

REPUBLIC OF KENYA

COMPETENCY BASED CURRICULUM

FOR

INSTRUMENTATION AND CONTROL

LEVEL 6



TVET CDACC

P.O. BOX 15745-00100

NAIROBI

CONTENTS

[COURSE OVERVIEW 3](#_Toc521928155)

[ESTABLISHING AND OPTIMISING PROCESS CONTROL STRATEGIES 4](#_Toc521928156)

[INSTALLING AND SERVICING STAND ALONE CONTROLLERS 10](#_Toc521928157)

[INSTALLING AND SERVICING PROGRAMMABLE LOGIC CONTROLLERS 19](#_Toc521928158)

[INSTALLING AND SERVICING DISTRIBUTED CONTROL SYSTEMS 26](#_Toc521928159)

[INSTALLING AND SERVICING HUMAN MACHINE INTERFACES 36](#_Toc521928160)

[INSTALLING AND SERVICING SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS 45](#_Toc521928161)

# COURSE OVERVIEW

**Units of Learning**

This course consists of core units of learning as indicated below:

**Core** **Units of Learning**

|  |  |  |  |
| --- | --- | --- | --- |
| **Unit of Learning Code**  | **Unit of Learning Title**  | **Duration Hours**  | **in**  |
| CIAC020 | Establishing and optimizing process control strategies | 60 |  |
| CIAC021 | Installing and servicing stand-alone controllers | 80 |  |
| CIAC022 | Installing and servicing programmable logic controllers | 100 |
| CIAC023 | Installing and servicing distributed control systems | 80 |
| CIAC024 | Installing and servicing human machine interfaces | 60 |
| CIAC025 | Installing and servicing supervisory control and data acquisition systems | 60 |
| **Total**  |  | 300 |

The total duration of the course is 300 hours.

**Entry Requirements**

An individual entering this course should have any of the following minimum requirements:

1. Kenya Certificate of Secondary Education (KCSE)

**Or**

1. Any equivalent qualifications as determined by Kenya National Qualifications Authority (KNQA)

**Assessment**

The course will be assessed at two levels: internally and externally. Internal assessment is continuous and is conducted by the trainer who is monitored by an accredited internal verifier while external assessment is the responsibility of TVET CDACC.

**Certification**

A candidate will be issued with a Certificate of Competency for each unit of competency. To attain the qualification National Certificate Level 3 in Instrumentation and Control, the candidate must demonstrate competence in all the units of competency as given in qualification pack. These certificates will be issued by TVET CDACC in conjunction with training provider.

# ESTABLISHING AND OPTIMISING PROCESS CONTROL STRATEGIES

**Unit Code:** CIAC020(Internal code)

**Unit Title:** Establish and optimize process control strategies

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC020- Establish and optimize process control strategies

**Duration of Unit:** 60 hours

**Unit Description**

This unit provides trainees with the knowledge and skills to establish and optimize process control strategies.

**Summary of Learning Outcomes**

1. Develop process control strategies
2. Optimize process control strategies

**Learning Outcomes, Specific Learning Outcomes and Content**

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| **Learning Outcome 1:** Perform the installation and configuration of routers, switches and media converters  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Interpret job documentation and manufacturers’ specifications  |  Reading and interpretation of job documentation and manufacturers’ specifications   | Written and/or oral and practical tasks on reading and interpreting job documentation and manufacturers’ specifications  |
| 1.2 Describe different types of control strategies and processes to be controlled  | * Types of control strategies such as Proportional, Integral, Derivative (PID), feed forward/back, ascade, ratio, continuous, batch, single-loop and multi-loop, their principles of operation, applications, advantages and limitations
* Processes and process parameters to be controlled
* Process control limitations
* Process requirements
* Multi-variable control processes
* Controller functions such as direct/reverse action, auto/manual and split range
* Process and Instrumentation Diagram (P&ID) and scientific apparatus
* Mathematical equations employed by strategies such as proportional-integral derivative (PID)
* Scientific Apparatus Makers Association (SAMA)
 | Written and/or oral tasks on different types of control strategies and processes to be controlled  |

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| 1.3 Use control equipment  |      | Control equipment Characteristics, importance, applications and limitations of control equipment Memory restrictions and number of input/output points Use, handling, maintenance and storage of speciliased equipment and materials such as computers and software  | Written and/or oral and practical tasks on using control equipment  |
| **Learning Outcome 2:** Optimize process control strategies  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Describe the process and procedure of optimizing of process control strategies  | * Work sequencing
* Identification and following of

OHS&E requirements * Identification and correct use of tools and equipment
* Interpretation of drawings and wiring and circuit diagrams
* Selection and use of tools, equipment and materials in accordance with system specifications and applications
* Increasing process control strategies
* Wiring
* Cable termination
* Process control specifications and strategies
* Manufacturers’ recommended

configuration routines * Tag descriptors and addressing
* Identification and application of configuration methods, software and requirements
* Application of specific control strategies and interaction of other processes
* Identification of control limits such as PID, alarm settings, and limits a
* Use of specialized equipment such as computers and software
 | Written and/or oral tasks on the process and procedure of optimizing process control strategies   |

