

# SEMPEO2-40 - SQA Unit Code FP3Y 04

## Wiring and testing programmable controller based systems



### Overview

This standard covers a broad range of basic competences that you will need to wire and test programmable controller based systems, such as PLC's (programmable logic controllers). This will prepare you for entry into the engineering or manufacturing sectors, creating a progression between education and employment, or will provide a basis for the development of additional skills and occupational competences in the working environment.

You will be expected to prepare for the programmable controller wiring and testing activities by obtaining all the necessary information, documentation, tools and equipment required, and to plan how you intend to carry out the activities and the sequence of operations you intend to use. It involves connecting and wiring up the equipment and the development, editing, inputting, testing and de-bugging of simple programs. You will be expected to connect peripheral components and communication links, and to load/download process controller programs, check them for errors, and create back-up copies of completed programs.

Your responsibilities will require you to comply with health and safety requirements and organisational policy and procedures for the programmable controller maintenance activities undertaken. You will need to take account of any potential difficulties or problems that may arise with the maintenance activities, and to seek appropriate help and advice in determining and implementing a suitable solution. You will work under a high level of supervision, whilst taking responsibility for your own actions and for the quality and accuracy of the work that you carry out.

Your underpinning knowledge will provide an understanding of your work, and will enable you to apply safely the appropriate wiring and connection techniques and procedures for programmable controller equipment. You will understand the programmable controller wiring and testing process, and its application, and will know about the controller and peripherals being wired and tested, and the tools and consumables used, to the required depth to provide a sound basis for carrying out the activities to the required specification.

You will understand the safety precautions required when carrying out the wiring and testing activities (especially those for ensuring the equipment is correctly isolated), and when using the various tools and test equipment. You will be required to demonstrate safe working practices throughout, and will understand your responsibility for taking the necessary safeguards to protect yourself and others in the workplace.

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#### **Specific Standard Requirements**

In order to prove your ability to combine different wiring and testing operations, at least one of the PLC systems worked on must be of a significant nature, and must cover a minimum of **five** of the items listed in scope 3.

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#### Performance criteria

*You must be able to:*

- P1 work safely at all times, complying with health and safety legislation, regulations and other relevant guidelines
- P2 plan the programmable controller wiring and testing activities before you start them
- P3 use appropriate sources to obtain the required circuit diagrams, wiring, programming and test information
- P4 obtain the correct tools and equipment for the wiring and testing operations, and check that they are in a safe and usable condition
- P5 position and secure the programmable controller components and peripheral devices safely and correctly, to meet specification requirements
- P6 connect and terminate the cables to the appropriate connections on the components
- P7 develop programmable controller programs, using the appropriate techniques and programming language
- P8 use appropriate test methods and equipment to check and prove the program integrity
- P9 deal promptly and effectively with problems within your control, and seek help and guidance from the relevant people if you have problems that you cannot resolve
- P10 leave the work area in a safe and tidy condition on completion of the wiring and testing activities

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### Knowledge and understanding

*You need to know and understand:*

- K1 the health and safety requirements, and safe working practices and procedures required when wiring and testing programmable controller equipment
- K2 the hazards associated with wiring and testing programmable controller equipment, and with the tools and equipment used (such as live electrical components, process controller interface, misuse of tools, using damaged or badly maintained tools and equipment, not following laid-down procedures), and how they can be minimised
- K3 the importance of wearing appropriate protective clothing and equipment (PPE), and of keeping the work area safe and tidy
- K4 the methods and procedures used to minimise the chances of infecting a computer with a virus
- K5 the implications if the computer you are using does become infected with a virus and who to contact if it does occur
- K6 what constitutes a hazardous voltage and how to recognise victims of electric shock
- K7 how to reduce the risks of a phase to earth shock (such as insulated tools, rubber mating and isolating transformers)
- K8 the interpretation of circuit and wiring diagrams, and specifications used for the wiring and testing activities (including BS and ISO schematics, wiring regulations, symbols and terminology)
- K9 the basic principles of operation of the programmable controller equipment/circuits being connected and tested, and the purpose of the individual modules/components used (such input and output devices)
- K10 the techniques used to connect programmable controller equipment (such as plugs, soldering, screwed, clamped and crimped connections) and if the controller is sinking or sourcing the required current to operate the input/output devices
- K11 the use of BS 7671/IET wiring, and other regulations, when selecting wires and cables, and when carrying out tests on systems
- K12 how to conduct any necessary checks to ensure the accuracy and quality of the wiring (such as visual checks for completeness and freedom from damage to conductors or components, mechanical checks for security of components and connections, ingress protection, electrical checks for electrical continuity and earth continuity, insulation resistance and polarity checks)
- K13 the main programmable controller types that are available, and the importance of understanding that a different programmable controller may use completely different codes for similar functions
- K14 the programming languages commonly used with programmable

