WATER SUPPLIES DEPARTMENT
STANDARD SPECIFICATION E-78-04
PROGRAMMABLE LOGIC CONTROLLER

This Specification should be read in conjunction with WSD Standard Specifications E-60-03, E-61-03, E-80-01, EM-00-03 and EM-90-01.

1. GENERAL

This Specification covers the general design, manufacture, programming and testing of programmable logic controller (PLC) for industrial process and/or control and monitoring applications.

Except for the miniature types with all-in-one design, the PLC shall comprise a chassis backplane, central processing unit (CPU), input and output (I/O) modules (digital and analog), communication/networking modules, voltage surge protection units, signal converters, signal isolators, power supply units, programming tools and other equipment necessary to form a complete working system.

Unless otherwise specified herein, the PLC shall also comply with Water Supplies Department (WSD) Standard Specification E-80-01.

2. DESIGN

2.1 General Principles

The PLC shall be designed for high reliability and ease of maintenance.

The PLC shall be designed and tested to operate in a highly noisy electrical environment and comply with IEC 60801 for electromagnetic compatibility.

The PLC shall be of modular design with interchangeability for all similar I/O modules and shall have capability for future expansion by the addition of required hardware and revision of user software and firmware as required.

The PLC hardware shall be suitable for operating at an ambient temperature up to 50°C with relative humidity up to 95%.

All system modules, main and expansion chassis shall be designed to operate with passive cooling methods.

The PLC shall support data access by a third-party server using Modbus/TCP to IEC 60870, DNP3, serial link with external/internal modem or OPC.

2.2 Maintenance

Maintenance and fault finding on the equipment shall be facilitated by diagnostic

indicators on the modules, provision of fault-locating routines on the programming tools and test points on the circuit boards. The assembly shall be designed for easy replacement without the need to disconnect and modify the field wiring. Where the modules are position dependent, the dedicated position for the modules shall be clearly identified on the chassis to prevent incorrect insertion.

2.3 Communications

The CPU shall be capable of communicating with a minimum of 30 peer devices, directly or optionally via an external networking unit. Depending on the application, the maximum network distance, network configurations, transmission media and communication speed shall be specified in the Particular Specification. The communication protocol shall have built-in error detection and signal re-transmission mechanisms to assure data integrity. The communications wiring shall be twinaxial, twisted pair, coaxial cable or fibre optic cable. Fibre optic cable shall be provided where the cable length exceeds the reliable operating limit of copper cable at the specified data transmission speed, or where specified for use in a noisy electrical environment. The programming tools shall be able to communicate with the CPUs using the same data network system.

The CPU shall have the following communication ports:

(i) One serial port (RS232C or EIA485)

(ii) One Ethernet port complying with IEEE802.3, not slower than 100Mbps and supporting both static IP (Internet Protocol) address configuration and automatic IP address configuration using DHCP (Dynamic Host Configuration Protocol)

The PLC shall be able to communicate with other control systems including the SCADA system and Distributed Control System over the standard communication module.

2.4 Application Program

(a) Design Philosophy

The application program of the PLC shall be fully tested and debugged to ensure correct sequence of operation. Every control step shall be checked via feedback signal from the plant before proceeding to the next step. A sequence failed alarm shall be initiated when the plant does not respond to the control command after a reasonable time. The correct sequence shall be adequately interlocked electrically to prevent inadvertent plant operation.

Manual overriding control shall be provided to enable the plant to be manually controlled as required. It is essential that the manual control command shall not be routed through PLC for plant control.

Unless otherwise specified in the Particular Specification, the program shall be

designed in such a way that when a running process is interrupted from PLC control to manual control, the last state of plant operation shall be maintained and the PLC shall be reset to the first step of the control sequence and shall relinquish the control. A separate hardwired switch shall be provided for this resetting purpose.

Except where specified otherwise, it shall be possible to bypass the sequence of steps under PLC control, i.e. the start of the control sequence may commence at any selected step of the sequence. It shall also be possible to alter the preset time duration of a sequence step and the alarm level of an analogue signal without modifying the control program.

The application programs for identical processes shall be in the form of subroutines readily called for operation by the respective processes. For identical processes, the relays, timers and I/O configurations shall be systematically identified with common nomenclature used for ease of future fault finding. Such nomenclature shall be well documented in the program.