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|   |   | Different programmes and their applications  |   |
|  |   | Use of original software  |  |
|  |   | Updating programmes: installation of updates and extending applications  |  |
|  |   | Debugging programmes * Cleaning programmes, methods of cleaning
* Removal of viruses and protection of system against viruses
 |  |
|  |   | Securing programmes  |  |
|  |   | Programming of control strategy using configuration software and routines  |  |
|  |   | Verification of end results according to workplace procedures  |  |
|  |   | Optimisation  |  |
|  |   | Testing  |  |
|  |   | Commissioning  |  |
|  |   | Completion of backup documentation  |  |
| 2.2 Demonstrate the procedure of optimising process control strategies  |   | Demonstration of procedure of optimising process control strategies  | Practical tasks on the optimization of process control strategies  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
	+ Guided practice by learners
	+ Self-paced learning

**List of Recommended Resources**

* 1. **Text books, websites, manuals**
	2. www.instrumentationtoolbox.com

 www.us.endress.com/en

* 1. Numerous videos, toolbox talks and safety tips and checklists can be found at: www.safety.cat.com
	2. Manufacturers’ manuals; Equipment maintenance documentation

* 1. **Tools and equipment and materials**
	2. Basic hand tools (Hammer, set of screw drivers, side cutters, long nose pliers, pinchers, allen keys, spirit level and spanners)
	3. Portable power tools (Hand drilling machine)
	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state
	11. Safety instrumented functions (SIFs) such as pressure relief and redundant control

# INSTALLING AND SERVICING STAND ALONE CONTROLLERS

**Unit Code:** CIAC021(Internal code)

**Unit Title:** Install and service stand-alone controllers (SACs)

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC021- Install and service stand-alone controllers (SACs)

**Duration of Unit:** 80 hours

**Unit Description**

This unit provides trainees with the knowledge and skills to install and service stand-alone controllers (SACs). This includes installing, configuring, maintaining, diagnosing, repairing and programming standalone controllers.

**Summary of Learning Outcomes**

1. Install stand-alone controllers
2. Configure stand-alone controllers
3. Carryout maintenance, diagnostics and repairs on SAC
4. Program stand-alone controllers

**Learning Outcomes, Specific Learning Outcomes and Content**

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| **Learning Outcome 1:** Install stand-alone controllers  |  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Describe the operation of SACs  | * Applications of SACs
* Different types of SACs including pneumatic and electronic
* Applications, advantages and limitations of different types of SACs
* Controller functions including direct/reverse action, auto/manual and PID
* Constructional features and principles of operation of SACs
* Functions of different components of SACs
* SAC operation theory
* SAC operating parameters
 | Written and/or oral tasks on the operation of SACs  |
| 1.2 Plan and prepare for the installation of stand-alone controllers  | * Work sequencing
* Identification and following of

OHS&E requirements * Interpretation of drawings and wiring and circuit diagrams
* Installation requirements and required power supply
* Identification and correct and safe use of tools and equipment
	+ Features of different tools and equipment
	+ Operational

characteristics, applications, advantages and limitations of tools and equipment  | Written and/or oral and practical tasks on planning and preparing for the installation of stand-alone controllers  |

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| 1.3 Identify inputs and outputs of SACs  |    | Purpose of inputs and outputs Identification of inputs and outputs  | Written and/or oral and practical tasks on the identification of inputs and outputs of SACs  |
| 1.4 Identify the effects and implications of different installation conditions  |   | Effects and implications of ambient temperature, humidity, dust, cleanliness and contamination  | Written and/or oral tasks on the effects and implications of different installation conditions  |
| 1.5 Select SACs for different applications  |       | Load characteristics Application Process Control strategy Power supply  | Written and/or oral and practical tasks on selecting SACs for different applications  |
| 1.6 Determine mounting position or location  |    | Mounting position Accessibility for maintanance  | Written and/or oral and practical tasks on the determination of the mounting position  |
| 1.7 Demonstrate the procedure of installing SACs  |      | Connecting SAC to the process system Configuration techniques Configuring SACs Completion of back-up documentation  | Practical tasks on the installation of SACs  |

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| **Learning Outcome 2:** Configure stand-alone controllers  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Explain different configuration and calibration techniques and procedues  | * Process control
* Different configuration techniques
* Advantages and disadvantages of the different configuration techniques
* Procedures of configuring
* Programming and customising SACs
* Calibration techniques applied to specific control strategies
* Use of calibration and configuration tools and equipment such as pneumatic test equipment, handheld programmers and software
* Features, applications, maintenance and storage of tools and equipment including special tools and equipment
 | Written and/or oral tasks on configuration and calibration techniques and procedures   |
| 2.2 Configure SACs with handheld programmers and computers  | * Control parameters and process limitations
* Isolation of equipment and make-safe procedures
* Connection of SAC
* Use of hand held programmers
* Rig SAC
* Trial run SAC
 | Written and/or oral and practical tasks on configuring SACs with handheld programmers and computers  |
| 2.3 Tune SAC to process conditions  | * Tuning of SAC
* Process control
 | Written and/or oral and practical tasks on tuning SAC to process conditions  |

