
- The system shall provide **ongoing access** to digital curriculum updates and technical support via the Matrix Learning Centre.

Quantity & Scope of Delivery

- The system shall be delivered as a **fully assembled training rig**, including:
  - Siemens PLC and HMI
  - All internal wiring and sensors preinstalled
  - Tray-based storage for cables and accessories
  - Global 24V DC power supply
- Each kit shall be suitable for use by **1–2 students simultaneously**.
- The system shall be **factory tested and ready to operate** out of the box.

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Electrical Safety Information

The **Industrial Maintenance Closed Loop PID Control System (Model IM0004)** is designed with safety in mind and complies with relevant low-voltage and EMC standards. Users must adhere to the following safety guidance to ensure safe and correct operation.

Key Safety Notes

- **Low Voltage Operation**:
  The system operates at **24V DC** only. It does **not** require or tolerate direct connection to mains voltage. Doing so will result in damage and void the warranty.
- **Power Supply**:
  Use only the **supplied 24V power adapter** with approved plug heads (UK, EU, US). The power supply is a Class II, CE-marked unit with overvoltage and short-circuit protection.
- **Enclosure and Wiring**:
  All electrical components are mounted in a protective enclosure or DIN rail panel with finger-safe terminals. No exposed live connections are present under normal use.
- **Fuse and Circuit Protection**:
  The system is internally protected by a **Siemens 5SY MCB** (3A, Curve B) to prevent overload or short-circuit damage.

Maintenance and Inspection

- Only qualified personnel should service or inspect internal wiring.
- Regularly inspect external cables for damage or wear.
- Do **not** modify wiring without referring to the system schematic and isolating power first.
- Always isolate power before performing any hardware fault insertion or removal of connectors.

Emergency and Fault Handling

- **Simulated Emergency Stop:**
  The system includes a dual-channel E-Stop for educational and simulation purposes only. It is not connected to a certified safety relay or safety-rated PLC. Pressing the button will halt outputs via PLC logic,

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but should not be relied on for personal protection in real emergency scenarios.

- **Reset Logic:**
  After the E-Stop is pressed, it must be manually reset (twist to release), followed by pressing the reset button on the front panel or HMI.
- **Recommended Emergency Action:**
  In a real emergency, the most effective method to isolate the system is to switch off the rear-mounted circuit breaker or unplug the 24V DC barrel connector. This fully cuts power to all components.
- **Fault LED Indicator:**
  A red system LED indicates a fault or simulated safety event. The system should not be operated until the issue is resolved.

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Standards Compliance

This system is designed for **educational and training use** and incorporates industrial-grade components and wiring practices. While it follows best practices in system layout and electrical safety, it is not intended for use in operational industrial environments.

The system aligns with the following standards **where applicable**:

- **EN 60204-1** – Electrical equipment of machines (informative compliance in wiring and protection practices)
- **EN 61010-1** – Safety requirements for electrical equipment for measurement, control, and laboratory use
- **Low Voltage Directive 2014/35/EU** – Applicable to included power supply and components
- **RoHS Directive 2011/65/EU** – Restriction of hazardous substances compliance for electronic components

Note: This product is intended for educational use only and does not fall under the full scope of the **Machinery Directive 2006/42/EC**. The emergency stop (E-stop) function is simulated via PLC logic and is not implemented using a safety-rated relay or redundant hardware. As such, the E-stop is not compliant with **BS EN 60204-1 Clause 9.2.2** and must not be relied upon for industrial safety purposes.

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