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

This Specification should be read in conjunction with WSD Standard Specifications E-61-03, E-80-01, E-90-01, E-90-02.

1. GENERAL

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

The PLC shall comprise a central processing unit, input and output modules (digital and analog), communication/networking modules, voltage surge protection units, signal converters, isolators, power supply units, programming tools and other equipment necessary to form a complete working system.

Unless modified 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 electrical noisy environment and comply with IEC 60801 for electromagnetic compatibility.

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

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

All system modules, main and expansion chassis shall be designed to provide for free air flow convection cooling without the use of an internal fan.

The PLC shall support data access by a third-party server using Modbus 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 requirement of disturbing the field wiring. Where the modules are position dependent, the modules shall be clearly identified on the chassis to prevent incorrect insertion.

2.3   Communications

The processor unit shall be capable of communicating with a minimum of 30 peer devices, optionally using an external networking unit. Depending on application, the maximum network distance, network configurations, transmission media and communication speed shall be specified in the Particular Specification. The communications shall have built-in error detection mechanisms to assure data integrity. The communications wiring shall be twinaxial, twisted pair or coaxial cable. Fibreoptic cable shall be provided where specified for use in noisy electrical environments. The programming tools shall be able to communicate to the processor units using the same network system.

The processor unit 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 automatic configuration using DHCP (Dynamic Host Configuration Protocol)

For future expansion, communications with other intelligent devices such as SCADA and Distributed Control Systems shall be able to be carried over various media such as radio, microwave, leased or dial up telephone lines, mobile telephone and IP network.

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 onto 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 as called from 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.

In cases 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 each other and different mnemonics/indications shall be provided.

(b)   Programming Language

The programming shall be carried out in a language complying with IEC 61131-3. The programming languages supported by the PLC shall include Ladder Diagram, Function Block Diagram, Sequential Function Chart and Structured Text.

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

(c)   Communication with SCADA or Distributed Control System

When 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 or Distributed Control System using OPC, Modbus or any other protocol as specified. Where supported by the protocol, the PLC shall use report by exception to reduce network traffic. The program shall also cater for the characteristics 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 power supply system shall have its output isolated from the mains input and be floating with respect to the mains earth. The power supply shall be protected against short circuits and power surge, and the power supply module of PLC shall contain its own overcurrent and overvoltage protection.

The normal power supply to the 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 from an uninterruptible power supply (UPS) equipment complying with WSD Standard Specification E-61-03. If particularly specified, the Supplier shall provide detailed power consumption requirements to the Purchaser to determine the rating of the UPS equipment.

3.2   System Inputs and Outputs

(a)   General

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

In order to provide flexibility of arrangement and to economize on hardware, all digital and analog I/O cards shall be physically interchangeable within the I/O card frame. Cards shall be labeled with module description to identify specific types of input cards from output cards.

Upon final selection and arrangement of I/O cards, the option shall be available to 'key' the card receptacles in the I/O structure to prevent future incorrect placement of I/O cards. Where physical keying is not available, the PLC shall have logic to prohibit processor running and produce fault indication on the processor module on detection of incorrect I/O placement.

A fault occurring on an input/output point shall not affect the operation of any other circuits. Removal/insertion of an input/output card shall not cause damage to a running PLC, otherwise interlock mechanisms shall be provided to prevent inadvertent removal/insertion of an input/output card until power is switched off.

The input/output cards shall be so allocated as to ensure a minimum number of equipment to be affected when a card is removed. The following requirement shall be met:-

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

(ii)   At least 10% spare channels shall be allocated as spare in each card.

(iii)   The circuit and connections for identical types of equipment under control shall be wired to the same position in separate input/output cards.

Wiring to I/O module terminals or harness shall be at least 0.5mm^2. Illuminated push button panels integral with input/output modules shall not be used unless prior approval has been obtained.

(b)   Digital I/O

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

Each digital I/O point shall be capable of being forced to an 'on' or 'off' state, overriding the processor unit logic control program 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 under module or processor fault conditions.

Digital outputs from the PLC shall use relays with contact rating as specified in Standard Specification E-80-01.

(c)   Analog I/O

Analog input shall be 4-20mA d.c. The analog inputs shall be multiplexed into a floating differential input analog-to-digital converter with inputs buffered and filtered to reduce mains noise. 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 chassis ground and internal electric ground. The isolation shall be able to protect 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

The PLC shall be able to acquire data remotely from 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

Where the I/O must be placed remotely from the processor's chassis, the I/O connection shall be made in the form of bus using shielded twisted pair, coaxial cable or twinaxial cable. Fibreoptic cable should be provided when specified for use in a highly electrical noisy environment.

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

3.3   Processor Unit

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

Where particularly specified or for a centralized process control system, a redundant processor unit complete with power supply shall be provided to form a hot standby system with bumpless transfer of control operation. To facilitate maintenance, manual switch over to the standby processor unit shall be effected by a key switch or through the programming tools.

The processor unit shall be capable for future expansion of input/output modules up to 30% without major modification or upgrading work being required. The capability of upgrading to better performance processor with higher speed and enhanced functionality with no change of the control program is desirable.

The processing unit shall be chosen such that, with the complete application program running, the response times shall be better than:

(i)   0.5 second for digital I/O points

(ii)   1 second for analog I/O points

The executive 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 (registers) should be loaded and stored in Battery Backup Dynamic RAM. A complete set of programs shall be stored in a CD-ROM and provided as back up.

The processor unit shall be selectable for the following operation mode with restricted security access either by a key switch or 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 processor units installed with the full set of processor supported instructions.

The minimum requirements of 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 processor unit and incorporate fault diagnostic and export function enabling data manipulation and printing of the processor control program, register contents and cross-referencing of address.

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

4.   **TESTING ON COMMISSIONING**

The minimum requirements for testing and commissioning of the PLC are 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 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 bumpless transfer where hot standby system is supplied

- End of this Specification -