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| 2.4 Document processes and procedures  |    | Documentation Filing  | Written and/or oral and practical task on documentation  |

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| **Learning Outcome 3:** Carryout maintenance, diagnostics and repairs on SACs |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 3.1 Identify SAC system upset  |  Types of system upset, their causes, effects and methods of prevention and control  | Written and/or oral and practical tasks on the identification of SAC system upset  |
| 3.2 Perform system diagnostic checks  | * System diagnostic tools, their features, operational characteristics, applications, advantages and limitations
* Safe use, handling, maintenance and storage of tools
* Performing of system diagnostic checks
 | Written and/or oral and practical tasks on system diagnostic checks   |
| 3.3 Identify SAC faults  | * Common faults, their causes, effects and methods of prevention and control
* Deviations
* Errors
* Faults
 | Written and/or oral and practical tasks on the identification of SAC faults   |
| 3.4 Replace SACs  | * Power Disconnection
* SAC Isolation
* Safety precautions
* Replacement replica
 | Written and/or oral and practical tasks on the replacement of SACs   |

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| 3.5 Describe the process and procedure of maintaining, diagnosing and repairing SACs according to manufacturers’ specifications  |                | Work sequencing Identification and following of OHS&E requirements Interpretation of drawings, wiring and circuit diagrams Identification of work requirements Identification and correct use of tools and equipment * Features of different tools and equipment
* Operational

characteristics, applications, advantages and limitations of tools and equipment Identification of controller functions, process controls, and process control strategies System diagnostics Isolating equipment and make-safe procedures Identification of controller deviations, faults, and errors Identification of process upset conditions and limitations: Remove/replace controller Tuning of controller parameters to varying process conditions Updating/upgrading of software and firmware: Calibrate controller Restoring controller to process system Completion of backup documentation  | Written and/or oral tasks on the process and procedure of maintaining, diagnosing and repairing SACs   |
| 3.6 Demonstrate procedures for maintaining, diagnosing and repairing SACs  |   | Procedure for maintaining, diagnosing and repairing SACs  | Practical tasks on maintaining, diagnosing and repairing SACs  |

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| **Learning Outcome 4:** Program SACs |  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 4.1 Explain different programming languages  | * Ladder diagrams
* Sequential function chart
* Different programs
 | Written and/or oral tasks on different programming languages  |
| 4.2 Select program and associated software  | * Different software
* Word processors
* Spreedsheets
* Databases
 | Written and/or oral and practical tasks on the selection of programs and associated software  |
| 4.3 Conduct tests  | * Different types of tests and their applications
* Procedures for conducting the different types of tests
* Trial run
* Debugging
* Recording test results
 | Written and/or oral and practical tasks on conducting tests  |
| 4.4 Document processes and procedures  | * Documentation
* Filing
 | Written and /or oral and practical tasks on the documentation of processes and procedures  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
	+ Guided practice by learners
	+ Self-paced learning

**List of Recommended Resources**

* 1. **Text books, websites, manuals**
	2. www.instrumentationtoolbox.com

 www.us.endress.com/en

* 1. Numerous videos, toolbox talks and safety tips and checklists can be found at: www.safety.cat.com
	2. Manufacturers’ manuals; Equipment maintenance documentation

* 1. **Tools and equipment and materials**
	2. Basic hand tools (Hammer, set of screw drivers, side cutters, long nose pliers, pinchers, allen keys, spirit level and spanners)
	3. Portable power tools (Hand drilling machine)
	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state
	11. Safety instrumented functions (SIFs) such as pressure relief and redundant control

# INSTALLING AND SERVICING PROGRAMMABLE LOGIC CONTROLLERS

**Unit Code:** CIAC022(Internal code)

**Unit Title:** Install and service programmable logic controllers (PLCs)

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC022- Install and service programmable logic controllers (PLCs)

**Duration of Unit:** 100 hours

**Unit Description**

This unit provides trainees with the knowledge and skills to install, configure, maintain, repair and programmme programmable logical controllers (PLCs).