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- controller based systems (such as structured, ladder, statement lists, logic function blocks, Boolean algebra)
- K15 the common programmable controller numbering systems (such as binary, octal, decimal, hexadecimal, binary coded decimal (BCD))
  - K16 the different programming codes used to identify factors such as sensor inputs, actuator and other outputs, process management and auxiliary functions
  - K17 the information and data required in order to produce a complete and accurate programmable controller program, and how to translate the operating criteria into logic programming format
  - K18 the factors to be taken into account when producing programs (including the type of programmable controller (unitary, modular, rack mounted) and its control capabilities); safety considerations and the product/environment being controlled by the process
  - K19 the methods and procedures used to check that the completed program will control the required parameters safely, accurately and efficiently (such as checking the program for errors against expected performance with regard to sequence of operations; checking that programmed instructions cover all operational requirements; using monitoring devices and test measurements to check inputs and outputs; using techniques such as 'force on- force off' to simulate process conditions; checking that failsafe devices and system emergency stops are operating correctly)
  - K20 how to identify system errors, and how to search a program within the programmable controller for specific elements and rectify the causes of the errors
  - K21 how to save the completed programs in the appropriate format , and the need to store the program safely and correctly, away from contaminants and possible corruption
  - K22 how to back up completed or edited programs, and the implications if this is not carried out effectively
  - K23 the fault-finding techniques to be used when the equipment fails to operate correctly
  - K24 the problems that can occur with the wiring and testing operations, and how these can be overcome
  - K25 when to act on your own initiative and when to seek help and advice from others
  - K26 the importance of leaving the work area in a safe and clean condition on completion of the wiring and testing activities (such as returning hand tools and test equipment to its designated location, cleaning the work area, and removing and disposing of waste)

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### Additional Information

#### Scope/range related to performance criteria

*You must be able to:*

1. Carry out **all** of the following during the wiring and testing of the programmable controller equipment:
  - 1.1 adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment (PPE) and other relevant safety regulations
  - 1.2 ensure the safe isolation of services during the wiring activities
  - 1.3 follow job instructions, wiring drawings and test procedures at all times
  - 1.4 check that the tools and test instruments are within calibration date and are in a safe and usable condition
  - 1.5 ensure that the programmable controller system is kept free from foreign objects, dirt or other contamination
  - 1.6 where appropriate, apply procedures and precautions
  - 1.7 return all tools and equipment to the correct location on completion of the installation activities
  
2. Connect and test equipment for **one** of the following types of programmable controller systems:
  - 2.1 monitoring system
  - 2.2 combination system
  - 2.3 process/product control system
  - 2.4 building services system
  - 2.5 diagnostic system
  - 2.6 other specific system
  
3. Connect up and test **one** of the following types of programmable controller equipment/components:
  - 3.1 unitary controller units
  - 3.2 rack mounted controller units
  - 3.3 modular controller unitsPlus **five** more items from the following:
  - 3.4 sensors (such as inductive, proximity, temperature, colour, optical)
  - 3.5 modems
  - 3.6 actuators (such as pneumatic or hydraulic)
  - 3.7 printers panels and sub-assemblies

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- 3.8 switches (such as emergency stop, limit, pressure)
  - 3.9 valves (such as pneumatic or hydraulic)
  - 3.10 electrical wires and cable connections
  - 3.11 safety interlocks
  - 3.12 signal transmission components/cables
  - 3.13 motor starters
  - 3.14 overload protection devices
  - 3.15 barcode scanners
  - 3.16 PC peripheral devices
  - 3.17 Analogue to digital modules
  - 3.18 PID (proportional, integral, derivative) controller
  - 3.19 other devices
4. Apply wiring and connection methods and techniques, to include **five** of the following:
- 4.1 locating and securing equipment in the correct positions
  - 4.2 attaching suitable cable identification
  - 4.3 making mechanical/screwed/clamped connections
  - 4.4 routing and securing wires and cables
  - 4.5 soldering and de-soldering connections
  - 4.6 using heat shrinking devices or boots
  - 4.7 sealing and protecting cable connections
  - 4.8 stripping cable insulation/protection
  - 4.9 crimping (such as tags and pins)
  - 4.10 adding cable end fittings
  - 4.11 connecting all input and output devices
5. Develop programs which use **one** of the following, as applicable to the type of controller and programming software:
- 5.1 ladder and logic diagrams
  - 5.2 function block diagrams
  - 5.3 statement/instruction lists
  - 5.4 structured text
  - 5.5 sequential function charts
  - 5.6 other specific programming language
6. Prove and edit the programmable logic controller program, using **five** of the following:
- 6.1 single block run
  - 6.2 edit facilities
  - 6.3 program save/store facilities
  - 6.4 data input facilities
  - 6.5 search facilities
  - 6.6 program full run
  - 6.7 program override controls

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- 6.8 graphic displays
  - 6.9 taking test measurements
  - 6.10 using monitoring mode
  - 6.11 using process simulation techniques (forcing contacts on/off)
  - 6.12 counter and timer settings
7. Use **two** of the following test instruments during the wiring and testing activities:
- 7.1 multimeter
  - 7.2 programming devices (such as loader terminal, hand held programmer, personal computer)
  - 7.3 signal generator
  - 7.4 network testing equipment
  - 7.5 other specific test equipment
8. Carry out **all** of the following on completion of the programming activity:
- 8.1 check and review program format and content
  - 8.2 edit programs using the correct procedure (where appropriate)
  - 8.3 check that the program is correctly titled and referenced
  - 8.4 ensure that programs are stored safely and correctly in the correct format
  - 8.5 create a separate backup copy of the program in case of file corruption
9. Use **three** of the following diagnostic techniques, tools and aids:
- 9.1 visual checks (such as signs of damage, missing parts, wear/deterioration)
  - 9.2 movement checks (such as loose fittings and connections)
  - 9.3 fault finding techniques (such as input/output, half-split, unit substitution)
  - 9.4 diagnostic aids (such as manuals, flow charts, logic diagrams, troubleshooting guides)
  - 9.5 test instrumentation measurement (such as continuity, voltage, resistance, current)
  - 9.6 controller error warning lights/displays
10. Wire up and test programmable controllers, in accordance with **one** or more of the following standards:
- 10.1 equipment manufacturer's specification/operation range
  - 10.2 BS7671/IET wiring regulations
  - 10.3 Other BS and/or ISO standards
  - 10.4 company standards and procedures



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