In case where a single PLC is required to control more than a single process loop, the programs of the system for each process loop shall be independent of one another and arranged in separate subroutines with different mnemonics/indications.

(b) Programming Language

The programming language supported by the PLC shall comply with IEC 61131-3 and shall facilitate the use of ladder diagrams, functional block diagrams, sequential function charts and structured texts.

The program functions shall include contacts, coils, timers, counters, mathematical and register manipulating functions.

(c) Communication with SCADA System or Distributed Control System

Where specified in the Particular Specification, the PLC shall report the status of its input/output points to and accept control from a third-party SCADA system or Distributed Control System using OPC, Modbus or any other protocols as specified. Where supported by the protocol, the PLC shall use report-by-exception algorithm to reduce network traffic. The program shall also cater for the characteristics and interfacing requirements of the communication media furnished by the Purchaser and implement the hand-shaking required such as modem dialling/answering and radio carrier keying.

3. EQUIPMENT AND COMPONENTS

3.1 Power Supply System

The normal power supply to the PLC system shall be 220V 50Hz or 24V d.c. as specified in the Particular Specification. PLC systems operating on a.c. supply shall

be powered by uninterruptible power supply (UPS) equipment complying with WSD Standard Specification E-61-03. PLC systems operating on d.c. supply shall be powered by diodes OR-ing the output from the AC/DC switching converter and the battery supply system complying with WSD Standard Specification E-60-03. Where specified, the Supplier shall submit detailed power consumption calculation to the Purchaser to substantiate the rating of the UPS and battery equipment.

The power supply shall be protected against short circuits and voltage surge. The power supply module of PLC shall have its own overcurrent and overvoltage protection circuits and have its outputs isolated from the mains supply and provide a chassis ground floated with respect to the mains earth.

3.2 System Inputs and Outputs

(a) General

All necessary signal input/output interfacing equipment shall be provided.

In order to provide flexibility of arrangement and to economize on hardware, all digital and analog I/O modules shall be physically interchangeable within the dedicated chassis for I/O modules. I/O modules shall be clearly labelled with module description to identify their types and identification numbers.

Upon finalization of arrangement of I/O modules, a 'key' shall be available to prevent future incorrect placement of I/O modules. Where physical keying is not available, the PLC shall have control logics to prohibit generation of process control commands by the CPU and produce fault indications on the CPU upon detection of incorrect placement of I/O modules.

A fault occurring on a channel of an I/O module shall not affect the operation of any other circuits. Removal/insertion of an I/O module shall not cause damage to a running PLC, otherwise interlock mechanisms shall be provided to prevent inadvertent removal/insertion of an I/O module when the power is on.

The I/O points shall be so allocated and grouped to the I/O modules that the number of equipment to be affected shall be minimized when the module is removed. The following requirements shall be met:-

(i) The number of input/output signals handled by a card shall not exceed 16.

(ii) At least 10% of the channels shall be allocated as spare on each module.

(iii) The circuit and connections for identical types of equipment under control shall be wired to the same channel on separate I/O modules as far as practicable.

Wiring to I/O module terminals or harness shall be at least $0.5mm^2$. I/O

modules integrated with illuminated push button panels shall not be used for the purpose of PLC I/O modules except for prior approval.

(b) Digital I/O Module

Digital I/O modules shall be equipped with light emitting diodes (LED) to provide visual display of the on/off status of each channel.

Each digital I/O channel shall be capable of being forced to an ‘on’ or ‘off’ state by the programming tools, which shall override the control of the CPU to allow testing or maintenance of a running system.

Digital inputs shall be from volt-free contacts.

Digital outputs shall be configurable to either hold its last state or reset upon detection of faults of the module or the CPU.

Digital outputs from the PLC shall drive relays to give volt-free contact signals with a contact rating as specified in Standard Specification E-80-01.

(c) Analog I/O Module

Analog input shall be 4-20mA d.c.. The analog inputs shall be of floating differential input buffered and filtered to reduce mains noise. Shared use of analog-to-digital converter by multiplexing signals from each channel on the module is also acceptable. The accuracy shall be better than 0.5% over the entire operating temperature range.