**Summary of Learning Outcomes**

1. Install programmable logic controllers
2. Configure programmable logic controllers
3. Maintain programmable logic controllers
4. Program programmable logic controllers

**Learning Outcomes, Specific Learning Outcomes and Content**

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| **Learning Outcome 1:** Install programmable logic controllers  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Describe the different types and operation of PLCs  | * Features, uses of different components, operational characteristics, applications, advantages and disadvantages
* Components of PLCs, their operating principles and uses including power supply, processor, memory and I/O
* PLCs’ architecture and capabilities
* Importance and procedure for the maintenance of PLCs
 | Written and/oral tasks on the operation of PLCs   |
| 1.2 Explain the effects of the environment on PLCs  |  Effects of: * ambient temperature
* moisture
* dust
* contamination
 | Written and/or oral tasks on the effects of the environment on PLCs  |
| 1.3 Describe the process and procedure of mounting and connecting PLCs according to system requirements  | * Work sequencing
* Identification and following of

OHS&E requirements * Use of tools and equipment
* Interpretation of drawings and wiring and circuit diagrams
* Determination of location
* Selection of PLC and components, such as power supply
* Connecting PLC, including cable terminations
* Monting of PLC
* Grounding methods
 | Written and/or oral tasks on the process and procedure of mounting and connecting PLCs  |

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| 1.4 Demonstrate the procedure of mounting and connecting PLCs  |   | Demonstration of procedure of mounting and connecting PLCs  | Practical tasks on mounting and connecting PLCs  |
| 1.5 Prepare documentation and back-up  |      | Inventory Filing Retrieval Back-up  | Written and/or oral and practical tasks on the preparation of documentation and back-up  |

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| **Learning Outcome 2:** Configure programmable logic controllers  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Describe programmable logic controller languages  |  Different programming languages and their applications * Ladder
* Function block
* Sequential function chart
 | Written and/or oral tasks on programmable logic controller languages   |
| 2.2 Explain operation of PLC programs  |  Features and operational characteristics of PLC programs  | Written and/or oral tasks on operation of PLC programs  |
| 2.3 Configure PLC  | * Control parameters and process limitations
* Isolation of PLC from the process
* Connection of PLC
* Software for programming/configuration
* Application of configuration techniques and methods
* Use of specialised equipment including computers
* Trial run PLC
* Testing
* Interpretation of results
 | Written and/or oral and practical tasks on configuring PLCs  |
| 2.4 Program PLC to process conditions  | * Program PLC
* Process control
* Identification of limitations
* Testing
* Commissioning
 | Written and/or oral and practical tasks on programming PLCs to process conditions  |
| 2.5 Document processes and procedures  | * Documentation
* Filing
 | Practical tasks on documenting processes and procedures  |

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| **Learning Outcome 3:** Perform maintenance and repair on programmable logic controllers |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 3.1 Explain computer applications related to PLCs  | * Identification of PLC functions
* Interpretation of applications
* Configurations
* Communication systems used by PLCs
 | Written and/or oral tasks on computer applications related to PLCs  |
| 3.2 Use diagnostic tools and equipment for the maintenance and repair of programmable logic controllers  | * The features, operational characteristics, applications, advantages and limitations of tools and equipment
* Correct and safe use, handling, maintenance and storage of tools and equipment
 | Written and/or oral and practical tasks on the use of diagnostic tools and equipment  |
| 3.3 Perform shut-down and start-up procedures for PLCs  | * Logical sequence of shutdown and start-up
* Precautions
 | Written and/or oral tasks on shutting down and starting up PLCs   |

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| 3.4 Describe the procedure of maintaining and repairing PLCs  |                | Work sequencing Identification and following of OHS&E requirements Identification and correct use of tools and equipment Interpretation of drawings and wiring and circuit diagrams Identification and use of programming software, diagnostic tools and equipment Identification of configuration parameters Interpretation of software reports and documentation to identify network programmes Disabling or by-passing of I/Os Performing shut-down and start-up procedures Upgrading software and firmware Modifications of programme Replacement/repair/modificat ion of components Replacement of batteries, fans, and environmental filters Backing-up of programmes and completion of back-up documentation  | Written and/or oral tasks on the procedure of maintaining and repairing PLCs  |
| 3.5 Demonstrate the procedure of of maintaining and repairing PLCs  |   | Demonstration of procedure of maintaining and repairing PLCs  | Practical tasks on maintaining and repairing PLCs  |

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| **Learning Outcome 4:** Program PLCs |  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 4.1 Explain different programming languages  | * PLC language such as ladder, function block, sequential function chart, and script
* Digital, discrete and analog signals
 | Written and/or oral tasks on explaining different programming languages  |
| 4.2 Select program and associated software  | * Programming standards
* Different software
* Word processors
* Spreedsheets
* Databases
 | Written and/or oral and practical tasks on the selection of programs and associated software.  |
| 4.3 Perform the programming of PLCs  | * Identify limitations
* Connect PLC
* Use of hand held programmers
 | Written and/or oral and practical tasks on programming PLCs  |
| 4.4 Conduct tests  | * Different types of tests and their applications
* Procedures for conducting

differet types of tests * Conducting different types of tests
* Recording and analysis of the results of different tests
* Trial run
* Debugging
* Making adjustments
 | Written and/or oral and practical tasks on conducting tests  |
| 4.5 Document processes and procedures  | * Documentation
* Filing
 | Written and/or oral and practical tasks on the documentation of processes and procedures  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
	+ Guided practice by learners
	+ Self-paced learning

**List of Recommended Resources**

* 1. **Text books, websites, manuals**
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* 1. Numerous videos, toolbox talks and safety tips and checklists can be found at: www.safety.cat.com
	2. Manufacturers’ manuals; Equipment maintenance documentation

* 1. **Tools and equipment and materials**
	2. Basic hand tools (Hammer, set of screw drivers, side cutters, long nose pliers, pinchers, allen keys, spirit level and spanners)
	3. Portable power tools (Hand drilling machine)
	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state
	11. Safety instrumented functions (SIFs) such as pressure relief and redundant control

# INSTALLING AND SERVICING DISTRIBUTED CONTROL SYSTEMS

**Unit Code:** CIAC023(Internal code)

**Unit Title:** Install and service distributed control systems (DCSs)

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC023- Install and service distributed control systems (DCSs)

**Duration of Unit:** 80 hours

**Unit Description**

This module provides trainees with the knowledge and skills to install, configure, maintain, diagnose and repair distributed control systems (DCSs).

**Summary of Learning Outcomes**

1. Install distributed control systems
2. Configure distributed control systems
3. Perform maintenance, diagnosis and repairs on distributed control systems

**Learning Outcomes, Specific Learning Outcomes and Content**

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| --- | --- |
| **Learning Outcome 1:** Install distributed control systems  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Describe the different types and operation of DCSs  | * Features, uses of different components, operational characteristics applications
* Architectures and capabilities of different types od DCSs
* Components of DCSs, their operating principles and uses including power supply, processor, memory and I/O
* DCS language including ladder, function block an script, their applications
* Digital/discrete/analog signals
* Communication systems used by DCS
* Software programming and version compatability, software and hardware limitations
* Obsolescence issues
* Compatability with other process control systems
* Communication networks and protocols
* Access and security levels
* Licensing and service contract agreements
* Service bulletins and alerts
* Data types such s binary, integer and floating point
* Hot standby and redundancy applications
* Working offline and online
 | Written and/oral tasks on the operation of DCSs   |

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| 1.2 Explain the effects of the environment on DCSs  |   | Effects of: * ambient temperature
* moisture
* dust
* contamination
 | Written and/or oral tasks on the effects of the environment on DCSs  |
| 1.3 Describe the process and procedure of mounting and connecting DCSs according to system requirements  |                  | Work sequencing Identification and following of OHS&E requirements Use of tools and equipment Drawings, wiring and circuit diagrams Determination of location Preparation of location: cleaning and clearing location of obstacles Selection of DCS according to architectures, capabilities, and compatibility (software and version) DCS language such as ladder, function block, and script DCS components such as power supply, processor, memory, and I/O Digital/discrete/analog signals Installation confirmation of DCS components such as cabinets, operator stations and servers Mounting of DCS and components such as I/O cards and power supplies Connection of wiring and network to DCS, including cable terminations Grounding methods Programming and testing Commissioning  | Written and/or oral tasks on the process and procedure of mounting and connecting DCSs  |

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| 1.4 Demonstrate the procedure of mounting and connecting DCSs  |   | Demonstration of procedure of mounting and connecting DCSs  | Practical tasks on mounting and connecting DCSs  |
| 1.5 Prepare documentation and back-up  |      | Inventory Filing Retrieval Back-up  | Written and/or oral and practical tasks on the preparation of documentation and back-up  |

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| **Learning Outcome 2:** Configure distributed control systems  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Describe different DCS languages  |  Programming languages and their applications * Ladder
* Function block
* Script
 | Written and/or oral tasks on DCS languages   |
| 2.2 Explain operation of DCS programs and operating software  | * Features and operational characteristics
* Programming standards
 | Written and/or oral tasks on operation of DCS programs  |
| 2.3 Configure DCS  | * Control parameters and process limitations
* Isolation of DCS from the process
* Connection of DCS
* Software for programming/configuration/ update
* Application of configuration techniques and methods
* Creation and validation of DCS configuration according to rack and cabinet layout
* Programming of DCS to include comments and displays
* Configuration of external communication with other systems and devices
* Back-up and restoring configurations, documentation
* Determination DCS control of the process
* Trial run DCS, testing, interpretation of results
 | Written and/or oral and practical tasks on configuring DCS  |

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| 2.5 Document processes and procedures  |    | Documentation Filing  | Practical tasks on documenting processes and procedures  |

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| **Learning Outcome 3:** Perform maintenance, diagnosis and repairs on distributed control systems |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 3.1 Clean distributed control systems   | * Cleaning equipment and detergents
* Cleaning solutions
* Methods of cleaning
 | Written and/or oral tasks on cleaning DCSs  |
| 3.2 Lubricate moving parts  | * Procedures for lubrication
* Oiling and greasing
* Types of oil and grease and their applications
 | Written and/or oral and practical tasks on lubrication   |
| 3.3 Secure distributed control systems  |  Tightening loose bolts, screws and nuts  | Practical tasks on securing DCSs  |