To eliminate problems caused by common earth, the inputs shall be isolated from the chassis ground and the internal electric ground. The isolation shall be able to protect the input against a minimum of 400V and a transient of 1500V. The inputs shall be protected against high induced or pick-up voltages.

The analog output current driver shall be capable of delivering 4-20mA d.c. into a 500 ohms load. The output shall be protected against open circuits. The overall accuracy for the transmitted analog signals shall be within 0.5% of the signal span over the operating temperature range of the equipment. If the analog outputs have one common point, the common point shall be the negatives of the output signal and shall be connected to the system at 0V.

(d) Fieldbus I/O Module

The PLC shall be able to communicate remotely with a smart device using Fieldbus complying with IEC 61158. The number and the type of Fieldbus devices shall be as specified in the Particular Specification.

(e) Remote I/O Module

Where the I/O must be placed remotely from the CPU chassis, use of a

separate chassis for remote I/O modules is acceptable. The connection between the CPU chassis and the remote I/O module chassis shall employ shielded twisted pair, coaxial cable, twinaxial cable or fibre optic cable. Fibre optic cable should be provided where the cable length exceeds the reliable operating limit of copper cable at the specified transmission speed, or where specified for use in a highly noisy electrical environment.

For applications on centralized process control system, detailed requirements of the redundant data network transmission, maximum distance between the CPU chassis and the remote I/O module chassis and the required communication speed shall be specified in the Particular Specification.

3.3 Central Processing Unit (CPU)

The CPU shall, in addition to performing normal control functions in accordance with the program, monitor the status of its own operation as self-diagnosis and initiate preset logic shutdown sequence in the event of system malfunction. Clear visual indication on the status of the unit shall be provided.

Where specified or for a centralised process control system, a redundant CPU complete with independent power supply module shall be provided to form a hot standby system with seamless transfer of the control operation. To facilitate maintenance, manual switch over to the standby unit shall be effected by means of a key switch or through the programming tools.

The CPU shall be readily expandable to cater for future expansion of I/O modules up to 30% without major modification or upgrading work being required. It shall have the capability of upgrading its processor for better performance, higher speed and enhanced functionality without substantial change of the application program.

The CPU shall be chosen such that, with the complete application program running, the response time shall be better than:

(i) 0.5 second for digital I/O points

(ii) 1 second for analog I/O points

The executable program and the logic control program shall be stored in a non-volatile memory e.g. EEPROM or Flash memory. On start up of the PLC, the logic control program and data (operands and registers) should be loaded and stored in the battery backed dynamic RAM. A complete set of programs shall be stored in a CD-ROM or USB memory stick and provided as back up.

The CPU shall be operable in the following modes with restricted security access by a key switch or other equivalent means:

(a) Program Mode (no scanning and control logic execution, programming are allowed)

(b) Test Mode (normal scanning, edits are not permanently active)

(c) Run Mode (normal scanning and control logic execution, control program cannot be edited)

3.4 Programming Tools

Where specified in the Particular Specification, a set of user-friendly PLC programming software shall be provided as programming tools. The software shall be installed on a conventional notebook computer and capable of programming all types of CPUs installed with a full set of processor supported instructions.

The PLC programming software shall include routines for entering and editing programs; monitoring the status of the control programs; storing, duplicating and printing programs; cross referencing the register and I/O addresses; and controlling the states of the processor including diagnostic functions. The PLC programming software shall be capable of downloading / uploading control logic programs to the CPU and shall incorporate fault diagnostic and export function enabling data manipulation and printing of the processor control program, register contents and cross-referencing of addresses.

Unless otherwise specified in the Particular Specification, the PLC programming software shall allow editing and testing of the application programs in formats that comply with Clause 2.4 (b) of this Standard Specification.

4. TESTING AND COMMISSIONING

The testing and commissioning of the PLC shall include, but not limit to, the tests and procedure listed below. The Contractor shall perform additional tests as applicable to demonstrate that the equipment complies with the Particular Specification:-

(a) Functional test of all input/output devices

(b) Functional test of the software programs by simulation

(c) Reloading of the software programs from the backup CD ROM or USB memory stick supplied

(d) Calibration of all analog I/O devices at 5 evenly spaced points on the entire range

(e) Test of the correct operation of duty/standby system failover mechanism to ensure seamless transfer where applicable.

- End of this Specification -