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| 3.4 Describe the process and procedure of maintaining, diagnosing and repairing DCSs  |                       | Work sequencing Identification and following of OHS&E requirements Identification and correct use of tools and equipment Interpretation of drawings, wiring and circuit diagramsU Use of programming software, diagnostic tools and equipment Identification of configuration parameters Interpretation of software reports and documentation to identify network programmes Effects of maintenance actions or errors Backing-up and restoring programmes Forcing, disabling and bypassing I/Os Performing shut-down and start-up procedures Upgrading software and firmware Modifications of programme Modification/ replacement/ repair of defective components Backup battery replacement Cleaning of fans and environmental filters Backing-up of programmes E-waste disposal Documentation of maintenance procedures, back-up and schedules Testing Commissioning  | Written and/or oral tasks onthe process and procedure of maintaining, diagnosing and repairing DCSs  |

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| 3.5 Demonstrate the procedure of maintaining, diagnosing and repairing DCSs  |   | Demonstration of the procedure of maintaining, diagnosing and repairing DCSs  | Practical tasks on maintaining, diagnosing and repairing DCSs  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
	+ Guided practice by learners
	+ Self-paced learning

**List of Recommended Resources**

* 1. **Text books, websites, manuals**
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* 1. Numerous videos, toolbox talks and safety tips and checklists can be found at: www.safety.cat.com
	2. Manufacturers’ manuals; Equipment maintenance documentation

* 1. **Tools and equipment and materials**
	2. Basic hand tools (Hammer, set of screw drivers, side cutters, long nose pliers, pinchers, allen keys, spirit level and spanners)
	3. Portable power tools (Hand drilling machine)
	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state
	11. Safety instrumented functions (SIFs) such as pressure relief and redundant control

# INSTALLING AND SERVICING HUMAN MACHINE INTERFACES

**Unit Code:** CIAC024(Internal code)

**Unit Title:** Install and service human machine interfaces (HMIs)

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC024- Install and service human machine interfaces (HMI)

**Duration of Unit:** 60 hours

**Unit Description**

This module provides trainees with the knowledge and skills to install, configure, maintain, diagnose, repair and programme human machine interfaces.

**Summary of Learning Outcomes**

1. Install human machine interfaces
2. Configure human machine interfaces
3. Perform maintenance, diagnosis and repairs on human machine interfaces
4. Program human machine systems

**Learning Outcomes, Specific Learning Outcomes and Content**

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| **Learning Outcome 1:** Install human machine interfaces  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Describe the operation of HMIs  | * Types of interfaces, their features, applications, advantages and disadvantages
* Types of HMI software, design hardware, and capabilities
* Compatability with other process control systems
* Communication networks and protocols
* Communication systems used by HMIs
* Digital, discrete and analog signals
* Access and security levels
* Interaction with process
* Working offline and online
 | Written and/oral tasks on describing the operation of HMI   |
| 1.2 Explain operational characteristics of HMIs and components  | * Functions including power supply, processor, memory and I/O
* Compatability with other process control systems
* Process of operation and use
* Maintenance
* Tag descriptors and addressing
 | Written and/or oral tasks on operational characteristics of HMIs  |
| 1.3 Explain the effects of the environment on HMIs  |  Effects of environment on HMIs * Ambient temperature
* Moisture
* Dust
* Contamination
 | Written and/or oral tasks on the effects of the environment on HMIs   |

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| 1.4 Mount and connect HMIs according to manufacturers’ specifications  |                    | Work sequencing Identification and following of OHS&E requirements Use of tools and equipment Interpretation of drawings, wiring and circuit diagrams Determination of location Preparation of location: cleaning/clearing obstacles Selection of types of HMI software, hardware according to design and capabilities Identification of data types such as Boolean, integer, and floating point Compatibility with other process control systems Communication networks and protocols Environmental conditions such as heat, cleanliness, and contamination Selection HMI software and operator interface equipment Installation of software Connection of communication links Select power supply Cable terminations Programming and testing Commissioning  | Written and/or oral and practical tasks on mounting and connecting HMIs  |
| 1.5 Prepare documentation and back-up  |      | Inventory Filing Retrieval Back up  | Practical assessment on preparation of documentation and back up  |

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| **Learning Outcome 2:** Configure human machine interfaces  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Describe HMI programming language  | * Identification of different programming language
* Ladder
* Function block
* Sequential function chart
* Script
 | Written and/or oral tasks on describing HMI programming language   |
| 2.2 Explain the operation of HMI programs  | * Features and operational characteristics of HMI programs and associated software including word processing, spread sheets and databases
* Criteria for selection of HMI programs and software
* Limitations of hardware and software
* Data types such as binary, integer and floating point
 | Written and/or oral tasks on the operation of HMI programs  |

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| 2.3 Configure HMI  |              | Configuration parameters Selection of HMI programs and associated according to applications and system requirements Selection of data types and addressing scheme Updating of programming software and firmware Generation of operator displays Validation of HMI configuration and displays Configuration of external communication Connecting HMI Cable termination Backing-up and restoring of configurations Trial rum HMI Completion of backup and documentation  | Written and/or oral and practical tasks on configuring HMI  |
| 2.4 Program HMI to process conditions  |         | Programming software and version compatability Use of original software Program HMI Process control Identification of limitations Testing Commissioning  | Written and/or oral and practical tasks on programming HMI to process conditions  |
| 2.5 Document processes and procedures  |    | Documentation Filing  | Written and/or oral and practical tasks on the documentation of processes and procedures  |

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| **Learning Outcome 3:** Perform maintenance, diagnosis and repairs on human machine interfaces |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 3.1 Explain computer applications related to HMIs  | * Identification of functions
* Interpretation of applications
* Configurations
* Communication systems
 | Written and/or oral tasks on computer applications related to HMI s  |
| 3.2 Use diagnostic tools for the maintenance, diagnosis and repair of HMIs  | * Types of diagnostic tools
* Features, operational characteristics and applications
* Use, handling, maintenance and storage of tools
 | Written and/or oral and practical tasks the use of diagnostic tools for the maintenance, diagnosis and repair of HMIs  |
| 3.3 Demonstrate procedures for the maintenance, diagnosis and repair of HMIs  | * Logical sequence of service
* OHS&E requirements and precautions
* Wiring and circuit diagrams
* Cleaning of HMIs
* Lubricating moving parts
* Installing updates
* Trouble shooting on HMIs
* Diagnosing HMI programs and associated software
* Updating of programming software and firmware
* Diagnosis of faulty operator displays
* Validation of HMI configuration and displays
* Re-configuring external communication
* Commissioning HMI
* Completion of backup documentation
 | Written and/or oral and practical tasks on the maintenance, diagnosis and repair of HMIs  |

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| **Learning Outcome 4:** Program human machine interfaces |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 4.1 Explain different programming languages  | * Ladder
* Function block
* Sequential function chart
* Script
* Programming standards
 | Written and/or oral tasks on different programming languages and programming standards  |
| 4.2 Select program and associated software  | * Different software and their applications
* Word processors
* Spreedsheets
* Databases
 | Written and/or oral and practical tasks on the selection of programs and associated software.  |
| 4.3 Program HMI  | * Identify limitations
* Connect HMI
* Use of hand held programmers
* Trial run HMI
 | Written and/or oral and practical tasks on programming HMI  |
| 4.4 Conduct tests  | * Different types of tests and their applications
* Demonstration of procedures for conducting different tests
* Trial run
* Debugging
* Making adjustments
 | Written and/or oral and practical tasks on conducting tests  |
| 4.5 Document processes and procedures  | * Documentation
* Filing
 | Written and/or oral and practical tasks on the documentation of processes and procedures  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
	+ Guided practice by learners
	+ Self-paced learning

**List of Recommended Resources**

* 1. **Text books, websites, manuals**
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* 1. Numerous videos, toolbox talks and safety tips and checklists can be found at: www.safety.cat.com
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	2. Basic hand tools (Hammer, set of screw drivers, side cutters, long nose pliers, pinchers, allen keys, spirit level and spanners)
	3. Portable power tools (Hand drilling machine)
	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state
	11. Safety instrumented functions (SIFs) such as pressure relief and redundant control

# INSTALLING AND SERVICING SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS

**Unit Code:** CIAC025(Internal code)

**Unit Title:** Install and service Supervisory Control and Data Acquisition systems (SCADA)

**Relationship to Occupational Standards**

This unit addresses the unit standard: IAC025- Install and service Supervisory Control and Data Acquisition systems (SCADA)

**Duration of Unit:** 60 hours

**Unit Description**

This module provides trainees with the knowledge and skills to install, configure, maintain and repair Supervisory Control and Data Acquisition systems (SCADA).

**Summary of Learning Outcomes**

1. Install Supervisory Control and Data Acquisition systems
2. Configure Supervisory Control and Data Acquisition systems
3. Maintain and repair Supervisory Control and Data Acquisition systems
4. Programme Supervisory Control and Data Acquisition systems

**Learning Outcomes, Specific Learning Outcomes and Content**

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| **Learning Outcome 1:** Install Supervisory Control and Data Acquisition systems  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 1.1 Decsribe the operation of SCADA systems  | * Interfaces
* Features, applications, advantages and disadvantages of SCADA systems
 | Written and/or oral tasks on the operation of SCADA systems   |
| 1.2 Explain operational characteristics of SCADA systems  | * Operational characteristics
* Components
* Process of operation and use
* Maintenance
 | Written and/or oral tasks on operational characteristics of SCADA systems  |
| 1.3 Explain the effects of the environmental on SCADA systems  |  Effects of: * Ambient temperature
* Moisture
* Dust
* Contamination
 | Written and/or oral tasks on the effects of the environmental on SCADA systems  |
| 1.4 Mount and connect SCADA systems according to drawings and manufcaturers’ specifications  | * Location and selection of equipment and components, including power supply, according to engineering designs, applications, control strategy
* Cable terminations
* Mounting of SCADA components
* Wiring of network to SCADA equipment
* Testing of wireless transmission
* Installation of other systems and processes to avoid interference
 | Written and/or oral and practical tasks on the mounting and connecting SCADA  |

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| 1.5 Prepare documentation and back-up  |      | Inventory Filing Retrieval Back up  | Practical assessment on preparation of documentation and back up  |

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| **Learning Outcome 2:** Configure Supervisory Control and Data Acquisition systems  |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 2.1 Describe SCADA languages  | Different programming languages * Function block
* Ladder
* Sequential function chart
* Script
 | Written and/or oral tasks on SCADA languages   |
| 2.2 Explain the operation of SCADA programs  |  Features, operational characteristics and applications of SCADA programs  | Written and/or oral tasks on the operation of SCADA programs  |

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| 2.3 Configure SCADA  |               | Identification of computer programs and software related to SCADA functions Identification of SCADA language Backing up and restoring of program and configuration Connecting SCADA systems Forcing, disabling and bypassing of I/Os Shutting down and starting up procedures for SCADA components Upgrading of software and firmware Modifying programs Replacement/repair/modificat ion of devices Replacement of backup batteries Cleaning of fans and environmental filters Trial run SCADA systems Completion of backup documentation  | Written and/or oral and practical tasks on configuring SCADA systems   |
| 2.4 Program SCADA to process conditions  |       | Program SCADA Process control Identification of limitations Testing Commissioning  | Written and/or oral and practical tasks on programming SCADA to process conditions   |
| 2.5 Document processes and procedures  |    | Documentation Filing  | Written and/or oral and practical tasks on the documentation of processes and procedures  |

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| **Learning Outcome 3:** Maintain and repair Supervisory Control and Data Acquisition systems |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 3.1 Explain computer applications related to SCADA  | * Interpretation of applications
* Configurations
* Communication systems
 | Written and/or oral tasks on computer applications related to SCADA  |
| 3.2 Use of diagnostic tools for maintaining and repairing SCADA systems  | * Diagnostic tools and their uses
* Constructional features, operational characteristics, applications, advantages and disadvantages
* Use, handling, maintenance and storage of tools
 | Written and/or oral and practical tasks on use of diagnostic tools for maintaining and repairing SCADA systems for maintaining and repairing SCADA systems  |
| 3.3 Demonstrate the procedures for the maintenance and repair of SCADA systems  | * Cleaning of SCADA system components, including fans and environmental filters
* OHS&E requirements and precautions
* Installing of updates, software and firmware
* Identification of computer programs and software related to SCADA functions
* SCADA language
* Backing up and restoring of program and configuration
* Forcing, disabling and bypassing of I/Os
* Shutting down and starting up procedures
* Modification of program
* Modification/replacement/ repair of defective components
* Backup battery replacement
* Completion of backup documentation
 | Written and/or oral and practical tasks on the procedures for the maintenance and repair of SCADA systems  |

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| **Learning Outcome 4:** Program Supervisory Control and Data Acquisition systems |  |
| **Specific Learning Outcomes**  | **Content**  | **Suggested Assessment Methods**  |
| 4.1 Explain different programming languages  | * Ladder diagrams
* Function block
* Sequential function chart
* Script
 | Written and/or oral tasks on different programming languages  |
| 4.2 Select program and associated software  | * Different programs and software and their applications
* Criteria for selection of programmes and software
* Word processors
* Spreedsheets
* Databases
 | Written and/or oral and practical tasks on the selection of programs and associated software  |
| 4.3 Conduct tests  | * Different types of tests and their applications
* Demonstration of procedures for conducting the different tests
* Trial run
* Debugging
* Making adjustments
* Recording and analysis of test results
 | Written and/or oral and practical tasks on conducting tests   |
| 4.4 Document processes and procedures  | * Documentation
* Filing
 | Written and/or oral and practical tasks the documentation of processes and procedures  |

**Suggested Delivery Methods**

* + Instructor led facilitation of theory
	+ Group and individual activities
	+ Practical demonstration of task
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	4. Soldering iron
	5. PPE including, coveralls, ear protection, safety shoes, fire extinguishers, first aid kit, safety glasses, glove, hard hat
	6. Markers/chalk
	7. Pencils and writing paper
	8. Cleaning facilities, equipment and materials including a well-equipped wash room, soaps, detergents, hand towels
	9. Layers of protection analysis (LOPA) and risk reduction
	10. Safety integrity level (SIL)/reliability of the SIS to get the process to a safe state

Safety instrumented functions (SIFs) such as pressure relief and redundant control